DESCRIPTION OF EARLY STAGES OF WHITE SEABASS, *ATRACTOSCION NOBILIS,* WITH NOTES ON DISTRIBUTION

H. GEOFFREY MOSER, DAVID A. AMBROSE, MORGAN S. BUSBY, JOHN L. BUTLER, ELAINE M. SANDKNOP, BARBARA Y. SUMIDA, AND ELIZABETH G. STEVENS
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center
La Jolla, California 92038

ABSTRACT

Eggs, larvae, and juveniles of *Atractoscion nobilis*, reared in the laboratory, are described and compared with those of *Cynoscion* species. Eggs of *A. nobilis* are among the largest reported for a sciaenid species (1.24-1.32 mm diameter), and the larvae have a distinctive morphology and pigment pattern that contrasts sharply with that of *Cynoscion* species. The larvae are robust, with long pectoral and pelvic fins and have a solid pigment sheath of melanophores and xanthophores that initially covers the head and trunk and expands to cover the body completely. The only other sciaenid with similar developmental stages is *Sciaena umbra* of the eastern Atlantic, Mediterranean, and Black Sea. Late-stage larvae of *Larimus fasciatus* of the western Atlantic have large, heavily pigmented paired fins, but the body pigment is not a solid cloak as in *A. nobilis*.

Atractoscion larvae occurred in only 104 samples of all CalCOFI collections made between 1950 and 1978. Larvae occurred from Santa Rosa Island, California, to Santa Maria Bay, Baja California, with highest concentrations in the Sebastian Viscaino Bay and San Juanico Bay regions. Most of the larvae occurred from May to August, with a peak in July.

RESUMEN

Se describen los huevos, larvas y juveniles de *Atractoscion nobilis* cultivadas en el laboratorio, y se comparan con especies de *Cynoscion*. Entre las especies de Sciaenidae, los huevos con mayores dimensiones corresponden a *A. nobilis* (1.24-1.32 mm. de diámetro), y sus larvas muestran una morfología bien definida, con el pigmento distribuido de forma diferente a la que presentan las especies de *Cynoscion*. Las larvas son robustas, con aletas pectorales y pélvicas largas, y llevan pigmento que incluye melanoforos y xantoforos. Esta capa de pigmento cubre inicialmente la cabeza y tronco, extendiéndose hasta cubrir completamente el cuerpo. *Sciaena umbra* es otro Sciaenidae con fases de desarrollo similar, y habita el Atlántico oriental, Mar Mediterráneo y Mar Negro. Las últimas fases larvales de *Larimus fasciatus* del Atlántico occidental, son de gran tamaño, con aletas pares densamente pigmentadas, pero la pigmentación del cuerpo no es una capa continua como en *A. nobilis*.

De todas las colecciones de CalCOFI efectuadas entre 1950 y 1978, únicamente 104 muestras contenían larvas de *Atractoscion*. Estas larvas se distribuían desde la Isla Santa Rosa, California, hasta Bahía Santa María, Baja California (México), y las mayores concentraciones de larvas aparecían en las zonas de las Bahías Sebastián Vizcaíno y San Juanico. La mayor parte de las larvas se obtuvieron en el período de Mayo hasta Agosto, con máximos en Julio.

INTRODUCTION

The white seabass, *Atractoscion nobilis*, is the largest sciaenid inhabiting the waters off California and western Baja California and, because of its size and high food quality, has been a prized sport and commercial species. Vojkovich and Reed (1983) summarize the decline of the fishery, despite numerous management regulations imposed since 1931, and emphasize the need for information about early life history.

The taxonomic status of the white seabass has been unclear since the original description of Ayres (1860), who placed it in the genus *Johnius*. Gill (1863) established the genus *Atractoscion* to include *A. aequidens* of the southern African and Australian coasts, and the white seabass. Jordan and Evermann (1898) made *Atractoscion* a subgenus of *Cynoscion*, and Trewavas (1977) re-established the genus *Atractoscion* to include *A. aequidens* and *A. nobilis*, based primarily on the fact that these two species lack the adult canine teeth typical of other *Cynoscion* species.

The purpose of this paper is to describe the early life history of *A. nobilis* and to present data on seasonal distribution of larvae from CalCOFI collections. Also, the early stages of *A. nobilis* are compared with those of *Cynoscion* to provide additional taxonomic characters of cynoscionine fishes.

MATERIALS AND METHODS

Specimens used in the description came from four sources. The original identification was based on a

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single larva taken from a reared batch of sciaenid eggs, mostly *Cheilotrema saturnum*, collected by plankton net at the surface off Tourmaline Canyon, San Diego, on July 6, 1978. The 8.3-mm larva was sampled on July 31, 25 days after collection. Temperature range of the 100-l rearing tank was 18.7-21.7°C, and the larva was fed a diet of the rotifer *Brachionus plicatilis* and nauplii of *Artemia salina*. A second source of specimens was a batch of eggs provided by the aquarium at Scripps Institution of Oceanography. On June 13, 1980, the eggs appeared in a tank containing two white seabass that had been collected as one-year-old fish and maintained in the tank for two years. The eggs were transported to the Southwest Fisheries Center and placed in a 100-l rearing tank. Hatching occurred after 3 days, and yolk was exhausted on about day 6, at which time *B. plicatilis* was added to the tank. The larvae did not feed, and all were dead on day 10. Temperature range in the tank was 16.5-20.0°C.

The principal sources of larvae were from two spawnings of captive adult *A. nobilis* maintained under modified environmental conditions at the Southwest Fisheries Center by Roger Leong (pers. comm.). The first spawning was on March 18, 1982, and, for a period of 8 days, specimens were supplied to us by Carol Kimbrell. The second spawning was on April 12, 1982, and larvae were reared by Carol Kimbrell according to procedures described in Hunter and Kimbrell (1980). Specimens were supplied to us daily, and some were photographed, after anesthetization in MS-222, to record live color pattern. All specimens were preserved in 4% Formalin.

One series was assembled to describe changes in morphology and pigment pattern, and another to describe head-spine formation and ossification of meristic elements. For comparative purposes, two series of *Cynoscion acoupa maracaiboensis* were also assembled from specimens supplied by Dr. Raymond Olivares, University del Zulia, Maracaibo, Venezuela. Techniques and terms used in the description follow those outlined in Moser and Ahlstrom (1970, 1978) and Ahlstrom et al. (1976).

Distributional data were obtained by examining all ichthyoplankton samples containing sciaenids taken by CalCOFI from 1950 to 1978, and by identifying and measuring specimens of *A. nobilis*.

DESCRIPTION (Figures 1-4)

Distinguishing Features

Eggs are larger (1.24-1.32 mm diameter) and have a larger oil globule (0.30-0.36 mm diameter) than those of the six other sciaenid species off California (Watson 1982, *Genyonemus lineatus;* Moser et al., other species[1]). Egg diameter of the other sciaenids is less than 1.0 mm, and oil globule diameter is less than 0.26 mm. Larvae hatch at a larger size (ca. 2.8 mm) and are larger at yolk depletion (3.7 mm) than in the other species, which hatch at 1.4-1.8 mm and are 2.4-3.0 mm at yolk depletion. First-feeding larvae are distinguished by a melanistic sheath that covers the head and trunk to slightly posteriad of the anus. *Menticirrhus undulatus* is similar but less intensely pigmented, is less robust, and is smaller at comparative states of development. Beyond initial feeding stages *A. nobilis* larvae become deep-bodied, and develop a large broad head and a solid pigment cloak that gradually covers the entire body. After notochord flexion the paired fins become enlarged and heavily pigmented, and a characteristic banding pattern develops on the body.

Eggs

The eggs of *A. nobilis* are among the largest known for Sciaenidae. For 25 eggs measured from the June 13, 1980, spawning the diameter range was 1.24-1.32 mm ($\bar{x}$ = 1.27 ± 0.02 SD), with an oil globule diameter range of 0.30-0.36 mm ($\bar{x}$ = 0.33 ± 0.02 SD). In the developing embryo the oil globule is located posteriad in the yolk sac. Melanophores begin to appear on the embryonic axis within the first day, and the embryo develops a solid sheath of melanophores on the head and trunk before hatching. Melanophores on the oil globule are concentrated on the inner surface.

Morphology

At hatching the larva is relatively undifferentiated and has a large ovoid yolk sac (ca. 0.9 × 1.5 mm). During the yolk-sac period relative snout-anus length and overall body depth decrease as the yolk is depleted (Table 1), and at the termination of the yolk-sac stage the gut begins to coil. The pectoral fin buds appear about midway through the yolk-sac period and have a well-differentiated base and blade by the end of the period.

During the preflexion and flexion stages relative snout-anus length, head length, head width, snout length, and body depth increase while relative eye diameter decreases gradually (Tables 1, 2). At notochord flexion, larvae have attained their highly characteristic morph—a massive head with large jaws, a pronounced convex dorsal profile, and a deep, robust trunk region that tapers gradually to a narrow caudal peduncle. In postflexion larvae there is a con-

[1]Manuscript (in preparation) on early stages of sciaenid species off California.

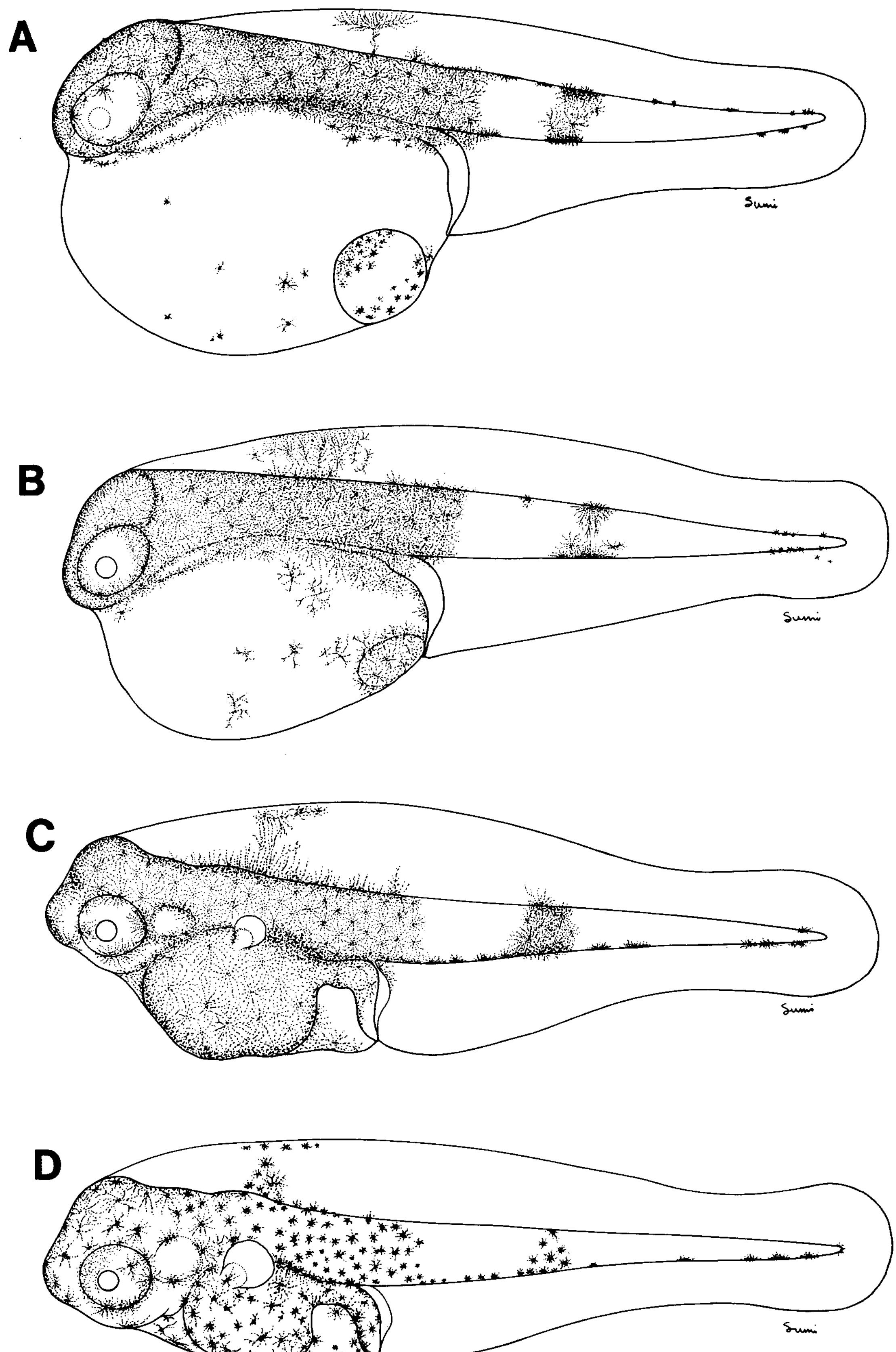

Figure 1. Yolk-sac larvae of *Atractoscion nobilis* from July 13, 1980, spawning. *A.* 2.8 mm, day 3; *B.* 3.2 mm, day 3; *C.* 3.5 mm, day 4; *D.* 3.7 mm, day 5.

TABLE 1
Measurements (mm) of Early Stages of *Atractoscion nobilis*

Body length	Age (days)	Snout-anus distance	Head length	Head width	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Yolk sac length	Yolk sac depth	Oil globule diameter
2.8	3	1.6	0.76	0.42	0.10	0.27	1.1	—	—	—	1.5	0.90	0.36
3.2	3	1.7	0.70	0.47	0.15	0.30	0.94	—	—	—	1.3	0.86	0.36
3.5	4	1.6	0.75	0.46	0.13	0.32	0.81	—	0.15	—	0.81	0.57	0.35
3.7	5	1.6	0.78	0.55	0.18	0.34	0.71	—	0.27	—	0.57	0.50	0.26
3.5	7	1.6	0.91	0.65	0.17	0.32	0.81	0.19	0.30	—	—	—	0.15
3.7	7	1.7	0.90	0.74	0.16	0.37	0.96	0.22	0.31	—			
4.0	8	1.8	1.0	0.79	0.22	0.40	1.0	0.25	0.35	—			
4.2	10	1.9	1.2	0.81	0.28	0.41	1.0	0.26	0.42	—			
4.5	10	2.1	1.2	0.88	0.25	0.44	1.2	0.28	0.44	—			
4.7	10	2.3	1.3	0.90	0.28	0.48	1.3	0.29	0.48	—			
5.1	14	2.4	1.4	1.0	0.35	0.49	1.5	0.29	0.52	—			
5.2	15	2.6	1.3	1.0	0.3	0.53	1.5	0.35	0.52	0.08			
5.5	15	2.6	1.5	1.2	0.38	0.55	1.7	0.36	0.60	0.08			
5.7	15	2.8	1.7	1.2	0.50	0.62	1.8	0.40	0.62	0.11			
5.9	15	2.9	1.7	1.2	0.50	0.64	1.9	0.46	0.60	0.10			
6.0	18	2.9	1.8	1.4	0.51	0.67	2.0	0.52	0.62	0.13			
6.2	18	3.1	2.0	1.5	0.48	0.68	2.1	0.46	0.65	0.20			
6.5	22	3.5	2.0	1.5	0.54	0.67	2.2	0.63	0.75	0.33			
6.8	22	4.0	2.3	1.6	0.50	0.83	2.6	0.80	0.76	0.49			
7.0	25	4.0	2.4	1.7	0.58	0.84	2.6	1.0	0.75	0.72			
7.4	25	4.2	2.6	1.9	0.66	0.89	2.8	1.2	0.81	0.88			
7.8	25	4.6	2.8	1.8	0.64	0.88	2.8	1.2	0.78	0.85			
8.2	25	5.1	3.0	1.9	0.62	0.94	2.9	1.4	0.80	1.0			
8.8	30	5.4	3.1	2.1	0.86	1.0	3.6	1.9	0.84	1.5			
9.2	30	5.6	3.2	2.4	0.95	1.0	3.5	1.8	0.83	1.7			
9.6	30	6.1	3.3	2.6	0.90	1.1	3.8	2.1	1.0	1.8			
10.0	29	6.4	3.4	2.5	0.92	1.0	3.6	2.0	0.84	1.7			
10.5	37	7.2	3.8	2.5	1.1	1.2	3.9	2.6	0.92	—			
10.7	37	7.2	4.0	2.6	1.0	1.2	3.8	3.0	1.0	2.0			
11.3	37	7.1	4.2	2.6	1.1	1.3	4.1	3.0	1.0	2.4			
11.7	37	7.8	4.2	2.7	1.1	1.3	4.2	2.9	1.0	2.3			
12.0	37	7.8	4.4	2.9	1.2	1.3	4.4	3.0	0.94	2.5			
12.2	37	7.8	4.3	2.9	1.2	1.3	4.2	3.3	1.0	2.7			
12.8	44	8.3	4.5	3.0	1.2	1.4	4.5	3.5	1.0	2.7			
13.1	36	9.2	5.0	2.9	1.2	1.5	4.8	3.6	1.0	2.9			
13.9	36	9.3	5.1	3.0	1.2	1.5	4.8	3.7	1.1	2.9			
14.9	44	10.3	5.2	3.5	1.3	1.7	5.2	4.2	1.1	3.6			
15.5	52	10.8	5.6	3.3	1.5	1.8	5.2	3.8	1.1	3.3			
15.8	48	11.3	6.3	3.3	1.9	1.5	4.9	4.2	1.1	3.7			
17.1	44	11.7	5.8	3.8	1.8	1.5	6.1	4.8	1.2	3.8			
17.2	49	11.8	7.2	3.4	1.5	1.9	6.3	5.3	1.1	4.3			
17.7	42	12.2	6.2	3.4	1.6	1.9	5.5	4.5	1.2	3.8			
18.7	48	13.3	7.5	4.0	1.9	2.1	6.3	5.3	1.2	3.8			
20.2	46	13.8	7.5	4.2	1.4	1.8	6.8	5.5	1.3	5.2			
20.5	46	14.2	7.3	4.2	1.6	2.0	6.7	5.6	1.3	4.8			
22.8	46	16.2	8.5	5.0	1.9	2.3	7.5	5.8	1.3	5.3			
23.0	46	16.2	7.8	4.5	2.0	2.2	7.6	6.0	1.4	5.3			
27.3	57	19.3	8.8	5.0	1.9	2.5	8.8	6.7	1.6	6.2			
38.1	76	26.6	13.8	6.0	2.7	3.5	10.7	8.0	1.9	6.3			
38.4	76	26.3	13.0	5.4	2.7	3.3	10.8	—	2.0	6.3			
53.6		37.1	17.2	7.2	4.2	3.7	14.0	9.7	2.5	10.0			
64.7		45.1	20.3	8.8	5.0	4.3	17.0	11.3	2.5	11.7			
75.2		51.9	22.8	10.0	5.3	5.2	20.2	12.7	3.2	13.3			
82.0		57.3	24.6	9.5	7.0	5.3	22.2	—	3.4	13.6			
98.4		69.5	30.3	13.0	6.7	5.8	24.7	—	4.2	15.3			

Specimens between dashed lines are undergoing notochord flexion. Specimens between solid lines are reared juveniles. Specimens below solid line are juveniles from Scripps Institution of Oceanography fish collection.

tinued relative increase in snout-anus length. Relative head length and body depth are slightly greater than in the previous stage. Relative snout length remains constant, but relative head width and eye diameter continue to decrease slightly. There is a gradual deepening of the body during this stage, to become somewhat slab-sided, and the entire dorsal profile becomes strongly arched, tapering abruptly at the caudal pedun-

TABLE 2
Morphometry of Larvae and Early Juveniles of *Atractoscion nobilis*

	Snout-anus distance / Body length	Head length / Body length	Head width / Head length	Snout length / Head length	Eye diameter / Head length	Body depth / Body length	Pectoral fin length / Body length	Pectoral base depth / Body length	Pelvic fin length / Body length
Preflexion									
$\bar{x}$ ± SD	47.6 ± 4.06	25.1 ± 2.69	69.9 ± 7.43	20.2 ± 3.26	38.5 ± 3.58	26.6 ± 5.18	6.0 ± 0.33	8.6 ± 1.90	—
(range)	(43.2 – 57.1)	(21.1 – 28.6)	(55.3 – 82.2)	(13.2 – 25.0)	(34.2 – 43.6)	(19.2 – 39.3)	(5.4 – 6.3)	(4.3 – 10.2)	—
N	11	11	11	11	11	11	7	9	0
Flexion									
$\bar{x}$ ± SD	50.8 ± 3.75	29.7 ± 2.77	74.4 ± 3.81	26.0 ± 2.95	36.0 ± 2.86	32.8 ± 2.75	8.2 ± 1.81	10.8 ± 0.61	3.0 ± 2.07
(range)	(47.3 – 58.8)	(25.0 – 33.8)	(69.6 – 80.0)	(21.7 – 29.4)	(31.6 – 40.8)	(28.8 – 38.2)	(6.5 – 11.8)	(10.0 – 11.6)	(1.5 – 7.2)
N	8	8	8	8	8	8	8	8	8
Postflexion									
$\bar{x}$ ± SD	64.2 ± 4.02	35.8 ± 1.15	66.7 ± 5.63	25.9 ± 2.21	31.4 ± 1.58	36.4 ± 1.80	23.0 ± 4.61	8.8 ± 1.14	18.3 ± 4.23
(range)	(56.8 – 70.2)	(24.0 – 38.2)	(58.0 – 78.8)	(20.7 – 29.7)	(29.4 – 35.0)	(33.5 – 40.9)	(14.3 – 28.2)	(7.1 – 10.9)	(10.3 – 24.2)
N	19	19	19	19	19	19	19	19	18
Reared Juveniles									
$\bar{x}$ ± SD	69.7 ± 1.20	36.8 ± 2.65	53.4 ± 6.73	22.6 ± 2.57	27.6 ± 2.18	32.4 ± 2.58	26.4 ± 2.49	23.5 ± 1.90	22.2 ± 3.11
(range)	(68.3 – 71.5)	(33.9 – 41.9)	(41.5 – 65.5)	(18.7 – 25.9)	(24.0 – 31.0)	(28.1 – 36.6)	(21.0 – 28.3)	(20.8 – 26.7)	(16.4 – 25.7)
N	12	12	12	12	12	12	11	11	11
Field-Collected Juveniles									
$\bar{x}$ ± SD	69.7 ± 0.63	30.9 ± 0.85	42.1 ± 2.10	24.6 ± 2.42	21.2 ± 1.34	26.3 ± 0.79	17.5 ± 0.60	24.4 ± 1.99	17.3 ± 1.27
(range)	(69.0 – 7.06)	(30.0 – 32.1)	(38.6 – 43.9)	(2.21 – 28.5)	(19.1 – 22.8)	(25.1 – 27.1)	(16.9 – 18.1)	(22.1 – 25.8)	(15.5 – 18.7)
N	5	5	5	5	5	5	3	3	5

Values given for each body part are expressed as percentage of body length or head length.

cle. In reared juveniles relative head width and body depth decrease as the body becomes terete.

Fin Formation/Meristics

Ossification of the principal caudal fin rays begins at the initiation of notochord flexion (ca. 5.6 mm); however, the full complements of 9+8 principal and 8+7 procurrent rays have not begun ossifying until larvae reach about 7.1 and 14.5 mm, respectively (Table 3). Notochord flexion is complete at about 7.0 mm SL. Ossification of rays begins in the other fins about midway through notochord flexion. The full complement of IX-X + I, 19-23 dorsal rays is ossifying just after notochord flexion is complete. Anal fin formation is similar, with the soft rays ossifying first and the full count of I-II, 8-10 present just after flexion. Both fins become lobate in postflexion larvae and early juveniles, as does the caudal fin.

Ossification of rays in the paired fins begins at about 6.0 mm, midway through notochord flexion (Table 3). The full complements of 15-18 pectoral and I,5 pelvic rays are present in early postflexion larvae. The fins enlarge rapidly in the postflexion stage. Average relative pectoral fin length is three times

TABLE 3
Meristics from Cleared and Stained Larvae of *Atractoscion nobilis**

Day	Body length	Dorsal fin rays	Anal fin rays	Pectoral fin rays	Principal caudal fin rays	Procurrent caudal fin rays	Vertebrae	Branchio-stegal rays	Pelvic rays
10	4.5	—	—	—	—	—	—	2	—
14	5.0	—	—	—	—	—	3	6	—
15	5.6	—	—	3	4 + 4	—	8	7	—
18	5.8	—	—	6	6 + 6	—	16	7	—
22	6.1	VIII + I,12	—,2	6	7 + 7	—	19	7	—,3
22	6.7	VIII + I,15	—,6	7	8 + 7	—	21	7	I,3
24	7.1	IX + I,18	I,8	12	9 + 8	0 + 1	20	7	I,5
25	7.6	IX + I,20	I,9	13	9 + 8	1 + 1	25	7	I,5
27	9.4	IX + I,22	II,10	16	9 + 8	4 + 4	25	7	I,5
37	9.9	X + I,22	II,10	18	9 + 8	6 + 6	25	7	I,5
35	11.0	X + I,21	II,9	17	9 + 8	7 + 7	25	7	I,5
42	13.5	X + I,19	II,10	17	9 + 8	7 + 7	25	7	I,5
42	14.5	X + I,23	II,10	17	9 + 8	8 + 7	25	7	I,5

*Counts of paired structures taken on left side.

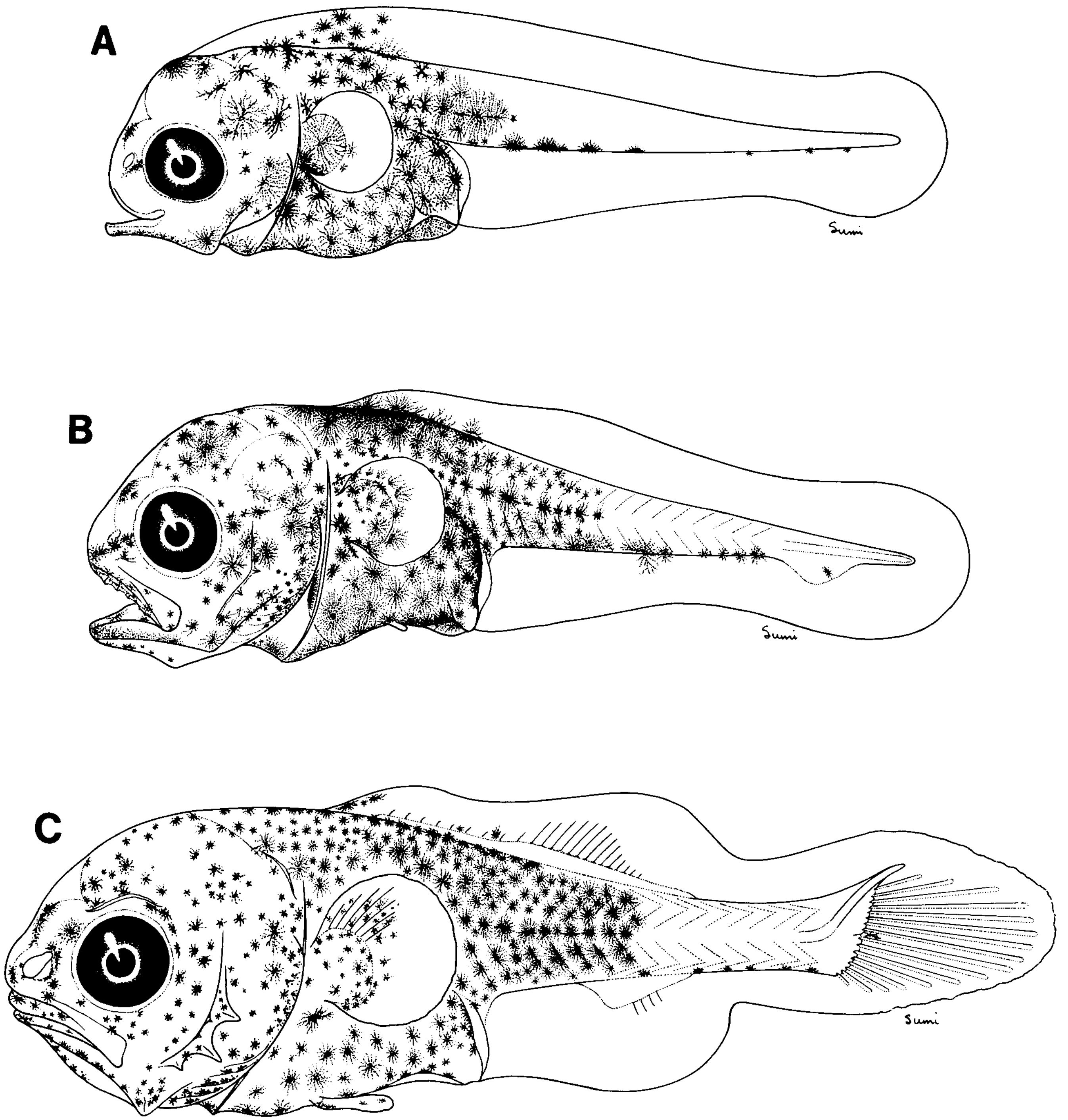

Figure 2. Larvae of *Atractoscion nobilis* from April 12, 1982, spawning. *A.* 3.7 mm, day 8; *B.* 5.1 mm, day 14; *C.* 6.5 mm, day 22.

greater in postflexion larvae than in flexion larvae, and relative pelvic fin length is six times greater. Both fins become lobate to somewhat fan-shaped in postflexion larvae (Figure 3).

Larvae begin to develop an array of head spines just before notochord flexion. The spines of the opercular series of bones appear first, with the preopercle developing the greatest number of spines (Table 4, Figures 3, 4). The posttemporal spines also develop early; the bone becomes trough-shaped, with spines forming on the anterior and posterior upturned edges. Anterior to the posttemporal bone, two scale bones develop in the region of the epiotic, one directly dorsal to the other. They too are trough-shaped and develop spines on the upturned edges. The frontal bone develops a supraocular crest bearing a series of spines. A longitu-

TABLE 4
Development of Head Spines (Left Side) in Larvae of *Atractoscion nobilis*

Bone	Location	Number of spines												
		Day												
		10	14	15	18	22	22	24	25	27	37	35	42	42
		Body Length (mm)												
		4.5	5.0	5.6	5.8	6.1	6.7	7.1	7.6	9.4	9.9	11.0	13.5	14.5
Preopercle	Anterior series	1	2	2	3	4	5	6	5	4	5	15	14	11
	Posterior series	—	2	3	3	3	4	5	5	6	10	8	12	8
Opercle		—	—	1	1	1	1	1	1	2	2	2	2	2
Subopercle		—	—	—	2	1	2	2	2	2	2	3	1	2
Interopercle		—	—	—	1	1	1	1	1	3	4	4	7	4
Posttemporal		—	—	—	—	—	—	—	1	6	10	7	7	6
Frontal	Supraocular	—	—	—	—	—	—	—	—	6	8	3	2	3
Pterotic		—	—	—	—	—	—	—	—	1	4	3	1	4
Scale Bone	Dorsal epiotic region	—	—	—	—	—	—	—	—	1	3	2	2	2
Scale Bone	Ventral epiotic region	—	—	—	—	—	—	—	—	1	4	4	3	3
Lacrymal		—	—	—	—	—	—	—	—	3	4	4	3	—
Dermospherotic		—	—	—	—	—	—	—	—	—	2	2	2	2
Circumorbitals		—	—	—	—	—	—	—	—	—	—	—	+	+

dinal crest develops on the pterotic, and bears up to 4 spines. The lacrymal bone develops 3-4 spines on its ventral margin at about 9.0 mm SL and, soon after, a small trough-shaped dermosphenotic (6th circumorbital) bone with 2 spines develops at the dorso-posterior margin of the orbit. At the end of the larval period 4 other circumorbitals develop around the posterior margin of the orbit, and each develops several spines.

Beginning at about 9.0 mm SL, scales, each with a single spine, appear on the opercle. They increase in number to almost cover the opercle at the end of the larval period.

Pigmentation

White seabass larvae develop two distinctive forms of pigmentation within a single pattern. Both melanophores and xanthophores begin to appear with equal prominence in the embryo; they increase in number and overlay each other almost exactly, to form a bicolored pattern. The following description applies to both melanophores and xanthophores, except as noted.

At hatching the entire head and trunk are pigmented solidly to slightly posteriad of the yolk mass (Figure 1). A postanal band is present on the tail, and, rearward of this, the dorsal and ventral midlines of the tail have melanophores only. This is the only place where both types of pigment cells are not present together. Above the trunk a tuft of pigment extends upward into the finfold and expands at the finfold margin. The oil globule is covered with pigment cells, and pigment is scattered over the yolk. As the yolk sac is depleted the gut mass becomes solidly pigmented, as does the pectoral fin base and, of course, the eye. At the end of the

TABLE 5
Measurements (mm) of Postflexion Larvae of *Cynoscion acoupa maracaiboensis*

Body length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length
7.3	4.2	2.4	0.6	0.56	2.2	—	—	0.16
7.6	4.3	2.8	0.6	0.64	2.5	0.80	0.40	0.72
7.8	4.4	2.7	0.6	0.64	2.7	0.88	0.44	0.68
8.1	4.8	2.9	0.7	0.70	2.7	0.92	0.52	0.76
8.9	5.6	3.3	0.8	0.80	2.9	1.2	0.64	0.88
9.3	6.2	3.4	0.9	0.72	2.8	0.80	0.64	0.72
10.3	6.9	3.7	1.0	0.80	3.2	1.5	0.80	1.1
10.5	7.0	4.1	0.96	1.0	3.2	1.84	0.64	1.2
13.5	9.4	5.3	1.3	1.1	4.2	—	0.76	2.1
14.2	9.5	5.2	1.1	1.3	4.4	3.1	0.84	2.1
$\bar{x} \pm$ SD	6.29 ± 5.10	36.3 ± 2.09	8.8 ± 0.81	23.2 ± 1.56	31.8 ± 1.51	12.4 ± 4.56	6.1 ± 1.12	10.0 ± 3.74
(range)	(56.4 – 69.8)	(32.3 – 39.5)	(7.6 – 9.9)	(20.3 – 24.8)	(29.6 – 34.4)	(6.0 – 21.7)	(3.8 – 7.8)	(2.2 – 15.4)
N	10	10	10	10	10	10	10	10

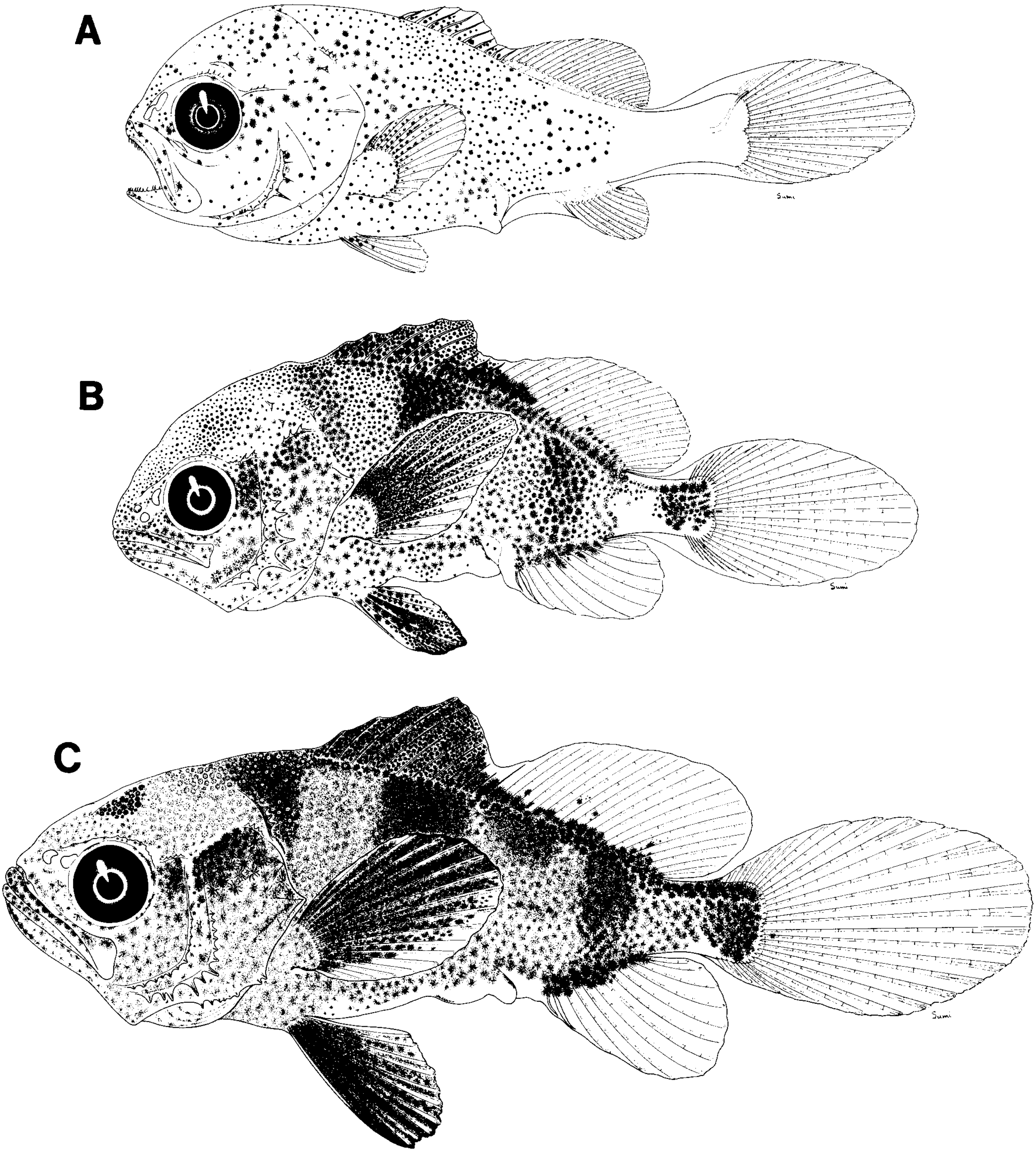

Figure 3. Larvae of *Atractoscion nobilis*. *A*. 8.3 mm, specimen reared from planktonic egg collection July 6, 1978, day 25. Note contracted state of melanophores; *B*. 10.7 mm, from April 12, 1982, spawning, day 37; *C*. 14.9 mm, from April 12, 1982, spawning, day 44.

yolk-sac period a postanal band is still present, but the dorsal midline melanophores are absent.

At the end of the first week (ca. 3.7 mm) the postanal band disappears. The postanal ventral midline series remains, with the melanophores of the anterior half of the series larger than those of the posterior half. The melanophores of the body cloak lying over the horizontal septum posterior to the pectoral fin appear larger and stand out as a line. Pigment begins to form on the pectoral fin blades.

Figure 4. Juveniles of *Atractoscion nobilis*. *A*. 33.5 mm SL, day 72, from April 12, 1982, spawning. *B*. 64.5 mm SL, day 103, from January 26, 1983, spawning.

During the remainder of the preflexion period the body sheath extends posteriad to almost midway on the tail, and pigment increases on the pectoral fin. During notochord flexion the body sheath progresses posteriad; pigment increases on the pectorals; and pigment begins to appear on the developing anterior dorsal fin and the pelvic fin.

In postflexion larvae the body sheath continues to expand posteriad, and the rapidly enlarging paired fins become heavily pigmented, as does the spinous dorsal fin. At about 10.0 mm SL, only the caudal peduncle and the caudal, soft dorsal, and anal fins remain unpigmented. A pigment patch appears at the base of the caudal fin (at ca. 10 mm), over the hypurals, and expands to meet the body sheath; thus the body is completely covered by ca. 15 mm. Pigment extends onto the bases of the soft dorsal and anal fins, but the caudal fin remains unpigmented until after the larval period.

Vertical pigment bands are usually present in *A. nobilis* as small as 10.5 mm SL (Figure 3B). The nape band and a band under the middle of the first dorsal fin (spines 5-9) are the first to appear. These are soon followed by a band under the middle of the second dorsal fin (rays 13-16), and at this stage the heavily pigmented caudal fin base also has the appearance of a band (Figure 3C). Some late-flexion larvae have a band under the anterior portion of the second dorsal fin (rays 3-7). Four intermediate bands or saddles develop between these 5 primary bands in juveniles, but these are fainter and narrower than the primary bands (Figure 4).

TABLE 6
Development of Head Spines (Left Side) in Postflexion Larvae of *Cynoscion acoupa maracaiboensis*

Bone	Location	Number of spines — Body length (mm) 6.9	7.5	8.3	8.4	9.8	10.3	10.7	13.5	14.2
Preopercle	Anterior series	3	4	4	6	4	5	4	7	8
	Posterior series	3	4	4	5	4	4	4	4	5
Opercle		—	—	—	1	2	2	2	2	2
Subopercle		1	1	2	1	1	2	1	1	3
Interopercle		1	1	1	1	1	1	1	1	2
Posttemporal		1	1	2	1	3	5	2	6	8
Frontal	Supraocular	2	3	3	4	6	6	6	10	11
Pterotic		—	—	—	—	—	1	—	2	3
Scale Bone	Dorsal epiotic region	—	—	—	—	—	—	1	2	2
Scale Bone	Ventral epiotic region	—	—	—	—	—	—	—	3	3
Lacrymal		—	—	1	—	1	1	1	1	—
Dermosphenotic		—	—	—	—	1	1	—	1	1
Circumorbitals		—	—	—	—	—	—	—	—	+

Comparison with Related Genera

Early life stages of *A. nobilis* differ markedly from those of 5 species of *Cynoscion* described in the literature: *C. acoupa maracaiboensis*[2]; *C. leiarchus* (Sinque 1980); *C. nebulosus* (Hildebrand and Cable 1934; Fable et al. 1978; Powles and Stender 1978); *C. nothus* (Hildebrand and Cable 1934; Powles and Stender 1978); *C. regalis* (Welsh and Breder 1923; Pearson 1941; Powles and Stender 1978); *C. striatus* (Weiss 1981). Egg diameters—known for *C. acoupa* (0.79-0.89 mm), *C. nebulosus* (0.70-0.85 mm), and *C. regalis* (0.80-1.05 mm)—are smaller than in *A. nobilis*. *Cynoscion* species, with the exception of *C. nebulosus*, are lightly pigmented at hatching, and first-feeding larvae have melanophores along the dorsal and ventral midlines, over the dorsal surface of the gut, and on the head, usually at the opercular region. With the exception of *C. nebulosus*, dorsal midline pigment is soon lost, and pigment is added to the head and over the body in patches that form vague bars in postflexion larvae. In *C. nebulosus* the dorsal and ventral midline pigment intensifies with development, as does a prominent lateral pigment line that extends along most of the body and forward as internal head pigment. This becomes a prominent irregular stripe in postflexion larvae and in juveniles.

As in *Atractoscion*, *Cynoscion* larvae develop a large bulbous head with large jaws; however, the snout and gut are shorter in *Cynoscion*. The body is rounded in cross section and tapers gradually posteriad from the head, contrasting with the deep, robust body form of *A. nobilis*. Larvae of *C. nebulosus* differ from other *Cynoscion* in having a more slender profile.

Series of postflexion larvae of *C. acoupa maracaiboensis* were measured and cleared and stained to compare morphometrics, head-spine development, and meristics with *A. nobilis* (Tables 5-7). Relative snout length, eye diameter, pectoral and pelvic fin length are markedly smaller in *C. acoupa*. Spines de-

[2]Olivares, R. MS. Observaciones preliminares sobre el desarollo de huevos y larvas vitelinas de la Curvina de Lago. *Cynoscion acoupa maracaiboensis* (Pisces: Sciaenidae).

TABLE 7
Meristics of Postflexion Larvae of *Cynoscion acoupa maracaiboensis*

Body length (mm)	Dorsal fin rays	Anal fin rays	Pectoral fin rays	Principal caudal fin rays	Procurrent caudal fin rays	Vertebrae	Branchiostegal rays	Pelvic rays
6.9	XIII + I,18	I,8	—	9 + 8	—	25	7	I,4
7.5	X + I,19	II,8	15	9 + 8	3 + 3	25	7	I,5
8.3	IX + I,21	II,8	12	9 + 8	3 + 3	25	7	I,5
8.4	X + I,22	II,8	17	9 + 7	6 + 5	25	7	I,5
9.8	X + I,19	II,8	16	9 + 8	6 + 5	25	7	I,5
10.3	X + I,19	II,8	17	9 + 8	6 + 5	25	7	I,5
10.7	X + I,20	II,8	16	9 + 8	7 + 6	25	7	I,5
13.5	X + I,20	II,8	17	9 + 8	9 + 8	25	7	I,5
14.2	X + I,19	II,8	18	9 + 8	10 + 9	25	7	I,5

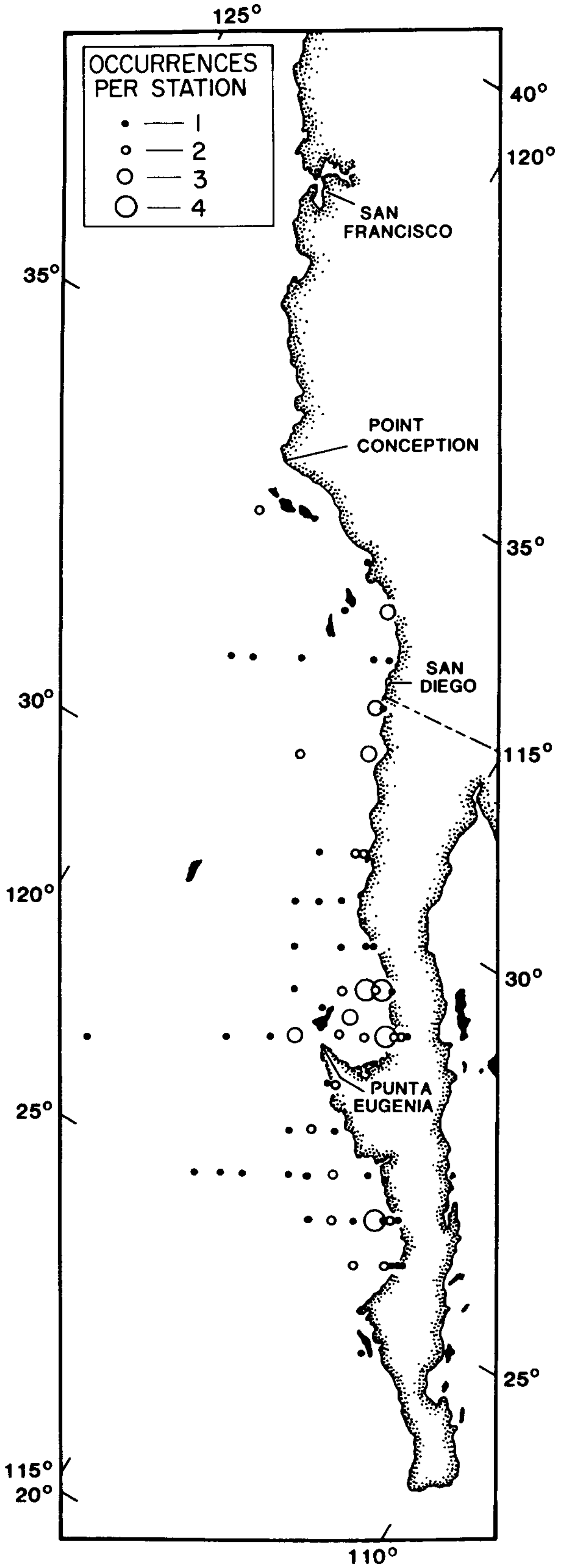

Figure 5. Occurrences of *Atractoscion nobilis* larvae in all CalCOFI samples taken from 1950 to 1978.

velop on the same bones, but there are fewer spines on the preopercle and lacrymal compared with *A. nobilis.*

To our knowledge the only species of sciaenid with early stages similar to *A. nobilis* is *Sciaena umbra* from the eastern Atlantic, Mediterranean, and Black Sea (Montalenti 1937; Dekhnik 1973). Egg diameter is 1.15-1.30 mm, with an oil globule diameter of 0.23-0.30 mm (Dekhnik 1973). Larvae are 2.5-2.6 mm at hatching and develop a body form and pigment pattern very similar to that of *A. nobilis.* Late-stage larvae of the western Atlantic species, *Larimus fasciatus,* have large, heavily pigmented paired fins, but the body pigment is not a solid cloak as in *A. nobilis* (Hildebrand and Cable 1934).

DISTRIBUTION

Atractoscion nobilis larvae occurred in only 104 of all CalCOFI tows made during 1950-78. Of these, 98 occurrences were recorded in tows made in April-August in a coastal zone with a seaward limit to station 60. Only 2 occurrences were on stations seaward of station 60—station 120.90 on cruise 5106 and station 130.65 on cruise 5906. Latitudinal limits were from CalCOFI station 83.55 near the northern Channel Islands to station 143.26 near Santa Margarita Island and Magdalena Bay, Baja California (Figure 5). Fifteen percent of the white seabass occurrences were in southern California waters, and the remaining 85% were along Baja California, with 50% north and 35% south of Punta Eugenia. The highest concentrations of larvae were found in the inshore regions of Sebastian Viscaino Bay and San Juanico Bay, Baja California. *A. nobilis* larvae were collected from January-October, but 92% of the occurrences and 95% of the individuals were taken from May-August. The peak month was July, with 55% of the occurrences and 60% of the individuals.

The size-frequency distribution of the white seabass larvae collected during the CalCOFI sampling program was narrow, with a mean length of 3.4 mm ± 1.10 SD and a range of 1.6-7.2 mm in the 122 larvae measured. Latitudinal trends in spawning season could not be determined with this limited length-frequency data.

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