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POSTLARVAL *NEOTHUNNUS MACROPTERUS, AUXIS THAZARD,* AND *EUTHYNNUS LINEATUS* FROM THE PACIFIC COAST OF CENTRAL AMERICA

By GILES W. MEAD
Illustrations by Walter B. Schwarz

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By GILES W. MEAD, *Fishery Research Biologist*

Until 1942, none of the spawning areas of the several species of eastern Pacific tunas was known. Since that year several such regions have been identified and in each case the discovery has been made by indirect means, through the collection and identification of the pelagic postlarvae, for the ripe eggs of the tuna have rarely been found. Knowledge of the location and extent of the spawning grounds of the tunas depends, therefore, on being able to identify the young taken in plankton collections. This paper provides a description of the identifying characters of the juveniles of several tunas.

In the late spring of 1949 I had the opportunity to make collections of pelagic postlarvae in waters off the Pacific coast of Central America. Supplementing this material, a series of uncatalogued specimens [1] from the California Academy of Sciences, which was collected off Central America during the 1932 cruise of the *Zaca,* was examined.

OBSERVATIONS ON ADULTS

The fishes collected in the spring of 1949 were taken from the motor vessel *Alphecca,* a tuna clipper fishing for the Westgate–Sun Harbor Co. of San Diego, Calif. Actual fishing was confined to the month of May in waters from 50 to 150 miles off the west coast of Nicaragua and El Salvador. During this period the 240-ton catch consisted of yellowfin tuna, *Neothunnus macropterus* (Temminck and Schlegel), and oceanic skipjack, *Katsuwonus pelamis* (Linnaeus), the former comprising the bulk of the catch by weight and number. Gonads of 25 of each species were examined for degree of maturity. It was apparent from this examination that the yellowfin tuna more than 75 centimeters long and all the oceanic skipjack were in advanced stages of sexual maturity. (Total lengths are taken from tip of snout to distal end of the shortest caudal fin ray.) Ovaries were swollen and turgid, although no ova were visible to the unaided eye. Testes of both yellowfin tuna and oceanic skipjack had milt in the central duct. Several large male yellowfin were running ripe, but no females in a similar condition were observed in the catch. Two female black skipjack, *Euthynnus lineatus* Kishinouye, 54.4 and 55.0 cm. in length were taken. Their ovaries were similar in degree of maturity to those of the oceanic skipjack. Two ripe female sierra mackerel, *Scomberomorus sierra* Jordan and Starks, were taken in a bait haul at Macapule, Mexico, in the Gulf of California. Eckles (1949) has described the postlarvae of this species. Although numerous attempts were made with a high-speed plankton net to recover the eggs from the surface layers of waters where mature fish were found, none proved successful.

Apparently the spawning season for the tunas is a long one and the spawning area large. Ehrenbaum (1924) outlines the probable spawning grounds in the Mediterranean region and in the Atlantic for the species represented in his collections by larvae and postlarvae. He also describes the degree of maturity and possible migrational routes of the adults. Similarly, various Japanese workers have attempted to delimit spawning areas in the western Pacific, and at present extensive work is being done near the Hawaiian Islands and the Philippines. The spawning areas of the tunas in Central America are now known to extend from Panama north to Nicaragua and El Salvador and off shore to a distance of more than 100 miles. It is also probable that spawning of yellowfin tuna and oceanic skipjack occurs off Mexico, since the *Zaca* collections made there include frigate mackerel and one larval black skipjack. It is not unlikely that future work will show that this spawning area extends throughout the tropical waters of Central America.

[1] Made available by Lillian Dempster of the California Academy of Sciences.

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OBSERVATIONS ON YOUNG

Since the tunas are subject to intensive fishing in many parts of the world their biology has long been under investigation. Kishinouye (1919) outlines the early work done on the larval stages of these fishes. As he points out in another paper (1926), the work of Ehrenbaum (1924) is probably the most important single work on the young stages of these fishes. The fishes described by Ehrenbaum (1924), Kishinouye (1926), Lütken (1880) and other early workers were generally less than 15 millimeters in length and were taken with plankton nets. For the larger sizes the investigator is dependent primarily on collections made under lights or on specimens found in the stomachs of adult fish. Such specimens as these have been described by the more recent workers, Schaefer and Marr (1948a, 1948b), Eckles (1949), Wade (1949), and others. In this paper I shall describe specimens principally between 10 mm. and 18 mm. in length, larger than those taken in plankton hauls, and note characters I have found useful in their identification.

As is generally the practice, the *Alphecca* often drifted at night while on the fishing grounds, offering an excellent opportunity for night collecting. The collections were made under a drop-light suspended immediately above the water. Fourteen such collections yielded, among others, juveniles of the following three scombrid fishes: *Neothunnus macropterus*, the yellowfin tuna; *Euthynnus lineatus*, the black skipjack; and *Auxis thazard*, the frigate mackerel. Early stages of all these species have been described by Schaefer and Marr (1948a, 1948b) from specimens taken in the spring of 1947 off Central America. The identification of their specimens made known spawning grounds for the yellowfin tuna, oceanic skipjack, black skipjack, and frigate mackerel off Costa Rica and Panama. The present collections extend the known limits of these spawning regions for three of these species 350 miles northwest up the Central American coast. Dates, positions, and other data for the collections are reported in table 1.

TABLE 1.—*Data on postlarval* Auxis thazard, Neothunnus macropterus, *and* Euthynnus lineatus *taken from the Pacific Ocean off Central America, May 1949*

Date	Location		Species	Number of specimens	Length in millimeters
	Latitude	Longitude			
May 7	11°23′N.	90°29.5′W.	A. thazard	28	10.5 to 28.5
May 10	10°58′N.	89°56′W.	A. thazard	2	10.0 to 28.0
			E. lineatus	2	7.5 to 10.5
May 15	11°46′N.	87°28′W.	A. thazard	3	11.5 to 35.0
May 16	11°46′N.	87°41′W.	A. thazard	2	27.0 to 30.0
May 17	12°16′N.	89°31′W.	A. thazard	2	28.0 to 30.0
			N. macropterus	25	15.5 to 25.0
May 19	11°20′N.	87°20′W.	A. thazard	36	14.5 to 31.0
			E. lineatus	23	13.5 to 18.0
May 22	11°26′N.	89°22′W.	A. thazard	15	18.0 to 35.0
May 24	10°47′N.	89°30′W.	A. thazard	57	13.5 to 48.0
May 27	12°50′N.	89°40′W.	A. thazard	1	19.0
			E. lineatus	2	18.0 to 23.5
May 28	11°05′N.	89°55′W.	A. thazard	76	10.5 to 48.5
			N. macropterus	12	10.5 to 16.0
May 29	11°05′N.	89°55′W.	A. thazard	12	19.5 to 35.0
May 30	12°11′N.	90°18′W.	A. thazard	27	24.5 to 40.5
			N. macropterus	5	19.5 to 26.5

KEY TO THE POSTLARVAE OF FIVE SPECIES OF CENTRAL AMERICAN SCOMBRIDS

A workable key for the identification of the postlarvae of scombrids known to occur off Central America is dependent on a few discrete external characters. The teeth and body shapes are similar in all species. Pigmentation, gill rakers, preopercular spines, viscera, and, to some extent, fin rays are in the process of development and show variation within each species at a given length. The characters used in the key presented here were taken from specimens of *Euthynnus lineatus* from 7.5 mm. to 32.5 mm., *Neothunnus macropterus* from 10.5 mm. to 26.5 mm., *Scomberomorus sierra* from 21 mm. to 71 mm., and *Auxis thazard* from 10 mm. to 48.5 mm. in length. The characters used separate species within these ranges but may not hold true for larger or smaller specimens. No specimens of *Katsuwonus pelamis* were examined but the description of Schaefer and Marr (1948b) based on two individuals, 21 mm. and 44 mm. in length, has been referred to in preparation of the key. There is no spot on the isthmus of the smaller of these two specimens. The larger fish was cleared and stained for bone study, thus destroying all pigmentation.

1a. More than 17 spines in the first dorsal. Total number of vertebrae more than 46, usually 47 or 48. First dorsal pigmented distally. Pigment spot on point of isthmus ..... *Scomberomorus sierra.*

1b. Less than 17 spines in first dorsal. Less than 46 vertebrae.

2a. First dorsal separated from the second by a distance equal to or greater than half the length of the first dorsal; usually 11 spines in first dorsal. Spot on isthmus. Vertebral count usually 20+19=39 ..... *Auxis thazard.*

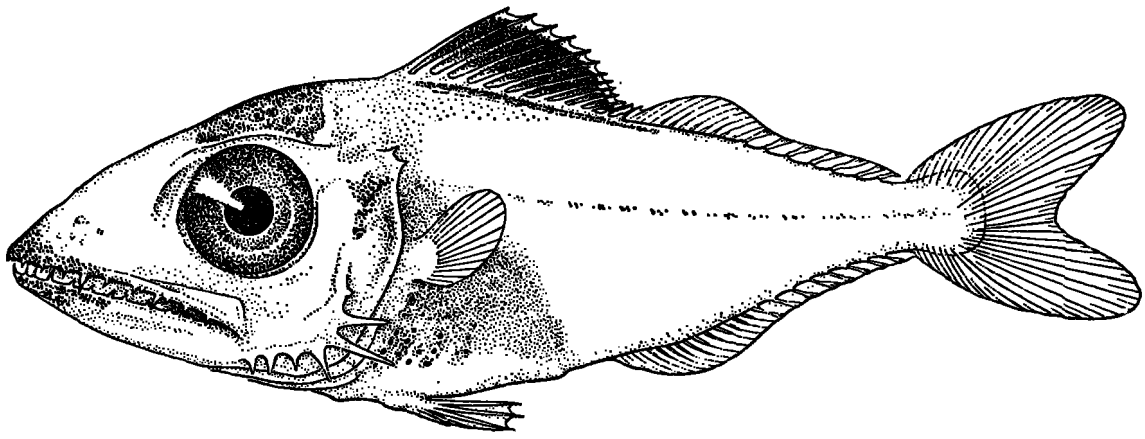

FIGURE 1.—*Neothunnus macropterus*, 10.5 millimeters long.

2b. First dorsal continuous or almost continuous with second dorsal.
3a. Pigment spot on point of isthmus. First dorsal 14 to 16, heavily pigmented. Vertebral count usually 20+17=37 ..... *Euthynnus lineatus*.
3b. No pigment spot on isthmus.
4a. First dorsal 13 or 14, entire fin heavily pigmented. Vertebral count 18+21=39 ..... *Neothunnus macropterus*.
4b. First dorsal 16, bearing a few moderately large spots distally. Vertebral count 20+21=41 ..... *Katsuwonus pelamis*.

NEOTHUNNUS MACROPTERUS (Temminck and Schlegel)

A total of 42 specimens of this species was taken in the collection, ranging from 10.5 mm. to 26.5 mm. in length. Representative specimens were cleared with potassium hydroxide and stained with alizarin (Hollister 1934) so that the bone structure could be examined and the fin rays counted. Fin-ray counts in very small specimens are virtually impossible if the specimens are not stained.

Neothunnus macropterus can be identified by its characteristic shape, vertebral count (18+21), and coloration, as described by Schaefer and Marr (1948b). No gill rakers can be seen in fish smaller than 15 mm. The position and extent of the visceral organs cannot be determined without sectioning. Schaefer and Marr (1948b) note the characteristics of the viscera and gill rakers in specimens over 15 mm. With the exception of the pectoral, the fins of a 10.5-mm. fish have within one or two rays of the complete complement of spines or rays. The number of rays in the pectoral fin increases from 13 in the 10.5-mm. specimen to 30 in fish of 30 mm. Each half of the upper and lower jaws bears 11 small, pointed, irregularly spaced teeth. It was found that these young yellowfin can be separated readily from the other species taken, without a special preparation, by the absence of any pigmentation on the point of the isthmus and by the heavily pigmented first dorsal fin. In all *Euthynnus lineatus* and *Auxis thazard* examined there is a pigment spot on the point of the isthmus overlying the junction of the pectoral and pelvic girdles. No postlarval *Katsuwonus pelamis* were available for study, but Milner B. Schaefer of the Pacific Oceanic Fishery Investigations informs me that this spot is not present on a 21-mm. specimen taken off Costa Rica. I have found no reference to this spot in the literature. This character is most useful for separating very small *N. macropterus* and *E. lineatus* since both have a black dorsal fin and they resemble each other closely in body shape until they attain a length greater than 15 mm.

Dermal pigmentation on a 10.5-mm. *Neothunnus macropterus* is restricted to a thin strip along the first dorsal fin insertion, a patch on the tip of the snout and the heavily pigmented first dorsal fin. Subcutaneous pigmentation occurs over the brain and in the peritoneum overlying the dorsal third of the viscera. In an 11-mm. specimen, the thin strip along the first dorsal insertion extends posteriorly to the base of the third ray of the second dorsal fin; by the 12-mm. stage it lines the upper margin of the body from the operculum to the terminal rays of the second dorsal. These two specimens show a faint strip along the postero-ventral margin of the orbit. From this size up to

33 mm., the largest yellowfin examined, the color pattern follows closely the description published by Schaefer and Marr (1948b).

A 12-mm. yellowfin displays three prominent spines at the angle of the preoperculum. Anterior to these are three lesser spines, and three others protrude from the preoperculum above the large spines. With increasing length of fish, all spines become more and more reduced in relation to the size of the head. They are apparently overgrown by the superficial layers of the preopercular bone. In fish of 26 mm., the only spines discernible are those at the angle of the preoperculum, and even these are noticeably less evident. There appears to be little, if any, growth in these spines over the size range of the fish in my collections.

AUXIS THAZARD (Lacépède)

This species is the most numerous in the night collections. Young stages are present in 12 of the 14 collections. The 157 specimens taken range from 10 to 49 mm. in length. In addition to the collections listed in table 1, two larger *Auxis*, 79 and 117 mm. fork length, were taken from the stomach of a large yellowfin caught on May 6 at 11°40′ N. latitude, 91°00′ W. longitude. These two fish, both broken and with the skin and fins digested away, can be recognized as members of the genus *Auxis* by the elongated right lobe of the liver, the total vertebral count (39), and the structure of the individual vertebrae as described by Kishinouye (1923: 460). The gill-raker counts,[2] 10+1+32 and 10+1+33, approximate the counts made by Schaefer and Marr (1948a) on most of their juveniles. In a recent paper, Wade (1949) separates the Philippine species, *Auxis thazard* and *A. tapeinosoma*, on the basis of characters among which only the gill-raker count is applicable to the young stages.[3] He also points out, as Schaefer and Marr (1948a) suggested, that there are probably two species of *Auxis* in Central American waters. If we assume that there are two species and that they can be separated by characters applicable to the Philippine species, my two juveniles, as well as the postlarvae large enough to show a definitive gill-raker count, are *A. thazard*. The gill-raker counts of 10 specimens are given in

[2] The method used in counting and recording gill rakers is the same as that used by Wade (1949) in his discussion of the genus *Auxis*.

[3] Wade's description of *Auxis tapeinosoma* agrees with that of Bleeker (1854). However, the pattern and extent of the corselet scales in Bleeker's figure (1854, pl. 7) of *A. tapeinosoma* agrees more closely with Wade's figure of *A. thazard*.

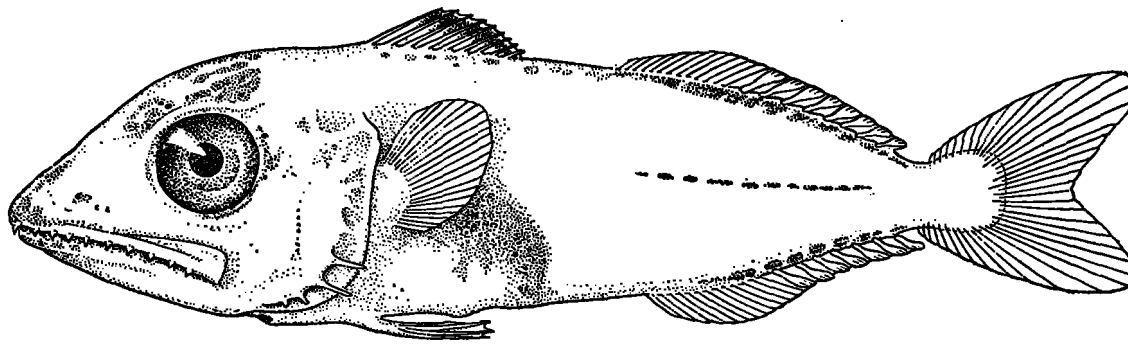

FIGURE 2.—*Auxis thazard*, 11.5 millimeters long.

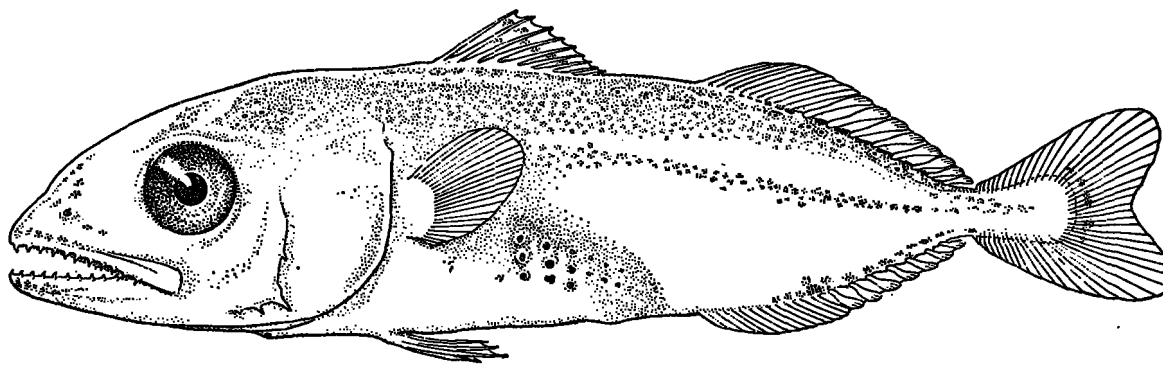

FIGURE 3.—*Auxis thazard*, 18 millimeters long.

table 2. The most anterior arch on both right and left sides was counted. Specimens No. 7 and No. 8 are apparently too small to have a complete set.

TABLE 2.—*Gill-raker counts*[1] *of postlarval and juvenile* Auxis thazard

Specimen	Fork length, in millimeters	Right first arch	Left first arch
No. 1	34	9+1+30=40	8+1+30=39
No. 2	34	8+1+30=39	8+1+29=38
No. 3	41	8+1+31=40	8+1+30=39
No. 4	38	9+1+31=41	7+1+32=40
No. 5	42	9+1+32=42	9+1+31=41
No. 6	35	7+1+30=38	6+1+28=35
No. 7	26	5+1+22=28	4+1+22=27
No. 8	30	7+1+28=36	7+1+26=34
No. 9	79	10+1+32=43	10+1+33=44
No. 10	117	10+1+33=44	10+1+33=44

[1] The method used in counting and recording gill rakers is the same as that used by Wade (1949) in his discussion of the genus *Auxis*.

The smallest *Auxis* in the collections is a damaged 10-mm. specimen. Dermal pigmentation is confined to narrow strips along the bases of the second dorsal and anal fins and the dorsal and anal finlets, along the lateral line from a point below the posterior end of the second dorsal fin to the posterior extent of the finlets, along the posteroventral margin of the orbit and to a small spot on the point of the isthmus. The fins are usually colorless although the first dorsal may bear a few scattered melanophores. Four small spines occur along the angle of the preoperculum. Each half of the upper and lower jaws bears about 10 small teeth. With increasing size of fish, the local centers of pigmentation expand. On fish of 13 mm. the dorsal strip of body pigmentation extends from the operculum to the caudal at its point of least depth, and a light coloration appears on the snout and operculum. All areas in the dorsal half of the body of fish larger than 20 mm. bear at least a light covering of pigment spots. The degree of pigmentation varies greatly from specimen to specimen in this species. The pattern here described is that found to be the most common.

EUTHYNNUS LINEATUS Kishinouye

This species is represented in the collections by 27 specimens, ranging from 7.5 mm. to 23.5 mm. in length. Two fish were cleared and stained and each was found to have a vertebral count of 37, the first caudal vertebra in each case being the twenty-first. As is the case with *Neothunnus macropterus* and *Auxis thazard*, the viscera of the smallest specimens cannot be studied adequately unless specimens are sectioned. Schaefer and Marr (1948a, 1948b) describe the viscera in specimens of *Euthynnus lineatus* more than 15 mm. long. The first dorsal, point of the isthmus, anterior half of the lower jaw, tip of the snout, posteroventral margin of the orbit, and operculum of the smallest specimen (7.5 mm.) bear scattered melanophores. Subcutaneous pigmentation covers the brain and the dorsal margin of the peritoneum. The only dermal pigmentation evident on the body of this specimen is a pair of light spots at the posterior end of the anal fin insertion. At 10.5 mm. in length, light pigmentation appears at the base of the first and second dorsals. Body pigmentation is still confined to the bases of the anal and the two dorsal fins. By 14 mm., the pigment has spread anteriorly from the base of the first dorsal to the area overlying the brain. Coloration along the lateral line first appears in a 16-mm. specimen as a few faint spots. On this fish

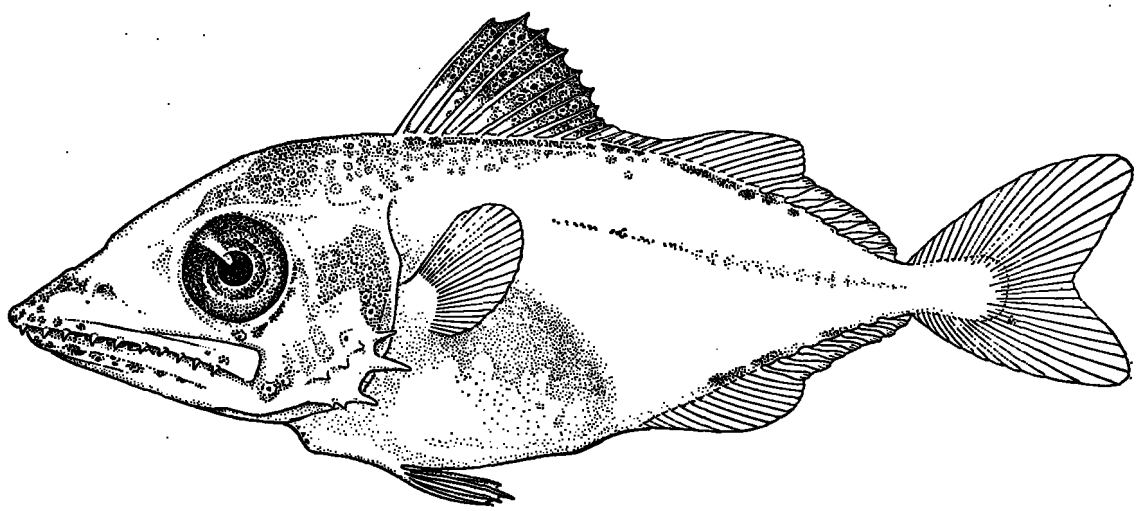

FIGURE 4.—*Euthynnus lineatus*, 14 millimeters long.

the dorsal body pigmentation extends posteriorly from the operculum to the end of the second dorsal. In the region of the second dorsal these spots form a faint line a half millimeter from the dorsal margin of the body. Above this line, along the insertion of the fin itself, is the horizontal bar of dark pigment characteristic of smaller specimens. By 17.5 mm., the lateral pigmentation has extended as far back along the line of the vertebral column as the posterior end of the second dorsal and anal fins. Coloration along the anal insertion is still restricted to the few patches characteristic of the smallest *E. lineatus*. The posterior half of the orbit is dark. Coloration of snout, jaws, and operculum is more dense. At 22 mm., coloration first appears over the terminal segments of the vertebral column and on the extreme base of the median caudal rays. The dorsal half of the body is dark as far back as the caudal peduncle.

Preopercular spines are longer and slenderer than those of *N. macropterus*. The angle of the preoperculum bears the three largest spines. Above these is a pair of small spines; anterior to them are three others. With increasing length of fish, all become overgrown to a certain extent. At 18 mm., the most dorsal and anterior spines are no longer visible without the use of special techniques. The remainder are visible, although less distinct, in the largest *E. lineatus* in the collections.

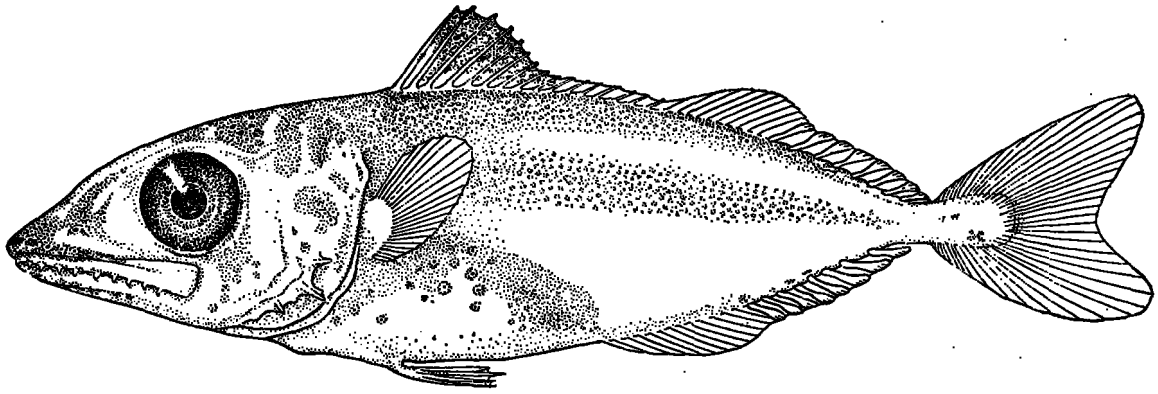

FIGURE 5.—*Euthynnus lineatus*, 22 millimeters long.

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