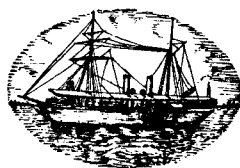
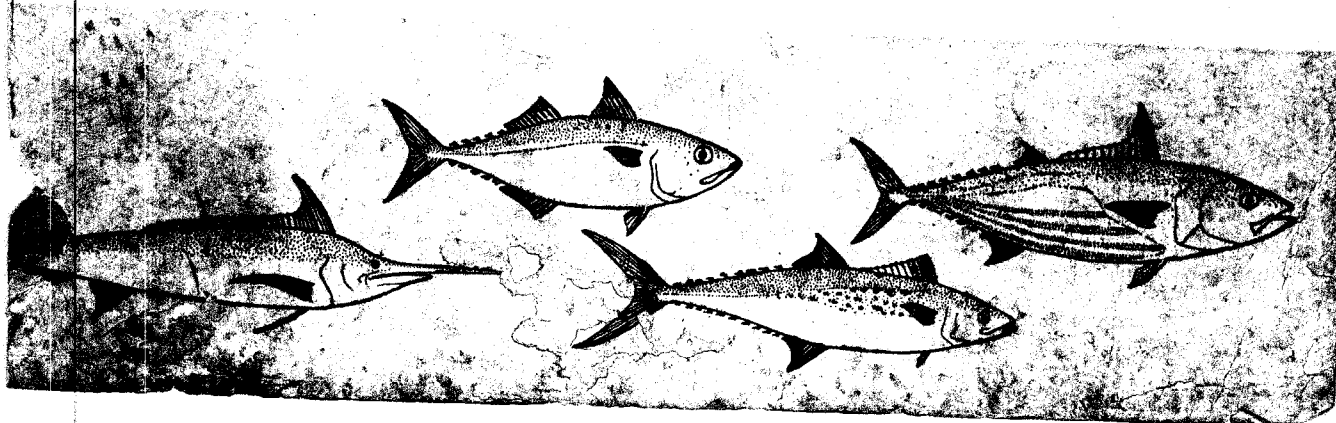


SYMPOSIUM ON SCOMBROID FISHES

PART I



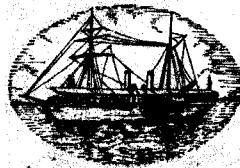
**MARINE BIOLOGICAL ASSOCIATION OF INDIA
MANDAPAM CAMP
S. INDIA**



PROCEEDINGS OF THE
SYMPOSIUM
ON
SCOMBROID FISHES

HELD AT MANDAPAM CAMP FROM JAN. 12—15, 1962

PART I



SYMPOSIUM SERIES 1
MARINE BIOLOGICAL ASSOCIATION OF INDIA
MANDAPAM CAMP
S. INDIA

EGGS, LARVAE AND JUVENILES OF INDIAN SCOMBROID FISHES

BY

S. JONES AND M. KUMARAN

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INTRODUCTION

Our knowledge about the life histories of scombroids has been very meagre till recent years in spite of the wide range of distribution and great economic importance of these fishes. The picture is however gradually changing in view of the increasing attention that is being paid especially in the Pacific region to the study of the biology of tunas and marlins which constitute at present major fisheries in the high seas. Most of the Pacific forms are distributed in the Indian Ocean also and this has helped considerably in the identification of the material collected from Indian waters.

The information available on the life history stages of scombroid fishes is scattered and incomplete and not easily available to Indian workers. In this account an attempt has been made to compile all information available on the eggs, larvae and juveniles of scombroids recorded from the Indian Ocean and contiguous seas. The species dealt with are listed below. The arrangement under the different families is for the sake of convenience and has no strict taxonomic significance. It was proposed to give an artificial key for the identification of the life history stages based on the available information but this idea was given up since it was felt that it might bring about confusion in view of our present imperfect knowledge of the distinguishing characters of the early stages.

Family : Scomberomoridae

Scomberomorus guttatus (Bloch and Schneider)

Scomberomorus commerson (Lacépède)

Scomberomorus lineolatus (Cuvier)

Family : Thunnidae

Neothunnus macropterus (Temminck and Schlegel)

Parathunnus obesus sibi (Temminck and Schlegel)

Thunnus thynnus alalunga (Bonnaterre)

Thunnus thynnus orientalis (Temminck and Schlegel)

Kishinoella tonggol (Bleeker)

Katsuwonus pelamis (Linnaeus)

Euthynnus affinis affinis (Cantor)

Auxis thazard (Lacépède)

Auxis thynnoides Bleeker

Sarda orientalis (Temminck and Schlegel)

Family : Scombridae

Scomber japonicus Houttuyn

Rastrelliger kanagurta (Cuvier)

Grammatorcynus bicarinatus (Quoy and Gaimard)

Family : Xiphiidae

Xiphias gladius Linnaeus

Family : Istiophoridae

Istiophorus gladius (Broussonet)

Makaira audax (Philippi)

Makaira mazara (Jordan and Snyder)

Istiompax indicus (Cuvier and Valenciennes)

Tetrapturus angustirostris (Tanaka)

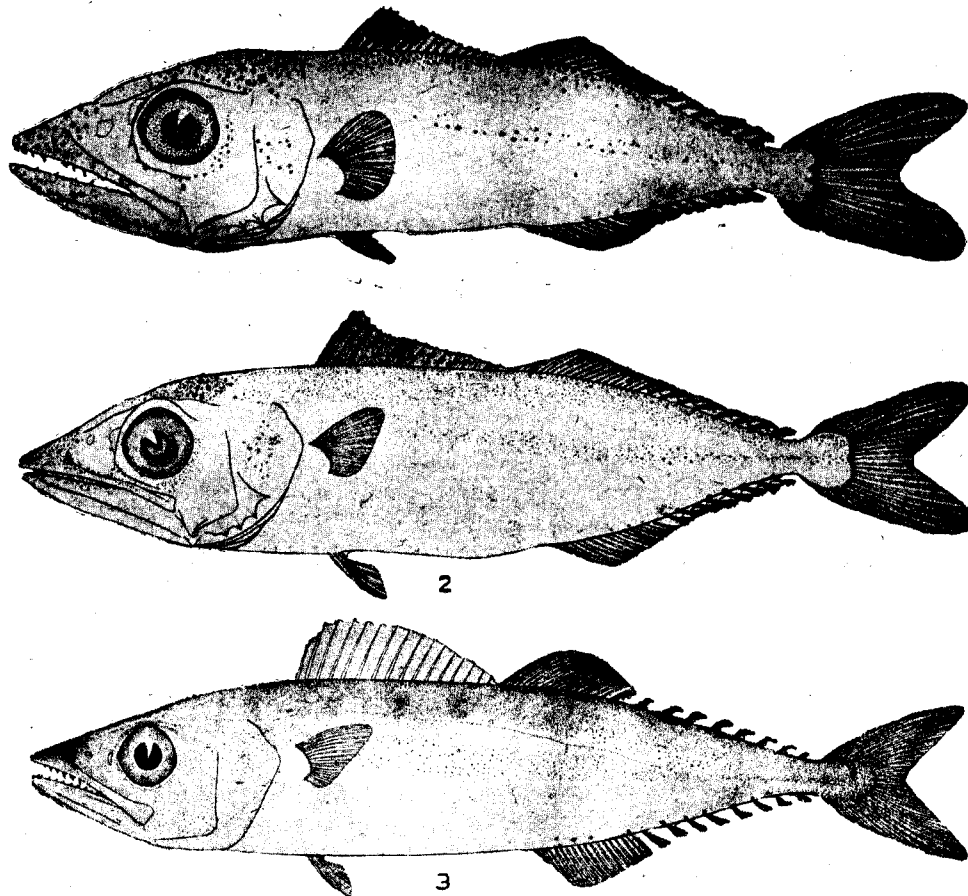
DESCRIPTION OF LARVAE

FAMILY : SCOMBEROMORIDAE

Scomberomorus guttatus (Bloch and Schneider)

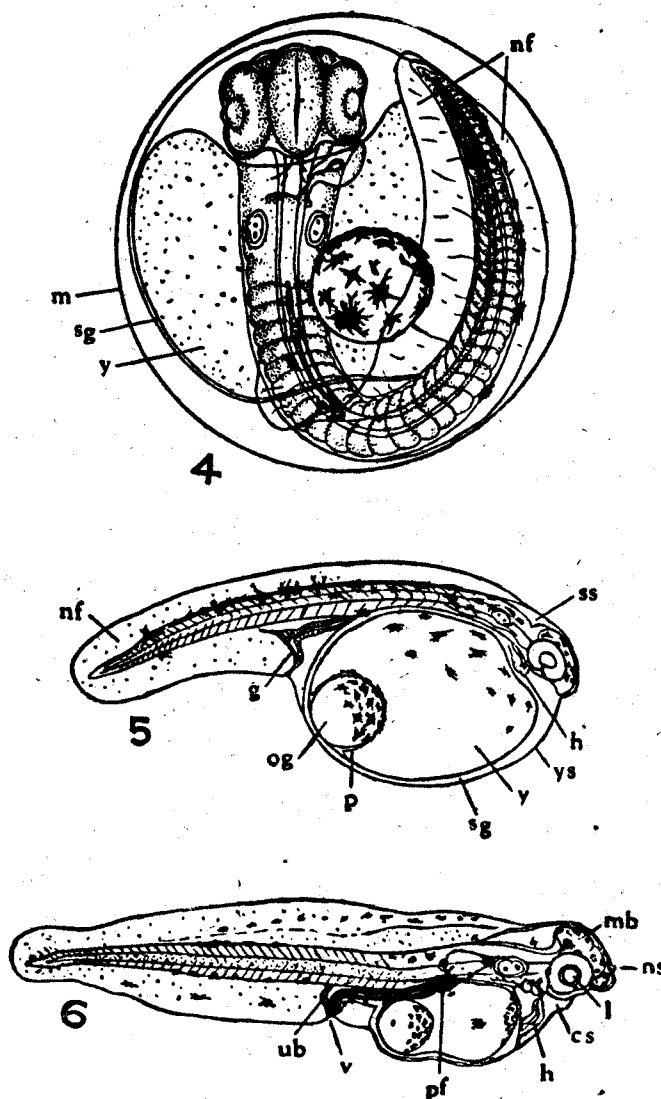
The spotted seerfish forming a fairly important fishery along the Indian coast during certain months is distributed widely in the Indo-Pacific from the Persian Gulf to the Western Pacific from Formosa and Japan to Indonesia.

Three types of eggs and the larvae hatched out of them were studied and described by Delsman (1931) who in spite of certain differences in pigmentation and size between them



Figs. 1-3. *Scomberomorus guttatus*. Fig. 1.—14.8 mm., Fig. 2.—22.9 mm., Fig. 3.—41.2 mm.
(Reproduced from Jones, 1961)

presumed them to be those of *C. guttatum* (= *S. guttatus*). But for various reasons it is doubtful whether they belong to any species of *Scomberomorus* (Jones, 1961). The identity of the larvae and juveniles as of *S. gattatus* described by Vijayaraghavan (1955) does not appear to be correct according to Jones (1961).



Figs. 4-6. *Scomberomorus commerson*. Fig. 4.—Egg with embryo just before hatching. Fig. 5.—2.5 mm. larva., Fig. 6.—3.2 mm. larva. (Reproduced from Munro, 1942)

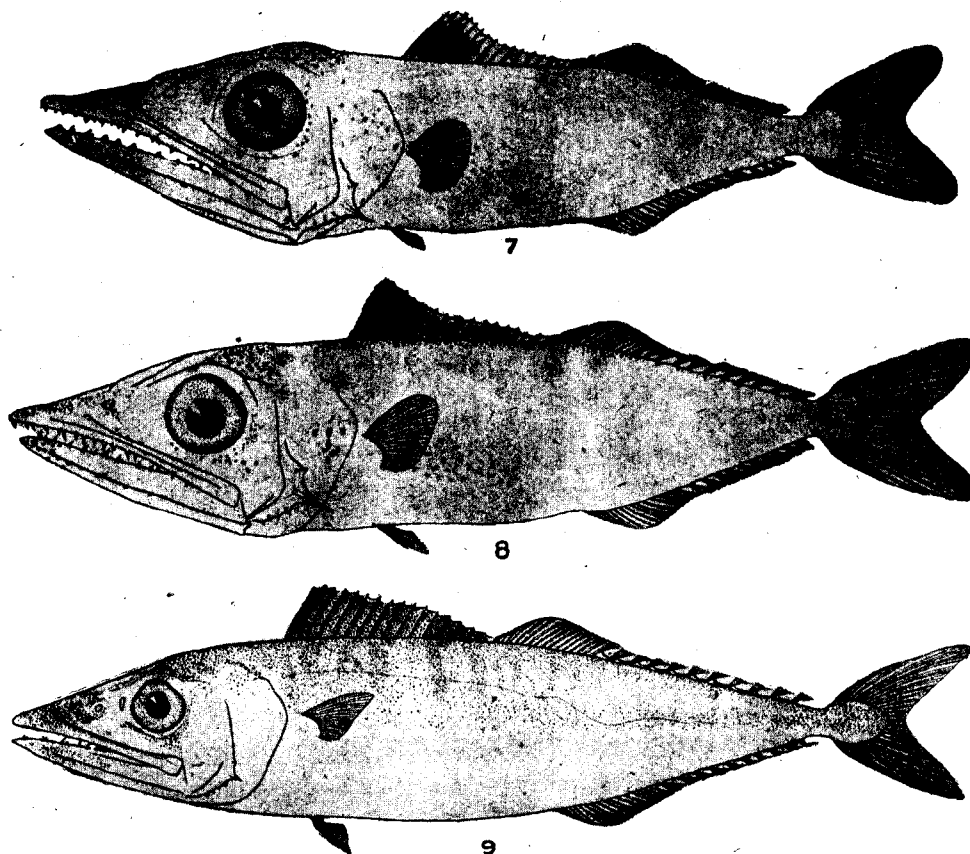
Three juvenile specimens described by Jones (1961) are reproduced here (Figs. 1-3). The head of juvenile of about 15 mm. is conspicuously large, being 2.7 in standard length. Snout is bluntly pointed and it is 1.5 times the diameter of eye. Preopercular spines are short and their tips do not reach the margin of the operculum. Comparatively small sized teeth are present in the jaws. All the fins are well developed, but membraneous interconnections persist between the finlets. Chromatophores have developed on the snout, above and below the orbitals, in the region of the hind brain, posterior portion of the opercle, along

the base of the dorsal fin, along the mid-lateral line and at the bases of the caudal and anal fins. With the growth of the fish, the head length becomes shorter in relation to the standard length. Preopercular spines get atrophied when the juvenile reaches a length of about 70 mm.

***Scomberomorus commerson* (Lacépède)**

Our present knowledge of the early life history of this widely distributed species in the Indo-Pacific is restricted to the studies by Munro (1942) from Queensland waters. He was able to fertilize the eggs artificially and rear the larvae hatched out of them. A late embryo and two early larvae are reproduced here (Figs. 4-6). The newly hatched larva is about 2.5 mm. in length and according to Munro (*op. cit.*) resembles the larvae of *S. maculatus* as described by Ryder (1882) in general appearance.

Juveniles occur in fairly large numbers during certain months along the Kerala coast. Three juvenile stages figured by Jones (1961) are reproduced here (Figs. 7-9). The head of juvenile measuring 14.4 mm. is only about 2.3 in standard length which is comparatively larger than in the corresponding stage of *S. guttatus*. The second preopercular spine which is the longest projects beyond the operculum, whereas it is not so the case with *S. guttatus* of similar size. As the fish grows, the depth of the body gradually increases and the head length becomes comparatively less in relation to the standard length.



Figs. 7-9. *Scomberomorus commerson*. Fig. 7.—14.4 mm., Fig. 8.—24 mm., Fig. 9.—42.4 mm.
(Reproduced from Jones, 1961)

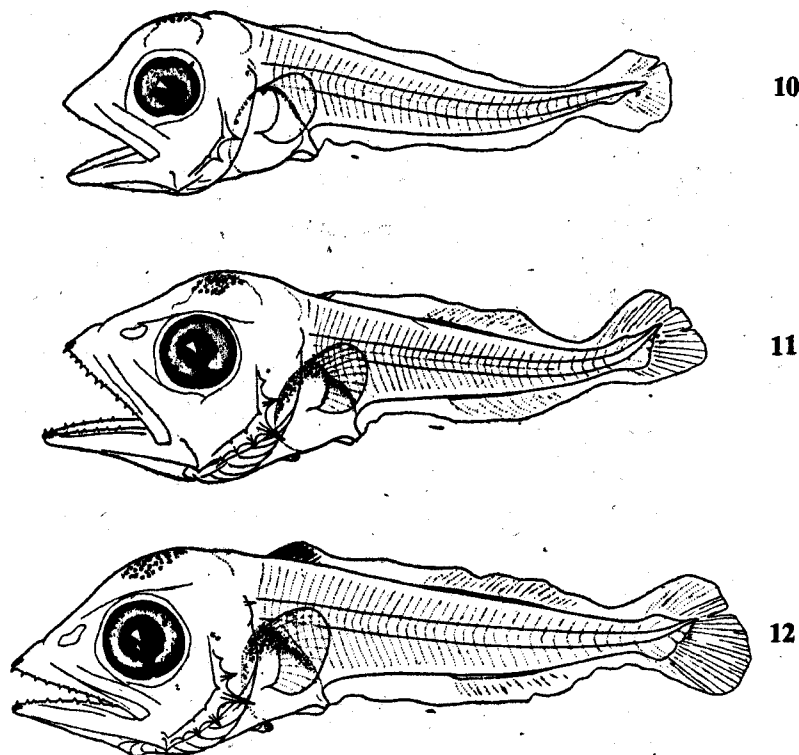
***Scomberomorus lineolatus* (Cuvier)**

S. lineolatus is widely distributed in the Indo-Malayan region but does not appear to be abundant as the other two species just described above. Even though adults and juveniles are usually caught from our waters, larvae have not so far been encountered. The juveniles described by Kuthalingam (1959) do not appear to belong to any species of *Scomberomorus* according to Jones (1961).

FAMILY : THUNNIDAE

***Neothunnus macropterus* (Temminck and Schlegel)**

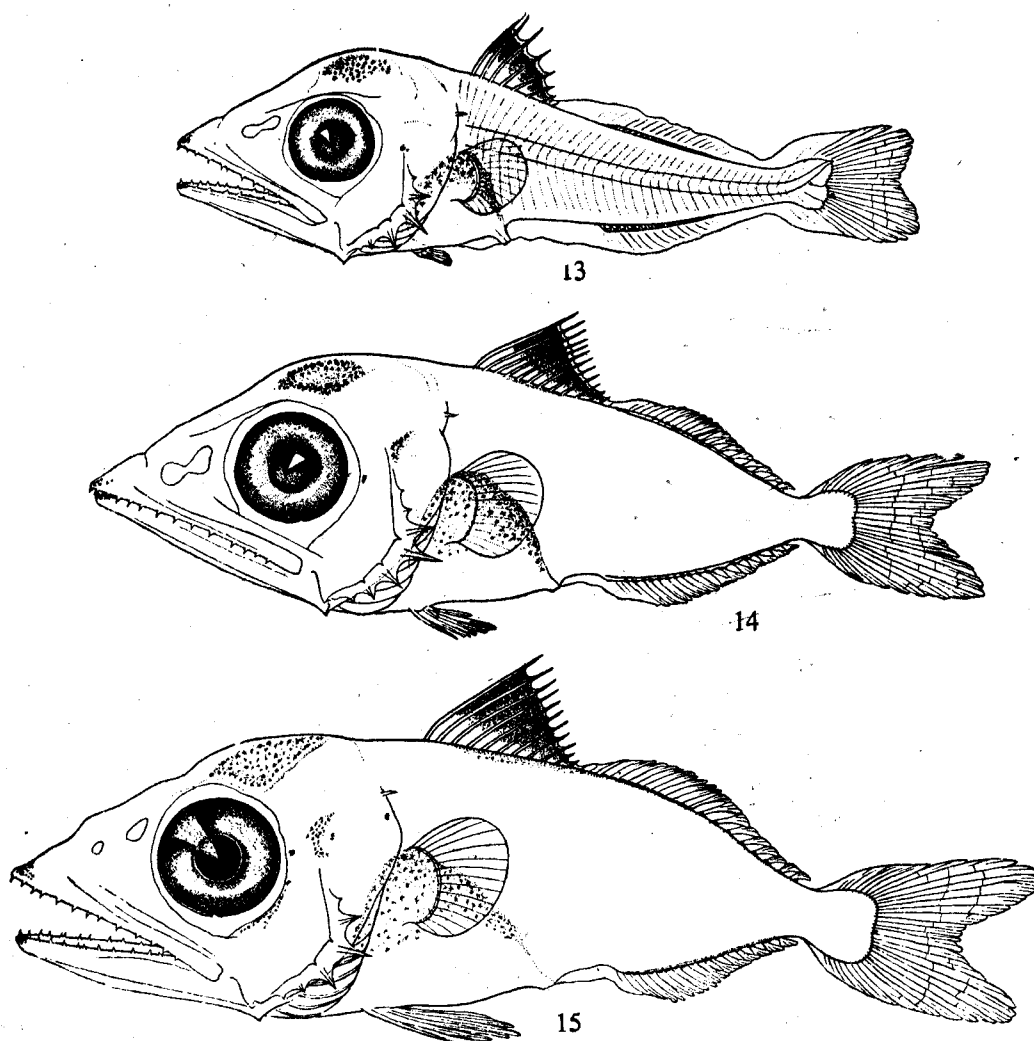
The yellowfin tuna is widely distributed in the warmer parts of the Indian and Pacific Oceans. The larval and juvenile stages of this species have been described by Wade (1950 and 1951), Matsumoto (1958) and Jones (1959c). The smallest recognizable specimen from Indian waters measured 3.88 mm. and was collected from the Laccadive Sea. The earliest stage identified positively as of this species from the Pacific by Matsumoto (1958) is 3.9 mm.



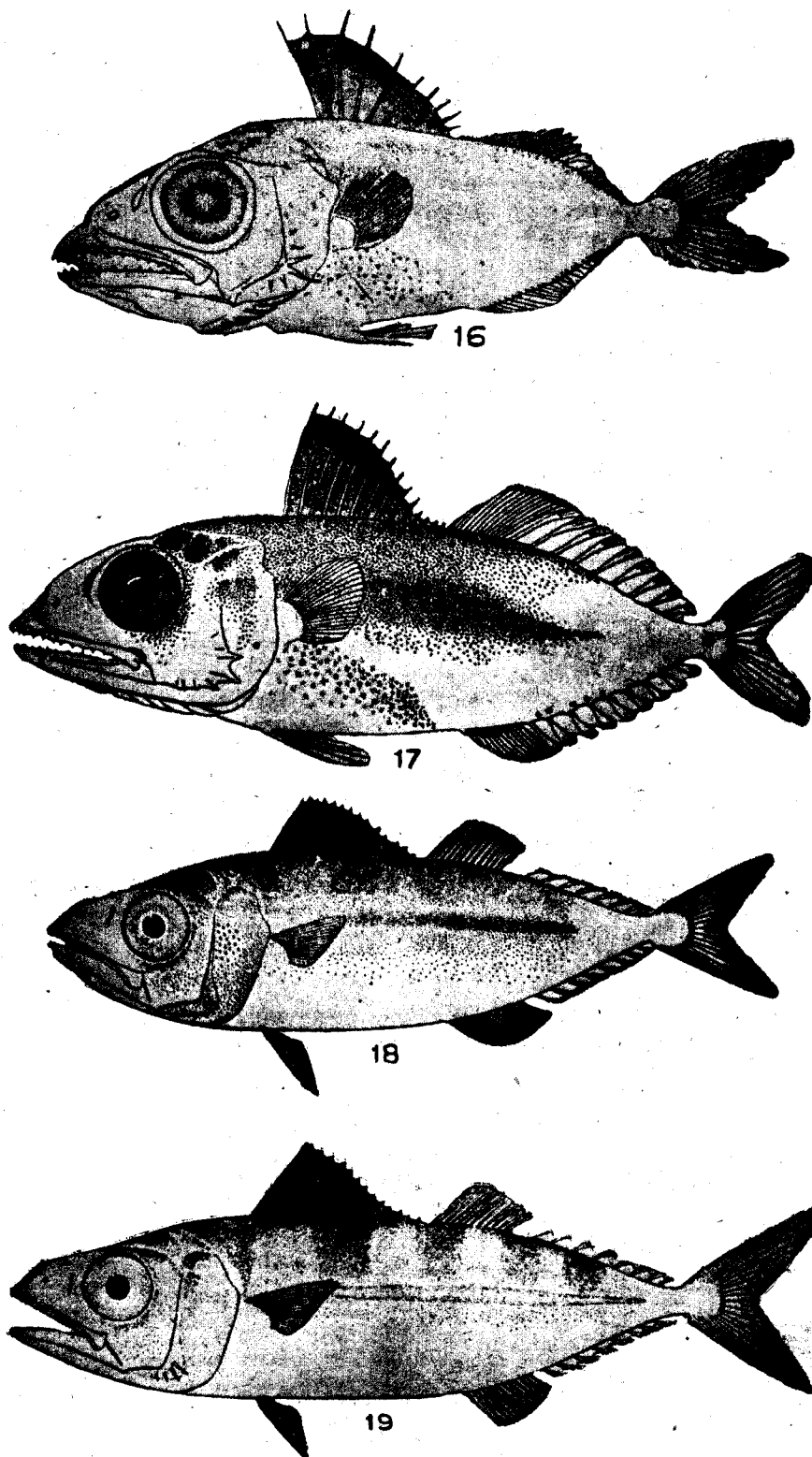
Figs. 10-12. *Neothunnus macropterus*. Fig. 10—3.88 mm., Fig. 11—5.25 mm., Fig. 12—6.85 mm. (Reproduced from Jones, 1959c).

Some of the typical larval and juvenile stages are reproduced in Figs. 10-19. The larvae of this species can be distinguished from those of *Katsuwonus pelamis* by the absence of chromatophores over the forebrain and on the midventral line near the caudal peduncle, the early development of dorsal spines and heavy pigmentation of the first dorsal in

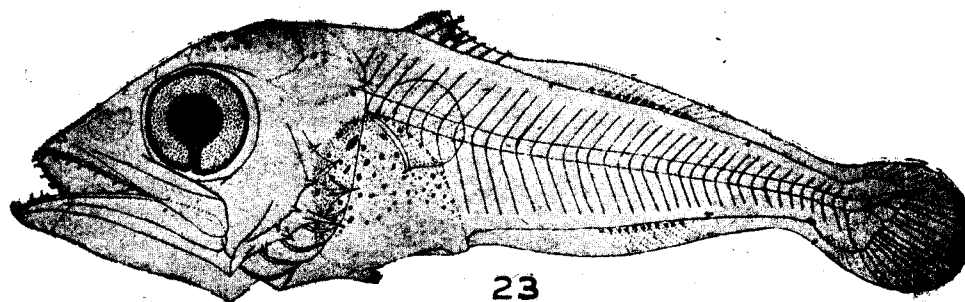
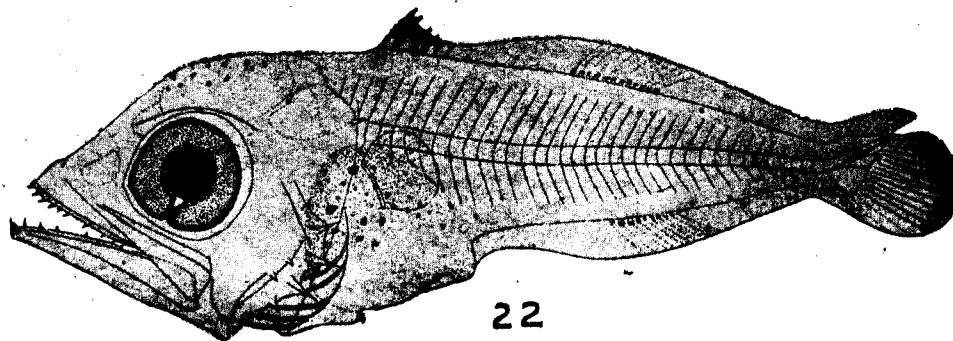
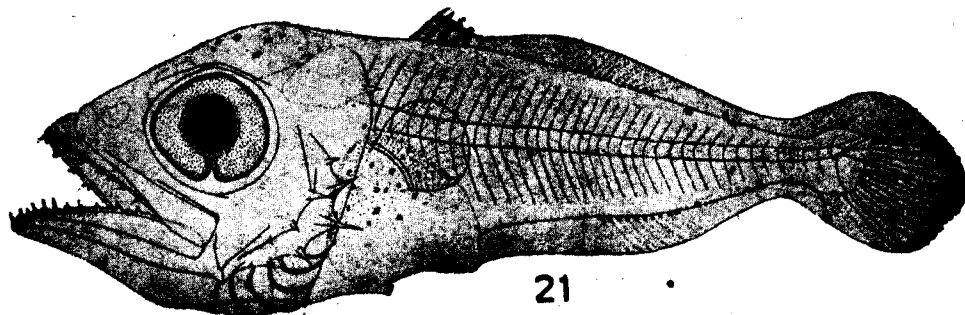
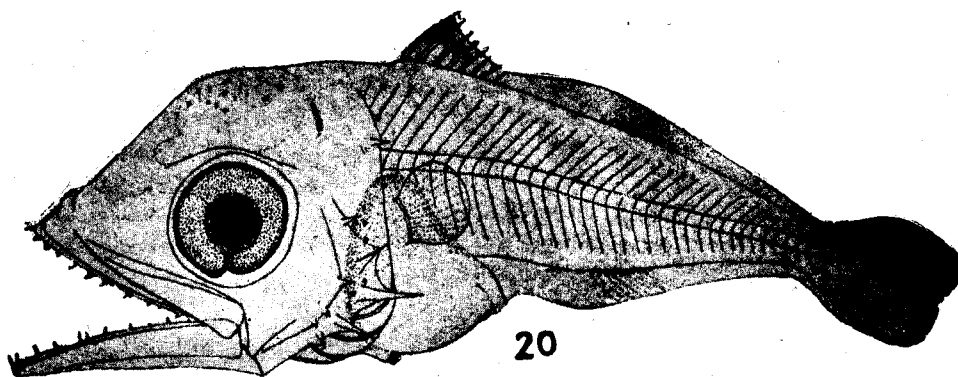
specimens of over 7 mm. total length. In specimens of about 5 mm. the dorsal outline tapers from the region of the head to the end of the tail and the ventral outline is rounded in the abdominal region and tapers gradually to the end of caudal. The snout is pointed and the diameter of the eye is less than the length of the snout. The first dorsal fin develops comparatively early and rudiments of spines are visible even in specimens of 6 mm. length. Such an early development of the first dorsal is in contrast with the late development of the first dorsal in *Katsuwonus pelamis*. Seven preopercular spines are visible in specimens of about 7.5 mm. and the one at the angle is the longest. In specimens of about 8 mm. length the dorsal contour is deep, the mouth is large and oblique and the maxillary almost reaches a vertical below the posterior margin of the pupil.



Figs. 13—15. *N. macropterus*, Fig. 13.—7.42 mm., Fig. 14—8.85 mm.,
Fig. 15.—10.56 mm. (Reproduced from Jones, 1959c)



Figs. 16-19. *Neothunnus macropterus*. Fig. 16.—14.25 mm. (Reproduced from Matsumoto, 1958), Fig. 17.—19 mm. (Reproduced from Schaefer and Marr, 1948), Fig. 18.—27 mm., Fig. 19.—37.5 mm. (Reproduced from Wada, 1950)



Figs. 20-23. Fig. 20.—*Parathunnus obesus sibi*, 6.05 mm. Fig. 21.—*Thunnus thynnus alalunga*, 6.47 mm.
Fig. 22.—*Thunnus thynnus orientalis*, 6.51 mm. Fig. 23.—*Kishinoella tonggol*, 6.94 mm. (Reproduced
from Matsumoto, 1961)

Chromatophores are present over the midbrain, along the hindbrain aspect, a few on the side of the head near the dorsal end of the preopercle and the posteroventral border of the eye. Body is unpigmented until the larva reaches a length of about 12 mm. excepting for the dorsal region of the abdominal sac which bears internally numerous chromatophores. The first dorsal is heavily pigmented in specimens of more than 7 mm. length. When the larva approaches 11 mm. length, the body becomes much deeper, the abdominal sac is large and elongate and the vent is posterior to the midpoint of the total length. In general, it attains juvenile features early even though the preopercular spines persist and the chromatophores have not formed on the body.

***Parathunnus obesus sibi* (Temminck and Schlegel)**

The big-eyed tuna is widely distributed in the Indo-Pacific and Japanese records clearly show its occurrence in Indian seas in appreciable numbers. A figure of 6.05 mm. larva from Matsumoto (1961) is reproduced here (Fig. 20). Larvae of *Parathunnus obesus sibi* (= *P. obesus mebachi*) are characterised by the absence of pigmentation over the forebrain and near the symphysis of pectoral girdle. Dorsal fin is heavily pigmented. Larvae of this species differ from those of *N. macropterus* in the presence of usually one to four chromatophores along the midventral line posterior to the vent.

***Thunnus thynnus alalunga* (Bonnaterre)**

The albacore is distributed in the warm waters of the Indo-Pacific and Atlantic. A larval specimen of *Thunnus germon* (= *T. thynnus alalunga*) measuring 6.47 mm. figured by Matsumoto (1961) is reproduced here (Fig. 21). Larvae are very similar to those of *P. obesus sibi* as they have chromatophores on the ventral midline of the trunk posterior to the vent and in the absence of chromatophores over the forebrain and near the symphysis of pectoral girdle. However, larvae of *T. thynnus alalunga* can be distinguished from *P. obesus sibi* and *N. macropterus* by the presence of a single chromatophore on the dorsal side of the trunk between the origins of second dorsal and caudal fins.

***Thunnus thynnus orientalis* (Temminck and Schlegel)**

The oriental bluefin tuna is widely distributed in the Pacific and its occurrence in Indian seas is indicated by the Japanese tuna longline catches. Larvae of this species have been tentatively identified by Matsumoto (1961) and the figure of a 6.51 mm. specimen given by him is reproduced in Fig. 22. Larvae of *T. thynnus orientalis* resemble very much the larvae of *P. obesus sibi* and *T. thynnus alalunga*. Chromatophores are present on the midventral line of the trunk. This species can be distinguished from *N. macropterus* and *P. obesus sibi* by the presence of usually two or three chromatophores near the mid-dorsal line of the trunk between the origins of second dorsal and caudal fins.

***Kishinoella tonggol* (Bleeker)**

The northern bluefin tuna is distributed extensively in the Indo-Pacific from the coasts of India to the Philippines, Japan and Australia. The figure of a 6.94 mm. specimen illustrated by Matsumoto (1961) is reproduced in Fig. 23 to facilitate easy identification. Larvae of *K. tonggol* are similar to the three species described above in the absence of pigments over the forebrain and at the symphysis of pectoral girdle. Dorsal fin develops early and is well pigmented. There are chromatophores between the origins of the dorsal and caudal fins as in the other two species just described above but can be distinguished from them by the first chromatophore which is found along the base of the first dorsal fin.

***Katsuwonus pelamis* (Linnaeus)**

The oceanic skipjack is circumtropical in distribution and forms an important fishery in some areas in the Indian, Pacific and Atlantic Oceans. The smallest specimen collected from Indian waters that was positively identified as *Katsuwonus pelamis* measured 2.63 mm. (Jones, 1959c). Wade (1950 and 1951) has described several larval and juvenile stages of this species from Philippine waters and Matsumoto (1958) has worked out in detail the larval stages obtained from the Central Pacific. Larval stages from the sea near Mariana and East Caroline Islands, the Kuroshio current near Japan, and the sea south-east of Okinawa have been described by Yabe (1955).

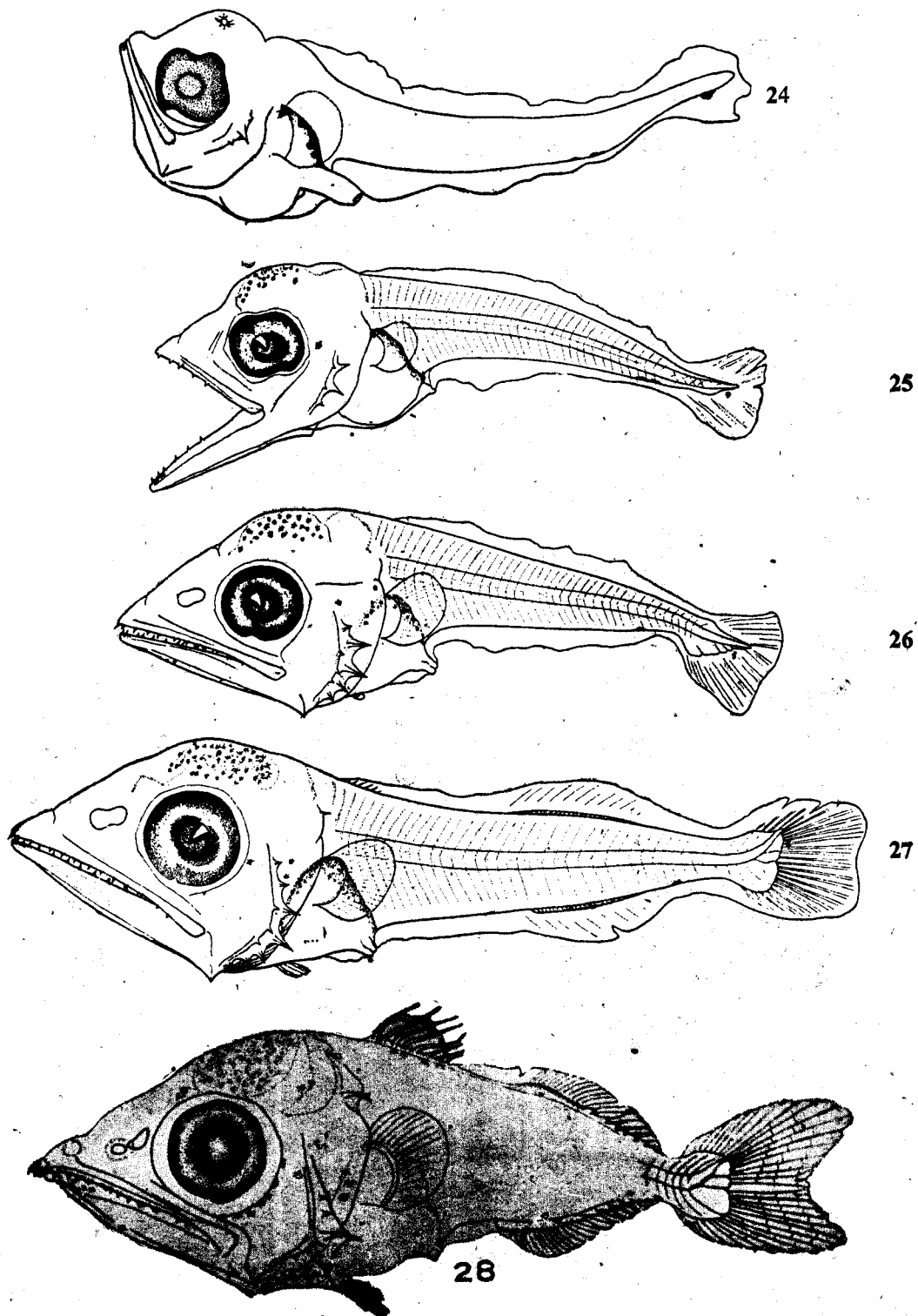
Figures of larval and juvenile stages of *K. pelamis* are reproduced in Figs. 24-32. The early larva has a large head in comparison to the body which is long and slender. The greatest depth is just posterior to the eye and the dorsal and ventral outlines taper gradually to the end of the caudal fin. The abdominal sac is characteristically small and is situated anteriorly. In specimens up to about 9 mm. length the vent is situated anterior to the midpoint of total length. The mouth is large and the angle of the jaws generally reaches to about a vertical below the posterior margin of the eye. The lower jaw is slightly included at the tip. The diameter of the eye is less than the length of the snout which is long and pointed. A maximum of eight spines are developed normally along the edge of the preoperculum, the one in the preopercular angle being the longest. The number of spines varies with the size of the larvae, the maximum number being present at about 8 mm. stage. These spines gradually get atrophied in juvenile stages. Rudiments of rays of the first dorsal begin to develop when the larva reaches a length of about 6.7 mm. In juveniles 20 precaudal and 21 caudal vertebrae could be counted.

The presence of a single chromatophore a little anterior to the caudal peduncle along the midventral line is very characteristic of this species and this persists even at a very later stage. Chromatophores begin to develop on the opercle in specimens of about 5 mm. and more. Early appearance of chromatophores over the forebrain in specimens of more than 7 mm. length, the presence of a single chromatophore on the middle of each mandible and the formation of a few chromatophores along the outer portion of the first dorsal fin are very characteristic. Dermal chromatophores are present at the tip of the lower and upper jaws. Most of the meristic characters of the adult could be distinguished in juveniles of about 27 mm. total length.

***Euthynnus affinis affinis* (Cantor)**

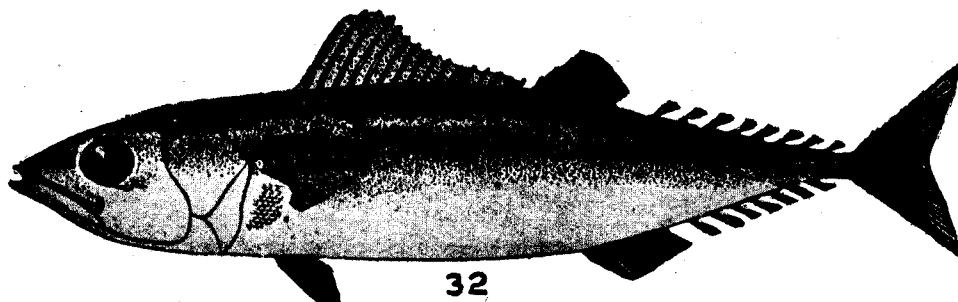
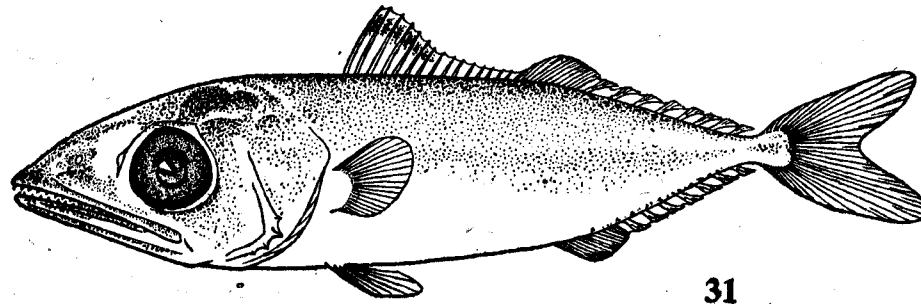
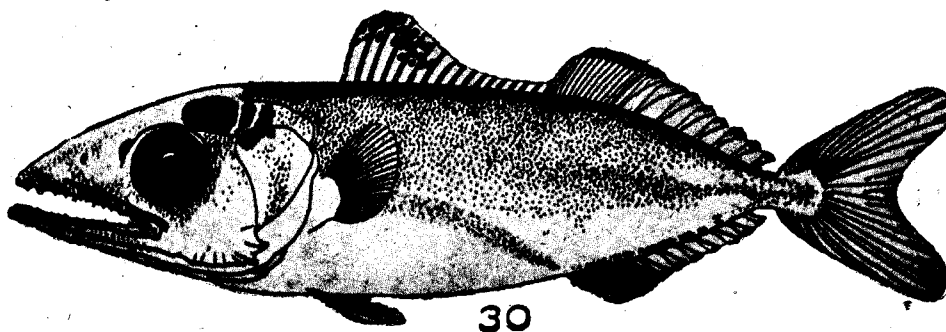
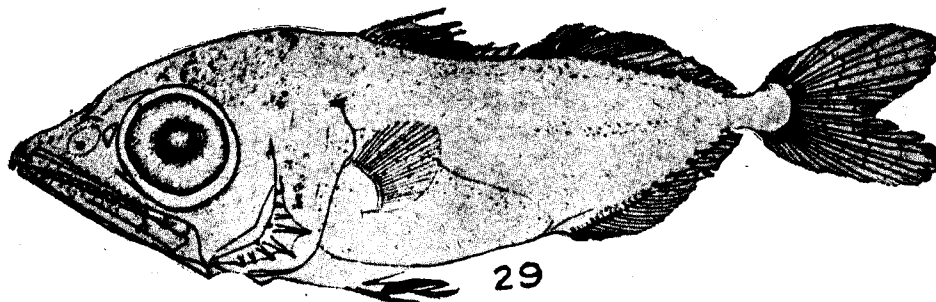
The little tunny is widely distributed in the Indian Ocean and some parts of the Western Pacific and forms a fishery of some magnitude at several places along the coasts of India. Wade (1951) and Matsumoto (1958 and 1959) have described the larval stages of *Euthynnus yaito* from the Philippine and Hawaiian areas. From the Laccadive Sea a few larval stages have been collected (Jones, 1960a) but for want of a connected series to enable their identity to be fixed beyond reasonable doubt they have not been described. Larval stages of *E. yaito* figured by Matsumoto (1958) are reproduced in this article (Figs. 33-36) since *E. affinis yaito* of the Pacific and *E. affinis affinis* occurring in Indian waters are very closely related and appear to be only geographic races.

Larval stages are characteristically long and slender and the head is comparatively large. The abdominal sac is triangular, small and anteriorly situated. The vent is far forward of the midpoint of total length even though it shifts posterior to the midpoint in

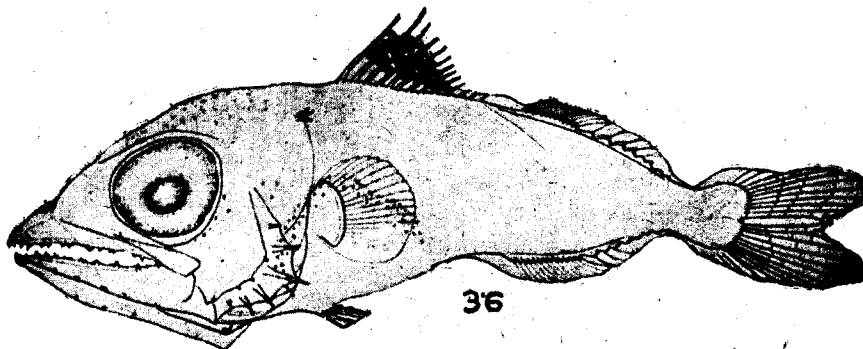
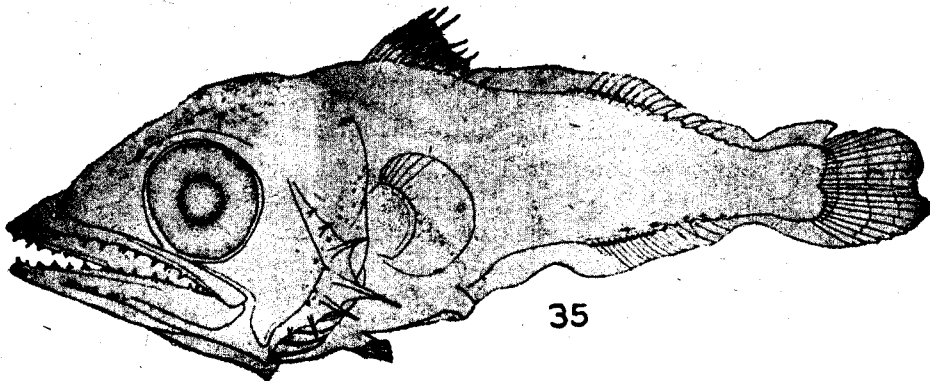
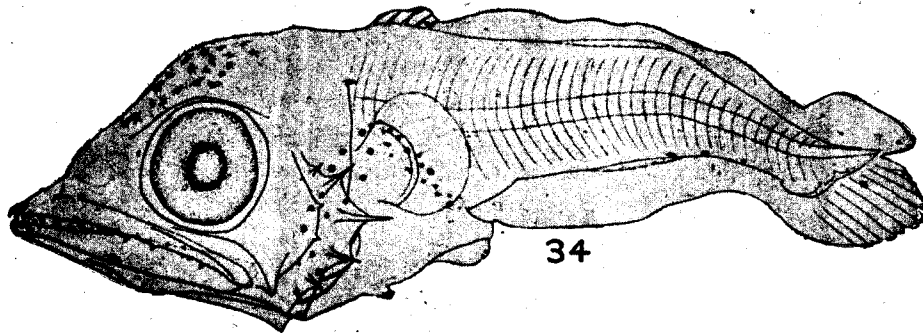
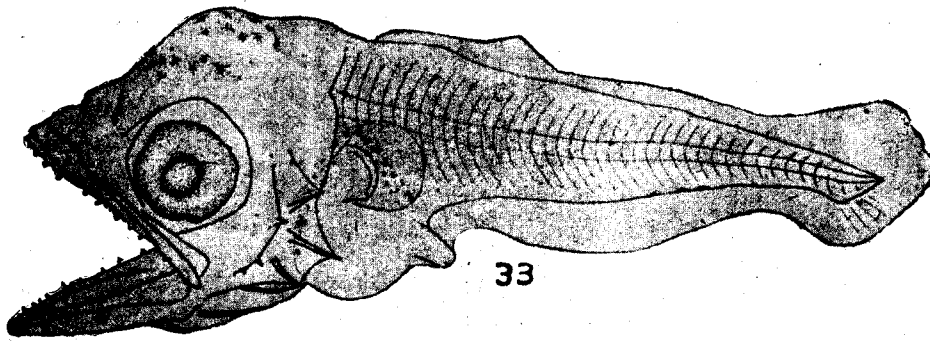


Figs. 24-28. *Katsuwonus pelamis*. Fig. 24.—2.97 mm., Fig. 25.—3.6 mm., Fig. 26—5.08 mm., Fig. 27.—7.08 mm. (Reproduced from Jones, 1959) Fig. 28.—8.75 mm. (Reproduced from Matsumoto, 1958)

later stages. Eye is rather large and its diameter in larvae upto 5 mm. exceeds the length of the snout whereas in larger specimens the snout is elongated and is more than the diameter of the eye. In specimens of about 7.5 mm. the body becomes much deeper, the abdominal sac is more elongate and the vent is situated posteriorly. Seven preopercular spines could be distinguished at this stage. 36 myotomes are present of which 20 are precaudal and 19 caudal.



Figs. 29-32. *Katsuwonotus pelamis*. Fig. 29.—14.25 mm. (Reproduced from Matsumoto, 1958). Fig. 30.—21 mm. (Reproduced from Schaefer and Marr, 1948). Fig. 31.—27 mm. (Reproduced from Jones, 1959c). Fig. 32.—113 mm. (Reproduced from Eckles, 1949).



Figs. 33-36. *Euthynnus yaito*. Fig. 33.—4.6 mm., Fig. 34.—5.5 mm., Fig. 35.—7.6 mm., Fig. 36.—9.6 mm.
(Reproduced from Mastuomoto, 1958)

Pigments are present on the membrane covering the brain and the side of the head behind the eye is slightly pigmented. An important distinguishing character is the presence of an irregular row of dark chromatophores along the posterior portion of the ventral midline and a series of four or five chromatophores in the anterior half of the mandible. Specimens of about 11 mm. in length closely resemble the juvenile form in having a deep body, well developed large head, more elongated abdominal sac and the posteriorly situated vent. Larvae of *Neothunnus macropterus* have better developed first dorsal fin than that of *E. affinis yaito* of about the same size. Slow development of the first dorsal fin, the nature of pigmentation and the smaller head of the latter distinguish it from *Katsuwonus pelamis*. The highly developed median fin membrane, the larger head and the pattern of distribution of the chromatophores especially on the midventral line near the caudal peduncle distinguish *Euthynnus* from *Auxis* larvae. Juveniles of *E. affinis affinis* (Figs. 37-39) gradually develop faint vertical bands on the upper half of body but these are not seen in the adult.

Auxis Cuvier

In the Indo-Pacific both *Auxis thazard* (Lacépède) and *A. thynnoides* Bleeker occur but the distinguishing characters of their larvae are little known because of close similarities existing in early stages. Larvae of *Auxis* from the Philippine waters and from the Central Pacific have been described by Wade (1951) and Matsumoto (1958 and 1959) respectively. A few larval specimens obtained from the Laccadive Sea have been worked out by Jones (1960b). Embryonic and early larval stages of *Auxis* sp. (Figs. 40-49) have been described by Mito (1961).

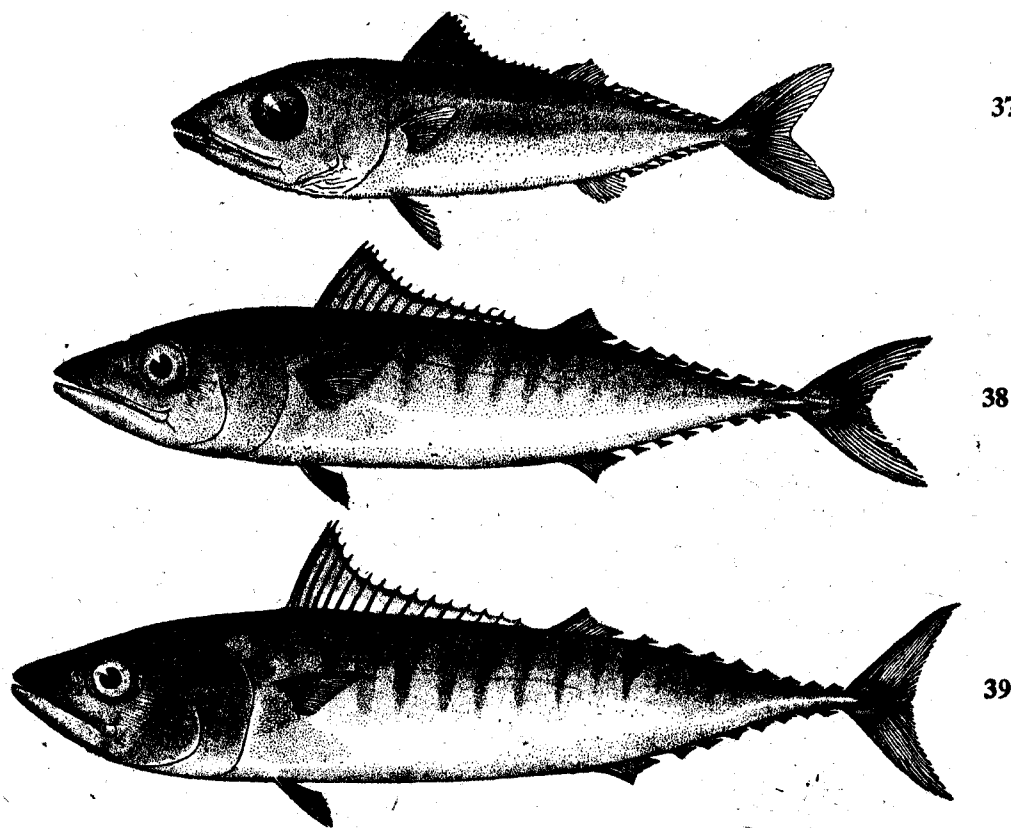
In the postlarval stages of *Auxis* the snout is short and pointed and its length is less than the diameter of the eye. Mouth is oblique and the maxillary reaches to a vertical below the middle of the eye. The head is not so large as in the other larval tunas and the dorsal outline of the head appears to be somewhat bulged. Vent is anterior to the midpoint of total length until the larva reaches a length of about 9.5 mm.

Normally three rows of chromatophores, along the midventral, middorsal and mid-lateral lines of the caudal peduncle develop in larger specimens. *Auxis* larvae can be distinguished from *E. affinis affinis* by the narrow fin membranes, the later development of the first dorsal fin, the presence of very few chromatophores on the first dorsal fin membrane and the difference in pigmentation in the region of the caudal peduncle.

However considerable dissimilarities in body proportions, pigmentation and general appearance could be seen between the 3.58, 3.68, 3.75 and 3.92 mm. *Auxis* larvae described by Mito (*op. cit.*), the 3.36 mm. larva described by Jones (1960b) and the 3.5 and 3.7 mm. stages described by Matsumoto (1959). This remains to be explained.

Auxis thazard (Lacépède)

Jones (1960b) while describing the *Auxis* larvae collected from the Laccadive Sea had indicated the possibility of their belonging to *A. thazard* which is the only species of the genus *Auxis* known to occur in the above area. When the 8.1 mm. larva of *Auxis thynnoides* (= *A. tapeinosoma*) described by Yabe and Ueyanagi (1961) is compared to the *Auxis* larva of similar size from the Laccadives, the latter is stouter with greater head length, which features are characteristic of the adult *A. thazard*. Therefore the *Auxis* larvae from the Laccadive Sea are provisionally placed under *A. thazard* and are shown in figures 50 to 53. Two juvenile stages of *A. thazard* described by Wade (1949) are reproduced here (Figs. 54 and 55).



Figs. 37-39. *Euthynnus affinis affinis*. Fig. 37.—24.5 mm., Fig. 38.—56.6 mm., Fig. 39.—96 mm., (Reproduced from Jones, 1960a)

According to Jones (1962) a re-examination of the juvenile *Ayxis* given under *A. thynnoides* by him earlier (Jones, 1960b) has shown that specimens from 44 mm. to 132 mm. in length cannot be assigned definitely to *A. thynnoides* and that one will be inclined to place them under *A. thazard* if only the gill raker counts are taken into consideration.

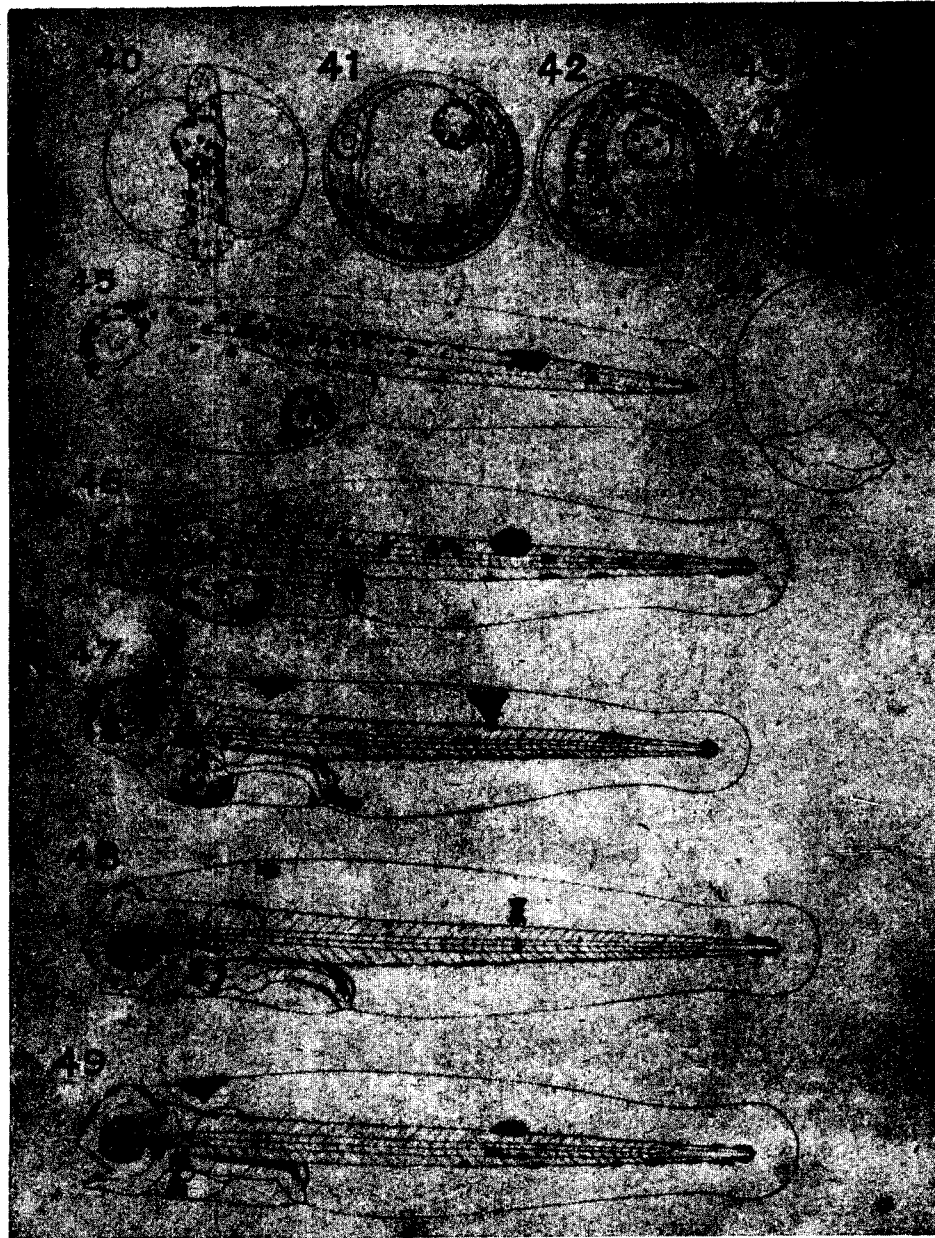
***Auxis thynnoides* Bleeker**

It is probable that some of the larval specimens of this species are present in the material worked out by Wade (1951) and Matsumoto (1958 and 1959). The figure of a larva of *A. thynnoides* measuring 8.1 mm. given by Yabe and Ueyanagi (*op. cit.*) is reproduced in Fig. 56. This is characterised by the comparatively slender body and small head. There are five preopercular spines. Larvae conforming to *A. thynnoides* have been seen by us in the Dana Expedition collections from station Nos. 3940, 3946 and 3955 in the Indian Ocean (Jones and Kumaran, 1962b).

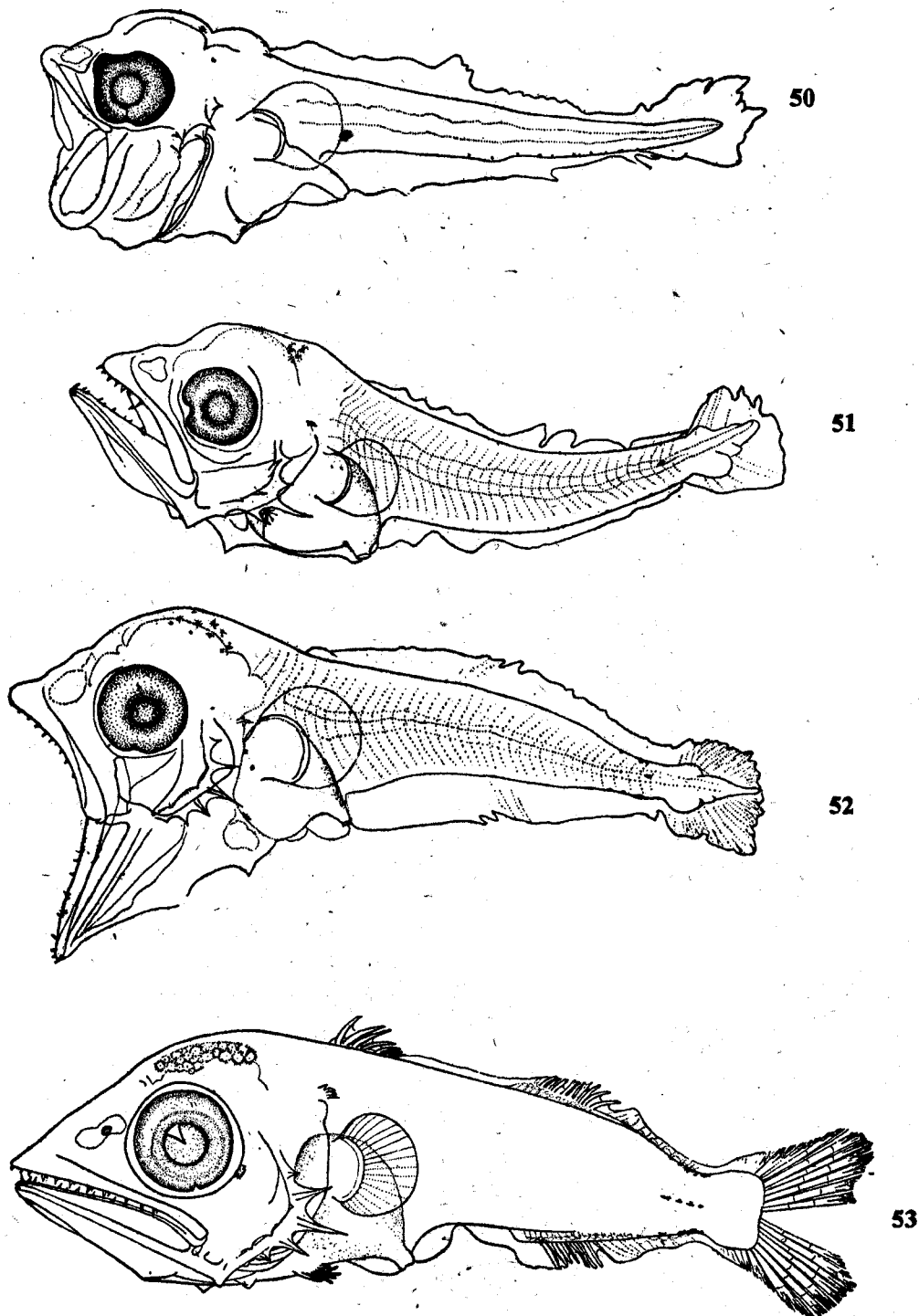
***Sarda orientalis* (Temminck and Schlegel)**

The oriental bonito is widely distributed in the warmer regions of the Indian and Pacific Oceans. No information is available about the larval stages of this species but late postlarval and juvenile stages of *Sarda chilensis*, which occur in the Eastern Pacific have recently been described (Pinkas, 1961 and Klawe, 1961b). The figure of 3.5 mm.

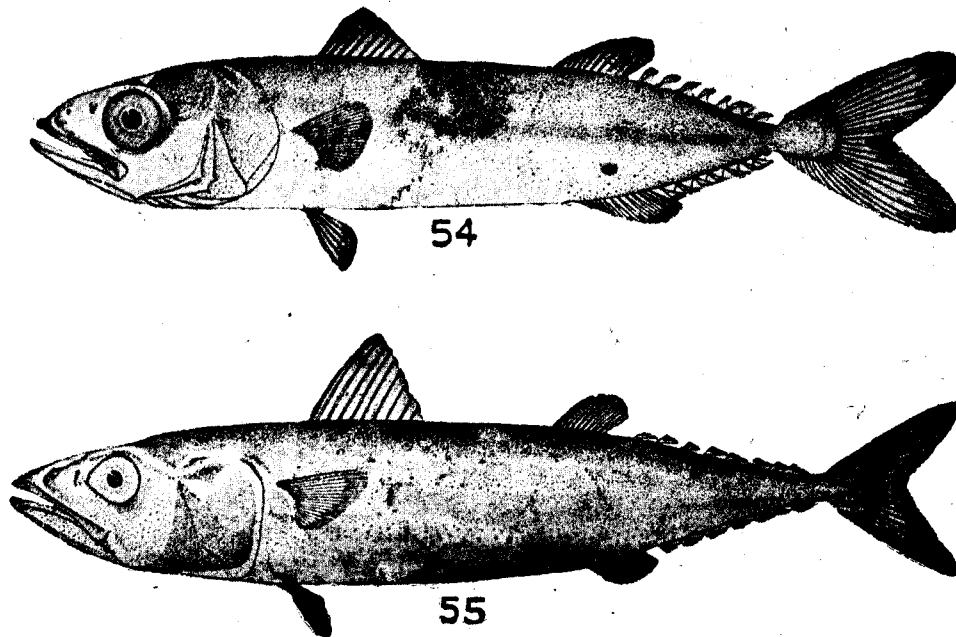
larva of *Sarda* sp. by Klawe (1961b) collected off Baja California where both *S. orientalis* and *S. chilensis* occur is reproduced here (Fig. 59) so as to facilitate identification of the



Figs. 40-49. Embryonic and early larval stages of *Auxis* sp. (Reproduced from Mito, 1961). Fig. 40.—Pelagic egg, 1.4 mm. in diameter., Fig. 41.—29—myotome stage, 9h. 30 m. after collection, Fig. 42.—10h. 30 m. after collection, Fig. 43.—Egg shortly before hatching, Fig. 44.—Empty egg capsule, Fig. 45.—Larva just hatched 2.7 mm. in total length, Fig. 46.—Larva 16h. 30 m. after hatching, 3.68 mm., Fig. 47.—Larva 30h. after hatching, 3.58 mm., Fig. 48.—3.92 mm., Fig. 49.—3.75 mm.



Figs. 50-53. *Auxis thazard*? Fig. 50.—3.36 mm., Fig. 51.—4.4 mm., Fig. 52.—5.08 mm., Fig. 53.—7.94 mm. (Reproduced from Jones, 1960b)



Figs. 54-55. *Auxis thazard*. Fig. 54.—26 mm., Fig. 55.—57.2 mm. (Reproduced from Wade, 1949)

larvae of *S. orientalis* which is the only species of the genus found in the Indian Ocean. There are three preopercular spines in the larva measuring 3.5 mm. The area of the fore-brain is pigmented. Posterior to the vent chromatophores are present along the midventral line upto the urostyle. At about 16 mm. stage there are about 8 preopercular spines, the fourth one from above being the longest. In the post-temporal region three or four small spines are present. These spines gradually disappear as growth advances. The ventral fin is heavily pigmented unlike in the larvae of other species.

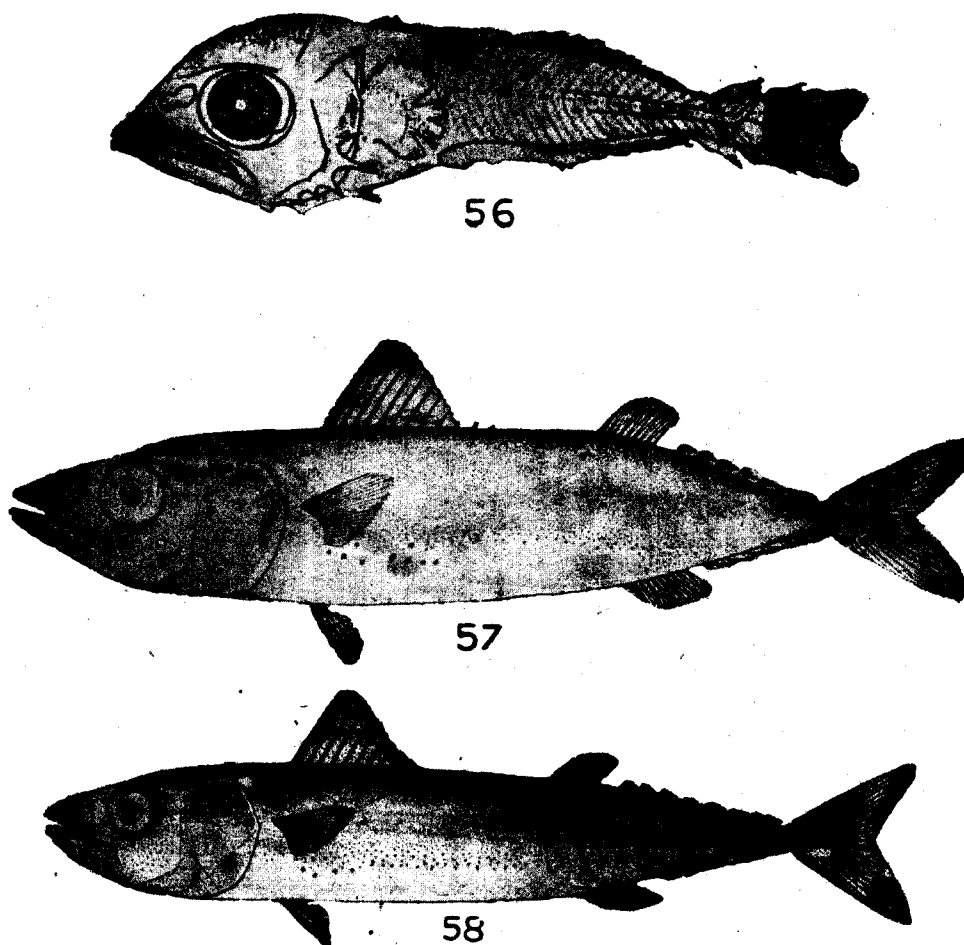
Juveniles are reported to occur occasionally along the Kerala coast and the figure of the earliest juvenile known from Indian waters (Jones, 1960b) is reproduced in Fig. 60. In juveniles of about 80 mm. length twelve transverse bands which are incomplete ventrally are present over the body which gradually change into the characteristic wavy lines of the adult. In larger juveniles more than 10 rows of somewhat horizontal streaks are present while the number in the adult is 7 or 8.

FAMILY : SCOMBRIDAE

Scomber japonicus Houttuyn

Scomber japonicus though rare in Indian coastal waters is distributed over a wide area in the Indo-Pacific. Some selected stages from the figures given by Uchida *et al.* (1958) are reproduced in Figs. 63-69.

The fertilized egg is pelagic and has an oil globule. The embryo is well pigmented (Fig. 64). The newly hatched prolarva (Fig. 65) is about 3 mm. in length. The vent is far anterior to the midpoint of total length and finfolds are broad. Pigments are visible on the head and dorsal side of the body. Only 28 myotomes could be counted at this stage. When the larva reaches a length of 3.6 mm. the post-anal portion is elongated

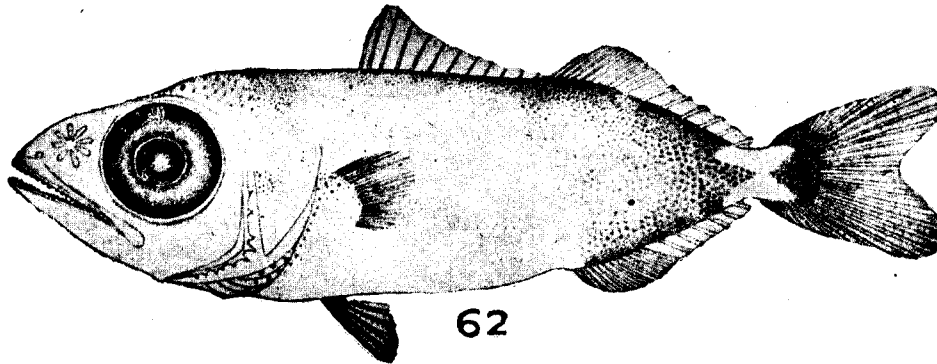
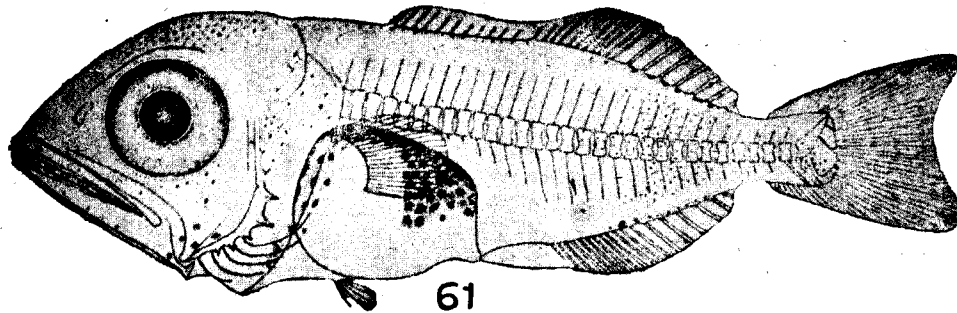
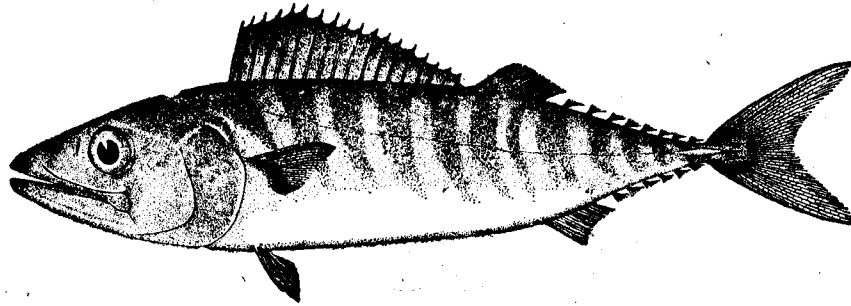
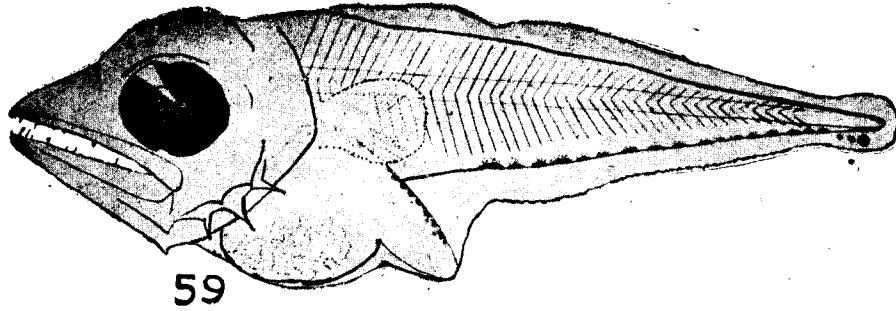


Figs. 56-58. *Auxis thynnoides*. Fig. 56.—8.1 mm. (Reproduced from Yabe and Ueyanagi 1961). Fig. 57.—33 mm., Fig. 58.—54 mm. (Reproduced from Wade, 1949)

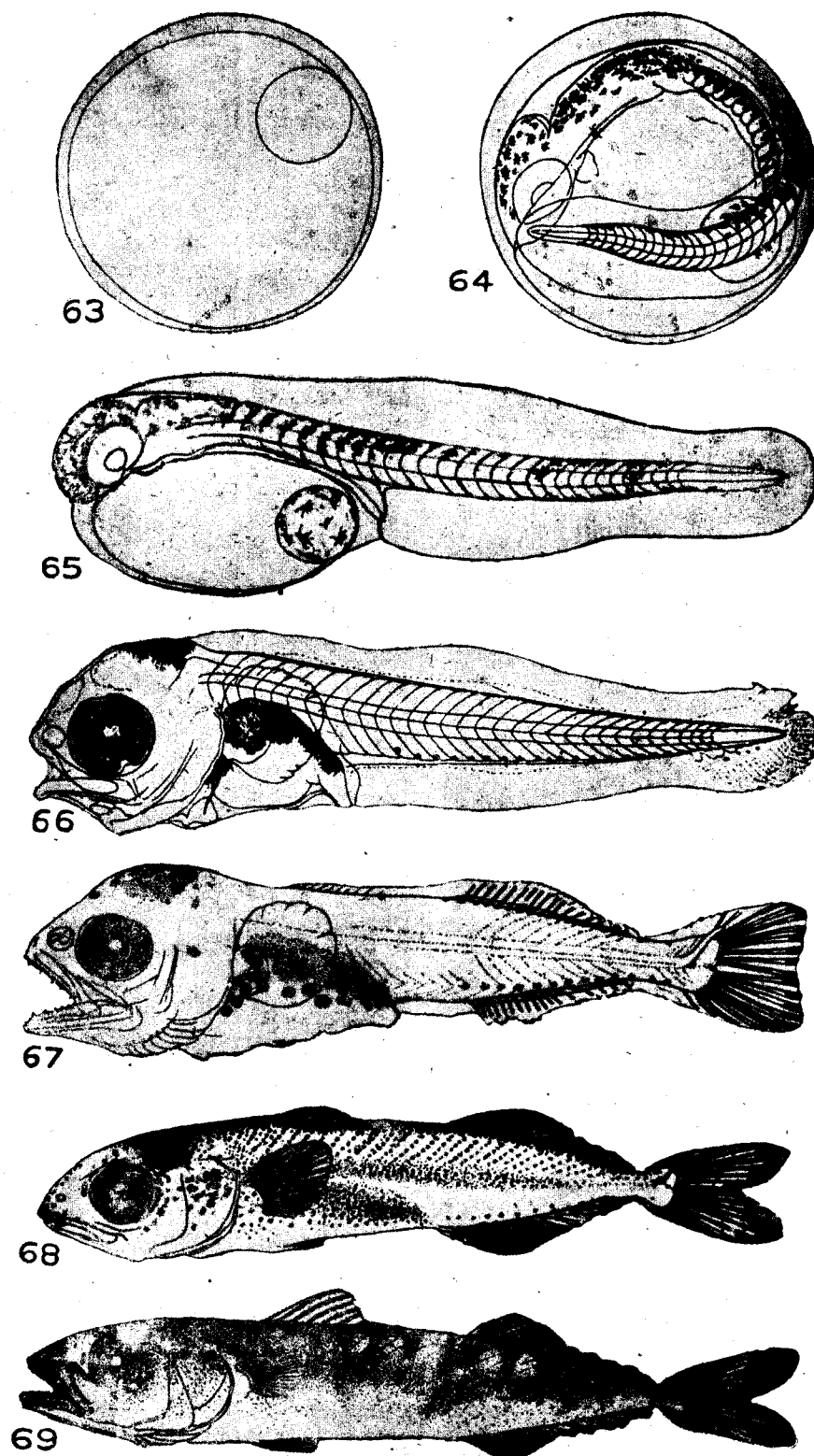
considerably and the head is about 6 in total length. Chromatophores are no more visible on the dorsal side of the body but a row of pigments is seen along the midventral line from vent to the urostyle. The peritoneum of the body cavity is well pigmented. Teeth are absent. At about 5 mm. (Fig. 66) the caudal fin shows striations and two or three pairs of teeth are present in the jaws. Maxilla reaches to a vertical below the middle of eye. In addition to the chromatophores along the midventral line, few pigments are visible below the urostyle. Spines and rays begin to develop at about 9.4 mm. stage (Fig. 67). The posterior region of the head is heavily pigmented. The depth of the body has increased and the vent is still anterior to the midpoint of body. The full complement of spines and rays have developed in specimens of 19 mm. and more in length. At this stage the head is about 4 in total length. Pigmentation over the body is more dense.

***Rastrelliger kanagurta* (Cuvier)**

Even though this species is widely distributed in the Indo-Pacific and forms a fishery of considerable magnitude in several areas very little is known about the larval stages



Figs. 59-62. Fig. 59.—*Sarda* sp., 3.5 mm. (Reproduced from Klawe, 1961b). Fig. 60.—*Sarda orientalis*, 80 mm. (Reproduced from Jones, 1960b). Fig. 61.—*Grammatorcynus bicarinatus*, 8.5 mm., Fig. 62.—*G. bicarinatus*, 17.5 mm. (Reproduced from Wade, 1951)

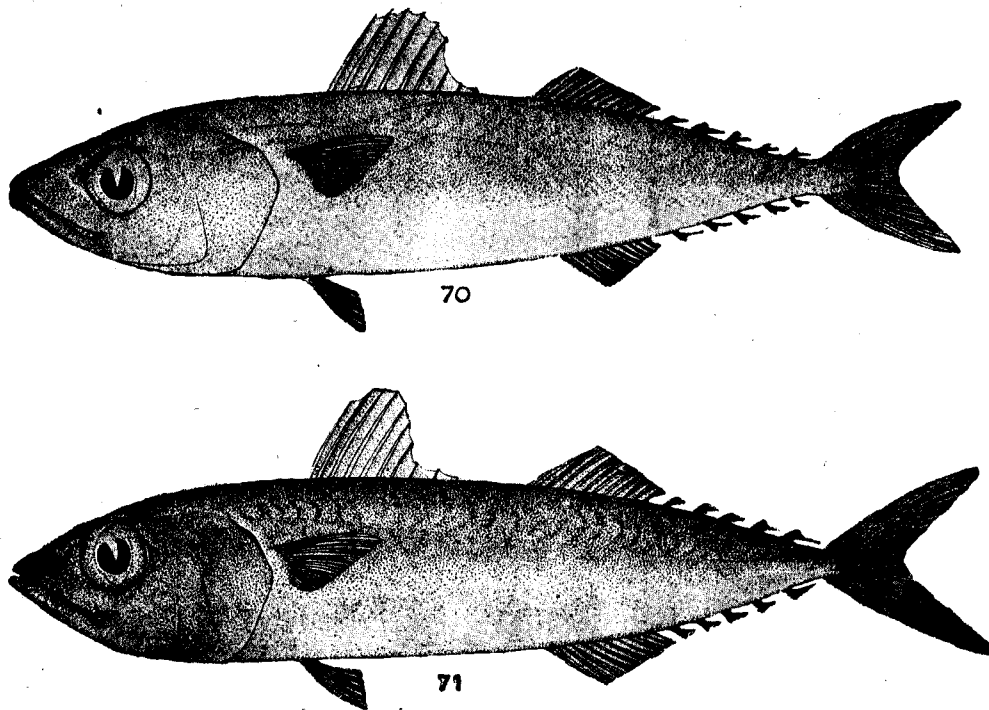


Figs. 63-69. *Scomber japonicus*. Fig. 63.—Unfertilized, ripe egg 1.1 mm., Fig. 64.—Pelagic egg with well developed embryo., Fig. 65.—Newly hatched larva 3.0 mm., Fig. 66.—5.0 mm., Fig. 67.—9.4 mm. Fig. 68.—19 mm., Fig. 69.—49.0 mm., (Reproduced from Uchida *et al.*, 1958).

excepting for their reported occurrence at Vizhingam, near Trivandrum (Balakrishnan, 1957) and at Madras (Kuthalingam, 1956). In the absence of any figures or descriptions these records are only of limited value. Juveniles occur in large numbers in certain fishing centres along the east and west coasts of India. Rao and Basheeruddin (1953) observed juveniles measuring 40-100 mm. off Madras in March-April 1953. Small sized mackerel of about 31 mm. have also been observed by Rao (unpublished). Two juvenile stages of mackerel collected from Vizhingam are illustrated here (Figs. 70 and 71). Preopercular spines which are present in the early juveniles of other scombroids appear to be absent in *Rastrelliger*. Juveniles have more or less the adult form even though the body proportions differ from the adult.

Grammatorcynus bicarinatus (Quoy and Gaimard)

The double-lined mackerel does not form a fishery of much economic importance in any area of the Indo-Pacific. This has been recently recorded from the Andamans (Jones, Silas and Dawson, 1960) where it is caught frequently in hook and line. The only available information about the early stages of this fish is from the Philippine waters (Wade, 1951) on 8 specimens ranging in size 8.5—17.5 mm.



Figs. 70-71. *Rastrelliger kanagurta*. Fig. 70.—34 mm., Fig. 71.—65 mm.

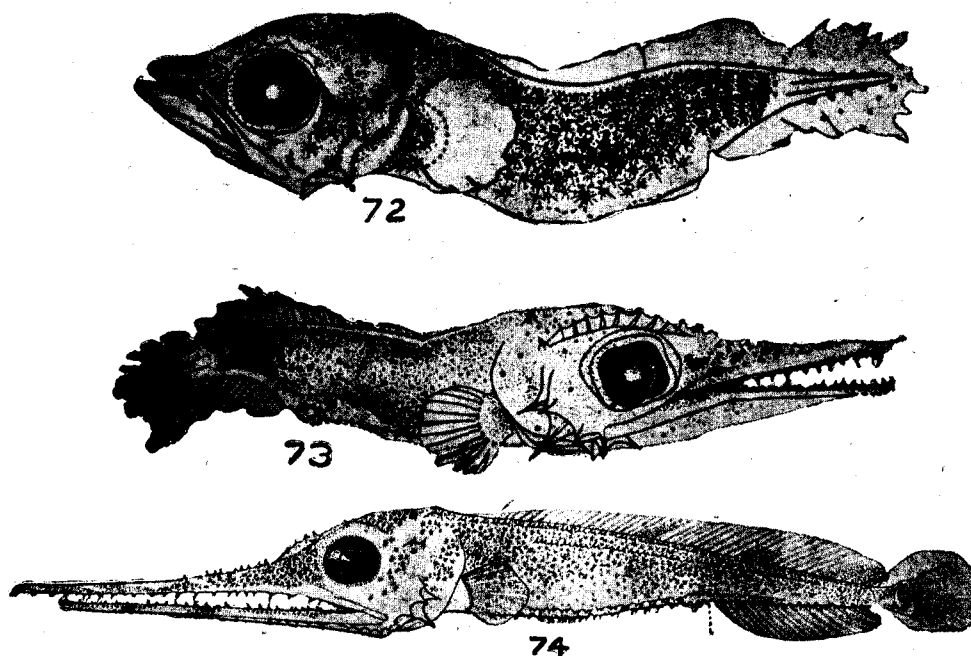
In the 8.5 mm. stage (Fig. 61) the head is large and the body is deep. The diameter of the eye is more than the length of the snout. There are spines along the edges of the preoperculum as in tuna larvae but differ from the spines of the latter in being conspicuously short. Pigmentation is present from the nape to above the eye, behind the eye, tip of the snout and posterior to the angle of the jaws. Pigmentation on the base of the median fins observed in the earlier stage increases and extends laterally over the posterior half of the

body in the later stages. The first dorsal is well developed and is without pigments upto at least 17.5 mm. stage (Fig. 62). The vertebral count is 31 as in mackerel but the difference in the number of spines of the first dorsal and presence of 7 dorsal and anal finlets helps to distinguish the later stages of this species easily.

FAMILY : XIPHIIDAE

Xiphias gladius Linnaeus

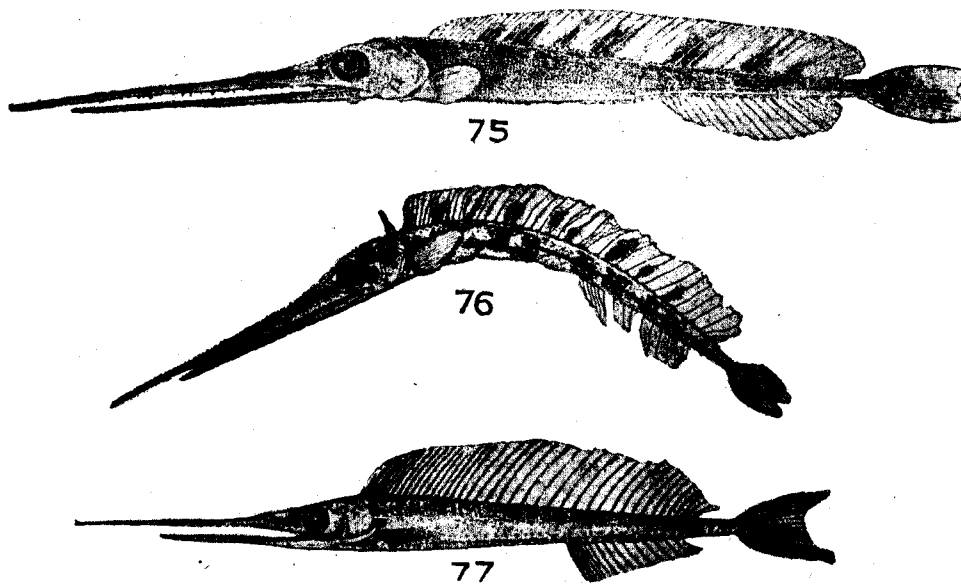
The swordfish has a wide range of distribution in the Indian, Pacific and Atlantic Oceans. Larval and juvenile stages of swordfish from the Atlantic and the Pacific have been described by Arata (1954), Nakamura *et al.* (1951), Yabe (1951) and Yabe *et al.* (1959) Taning (1955) has dealt with the distribution of larvae based mainly on the collection made by the Dana Expeditions. One postlarva was collected from the Laccadive Sea (Jones, 1958). Some of the larval and juvenile stages described by earlier workers are reproduced here (Figs. 72-77) to facilitate identification. Eggs and the larvae hatched out of them have been described by Sanzo (1922). Considerable differences observable between the newly hatched larva measuring 5.56 mm. described by him and the larva measuring 5.1 mm. collected from the Pacific (Yabe, *et al.*, 1959) which is structurally more advanced and bears unmistakable features of *Xiphias* could probably be attributed to the reduction in size that might take place during the transition from the prelarval to the postlarval stage if the former's determination of the identity of the egg is correct.



Figs. 72-74. *Xiphias gladius*. Fig. 72.—5.1 mm., Fig. 73.—8.2 mm. (Reproduced from Yabe *et al.*, 1959).
Fig. 74.—16.27 mm. (Reproduced from Jones, 1958)

The smallest specimen positively identified by Yabe *et al.* (1959) measured 5.1 mm. This has developed chromatophores and the snout is already elongated and the vent is far posterior to the midpoint of total length. The larva of swordfish can be easily recognized

by the nature of spination on the head and body and the long snout. In smaller specimens the spination on the head consists of a supraorbital ridge, preopercular spines, cranial spines and a temporal spine. Keeled spines on the body characteristic of later stages are absent in early stages. In specimens of about 15 mm, the spination consists of interrupted groups on the snout, a preorbital ridge with 8 spines, two closely set rows of short spines along the preopercle, a keeled ridge of spines below the angle of the jaws, 2 spines dorsolateral to the cranium and 2 spines in the temporal region. Rows of spinous scales over the body are connected at their bases. The body is more or less heavily pigmented with the ventral side lighter in colour.



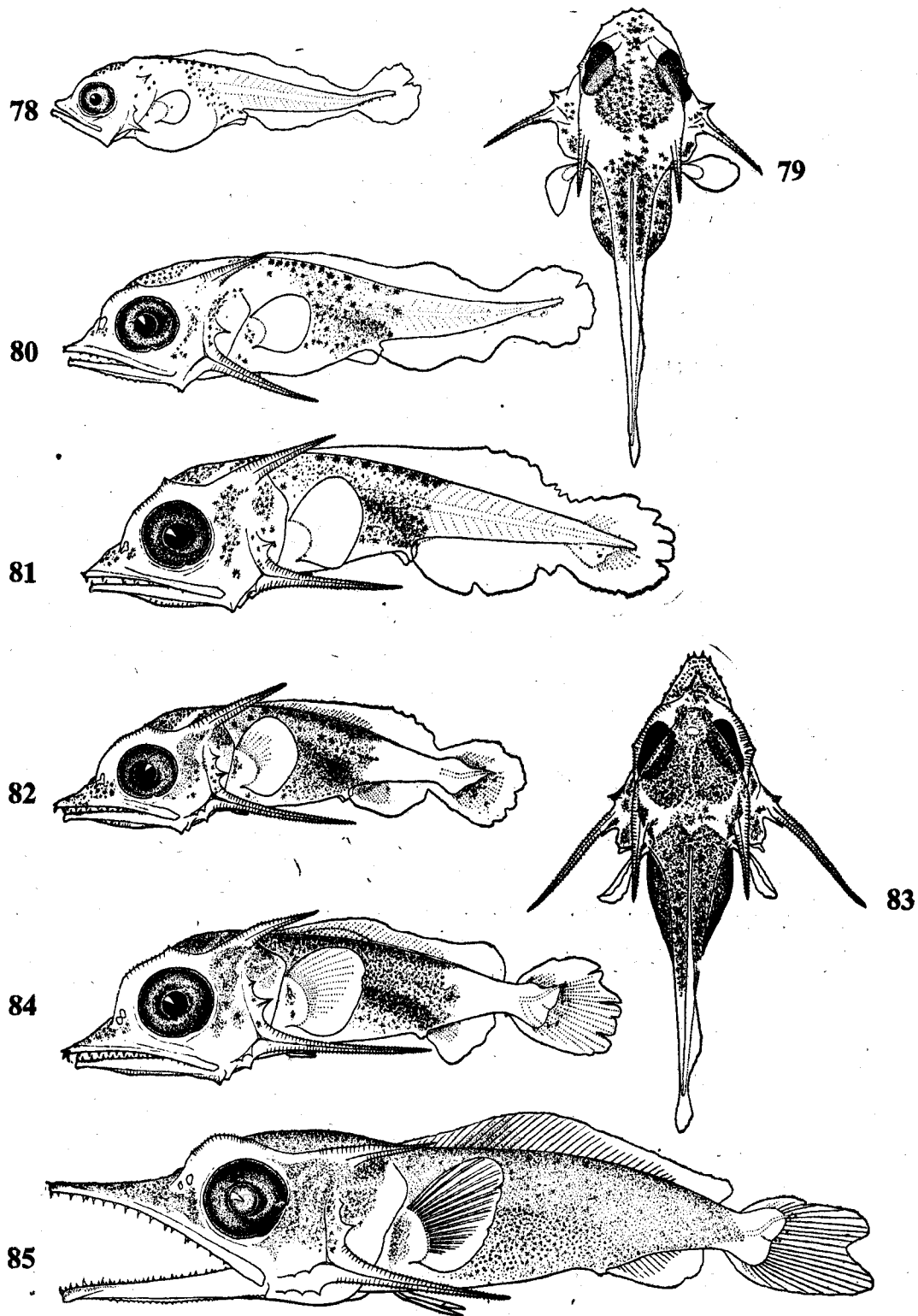
Figs. 75-77. *Xiphias gladius*. Fig. 75.—46.3 mm., (Reproduced from Taning 1955). Fig. 76.—73 mm. (Reproduced from Yabe *et al.*, 1959). Fig. 77.—252 mm. (Reproduced from Nakamura *et al.*, 1951).

FAMILY : ISTIOPHORIDAE

Istiophorus gladius (Broussonet)

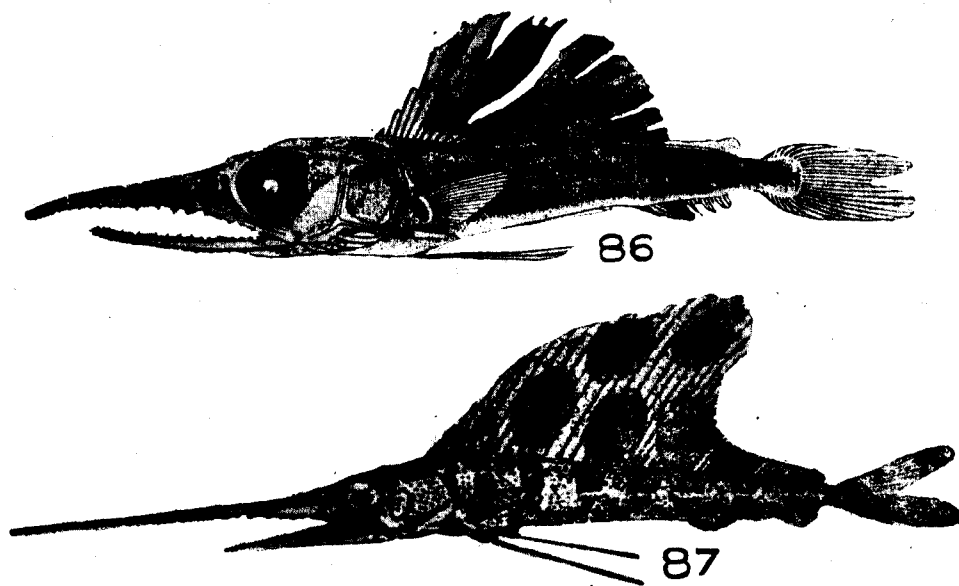
It appears that for reasons given elsewhere (Jones and Silas, 1962) the sailfish of the Pacific and the Indian Oceans comprise only of a single species. For the purposes of this study the two are considered to be synonymous and the specific name *gladius* which has priority over *orientalis* or any other name proposed for the sailfish of the Indo-Pacific is used. *I. gladius* is abundant in the tropical seas and strays into the temperate areas but has a rather limited distribution range than the marlins and the swordfish.

From the nature of distribution of the larvae in the Laccadive Sea, Jones (1959a) concludes that sailfish breeds over a fairly extensive area in this part of the Indian Ocean. Yabe (1953a) has described the larvae collected from the south-western sea of Japan and presumes that spawning occurs near that area. 55 istiophorid larvae collected from the Indian and Pacific Oceans by the Danish Dana Expedition of 1928-30 were also studied. In the Eastern Indian Ocean, spawning takes place west of Sumatra and in the Western Indian Ocean near Madagascar and Seychelles Islands.



Figs. 78-85. *Istlophorus gladius*. Fig. 78.—3.4 mm., Fig. 79.—Dorsal view of 4.17 mm., stage., Fig. 80.—4.74 mm., Fig. 81.—5.42 mm., Fig. 82.—6.51 mm., Fig. 83.—Dorsal view of 6.51 mm., stage. Fig. 84.—7.88 mm., Fig. 85.—11.75 mm., (Reproduced from Jones, 1959a)

Larval stages of sailfish figured by Jones (1959a) are reproduced in Figs. 78-85. In addition, 2 juveniles measuring 23.5 mm. and 127 mm. illustrated by Yabe (1953a) and Deraniyagala (1949) respectively are reproduced in Figs. 86 and 87. The vent is posterior to the midpoint of total length even in the smallest known specimen measuring 3.4 mm. in which yolk is present. The diameter of eye is about 8 in total length. The pterotic and preopercular spines are short in early stages. The orbital crest and the pterotic and preopercular spines are serrated. The preopercular spine reaches upto the vent in specimens measuring 6-8 mm. The pterotic and preopercular spines are comparatively shorter in larger specimens. The position of the eye is somewhat high *i.e.*, the tip of the snout is almost in a line with the centre of eye. In a specimen measuring 11.75 mm. the snout has elongated, the dorsal fin has increased in height, the caudal fin is forked and the pelvic fin has increased in length. The dorsal fin of juveniles measuring more than 20 mm. is almost semi-circular in outline and its anterior rays are short.

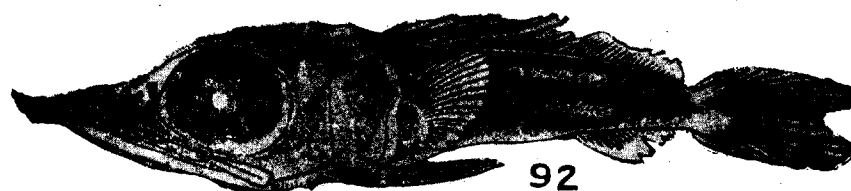
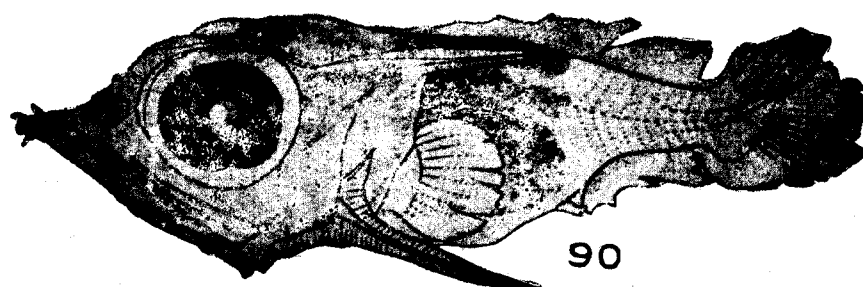
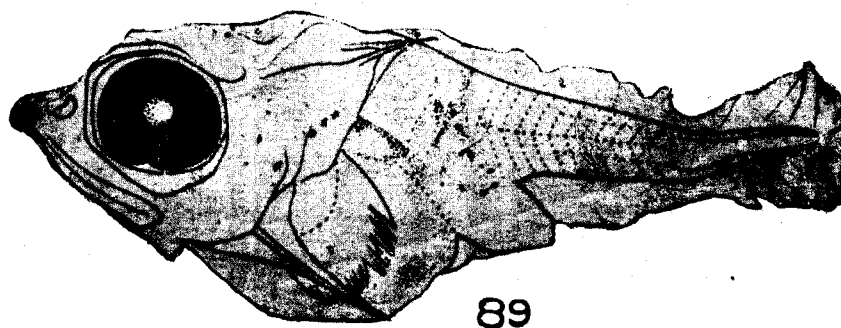
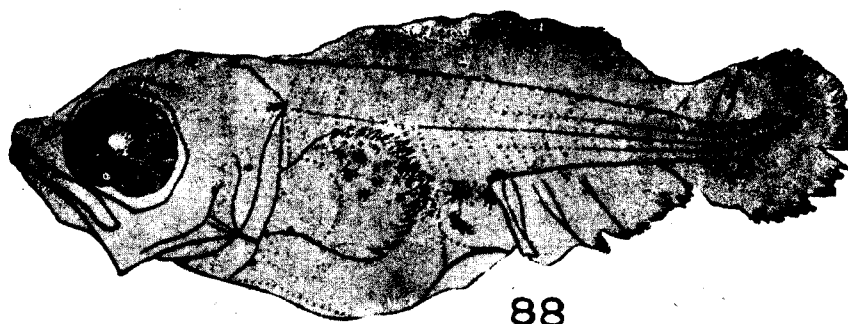


Figs. 86-87. *Istiophorus gladius*. Fig. 86.—23.5 mm., (Reproduced from Yabe, 1953a). Fig. 87.—127 mm. (Reproduced from Deraniyagala, 1949).

Makaira audax (Philippi)

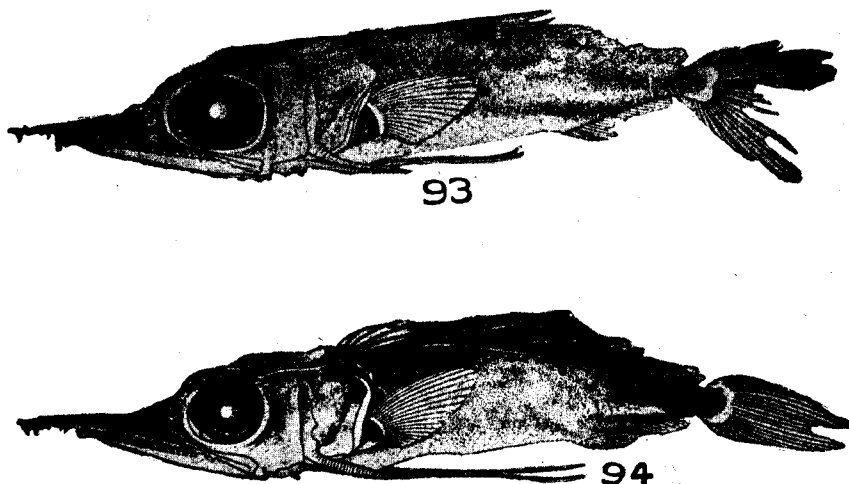
The striped marlin, *Makaira audax* is distributed in the tropical and sub-tropical areas of the Indian and Pacific Oceans in varying degrees of abundance. Larval stages of *M. mitsukurii* (= *M. audax*) collected from the North Pacific, South Pacific and the Indo-Australian Archipelago have been described by Ueyanagi (1959). Based on 19 specimens collected from the Indian Ocean by the Dana Expedition, it is observed that spawning takes place in the Eastern Indian Ocean west of Sumatra and Java and in the Western Indian Ocean near Madagascar.

Larvae of *M. audax* (Figs. 88-94) resemble closely those of the sailfish. Larval *M. audax* can be distinguished from sailfish larvae by the comparatively large head and eyes, the relatively low position of the eye and the deep body. The centre of the eye and the tip of the snout are approximately in the same level. The head in the larvae of



Figs. 88-92. *Makaira audax*. Fig. 88.—2.9 mm., Fig. 89.—3.1 mm., Fig. 90.—5.0 mm., Fig. 91.—7.9 mm., Fig. 92.—10 mm., (Reproduced from Ueyanagi, 1959).

striped marlin is somewhat longer than that of the sailfish of comparable size. Preorbital ridge, pterotic and preopercular spines are present as in other related species. Head length usually exceeds 40% of total length in specimens 4–9 mm. long. In older stages, the pelvic fin is comparatively longer than that of sailfish.



Figs. 93–94. *Makaira audax*. Fig. 93.—17.4 mm., Fig. 94.—21.2 mm., (Reproduced from Ueyanagi, 1959).

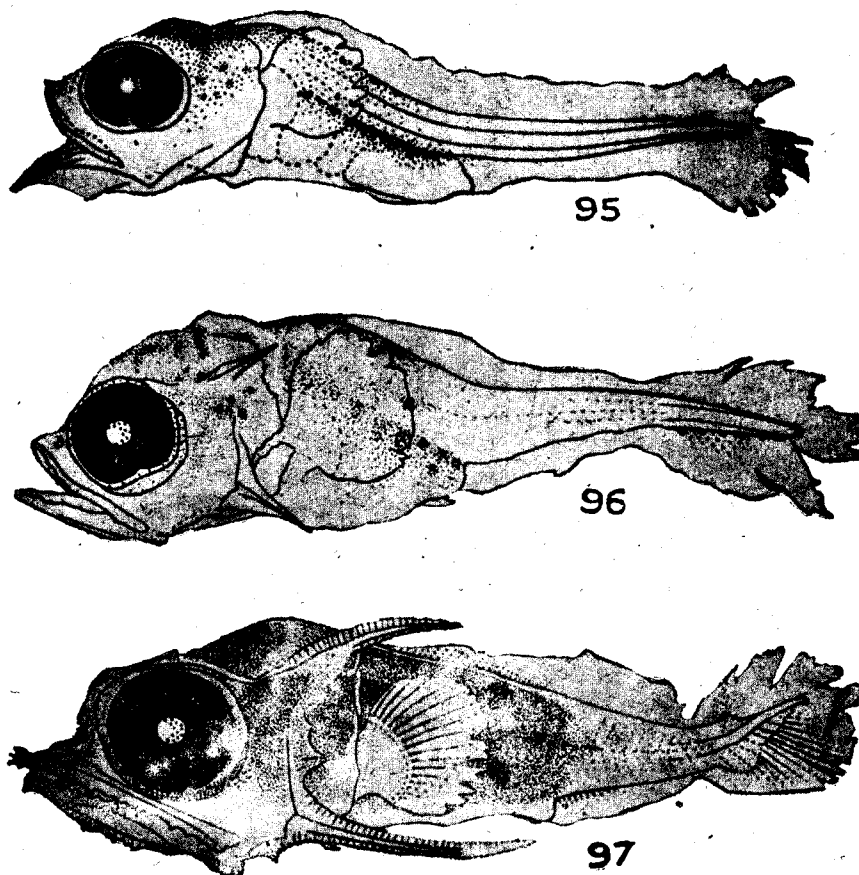
Makaira mazara (Jordan and Snyder)

The blue marlin of the Indo-Pacific, *Makaira mazara* (= *Eumakaira nigra*) forming a good fishery in the Pacific is abundant in the Eastern Indian Ocean also. Larval and juvenile stages of this species (Figs. 95–103) from the Western Pacific and the Indian Ocean have been described by Ueyanagi and Yabe (1959). 36 larval specimens collected by the Dana Oceanographical Expedition (1928–30) have been examined by us. From the Central Pacific, larvae have been collected between 5°N–20°S lat. The tropical Eastern Indian Ocean West of Sumatra appears to be one of the important spawning grounds of this species. (Jones and Kumaran, 1962a.)

It is very difficult to distinguish between the larval stages of sailfish and *M. mazara* because of close similarities existing between them. However, minor differences have been noticed between the two. In the sailfish, the snout has a sharp pointed appearance and the eye is comparatively smaller whereas in *M. mazara* the snout is blunt and the eye is slightly larger. The position of centre of eye is at a higher level from the horizontal line from snout. Anterior edge of orbit is slightly produced forward. The ventral fins in later stages are longer than those of the sailfish of comparable size.

Istiompax indicus (Cuvier and Valenciennes)

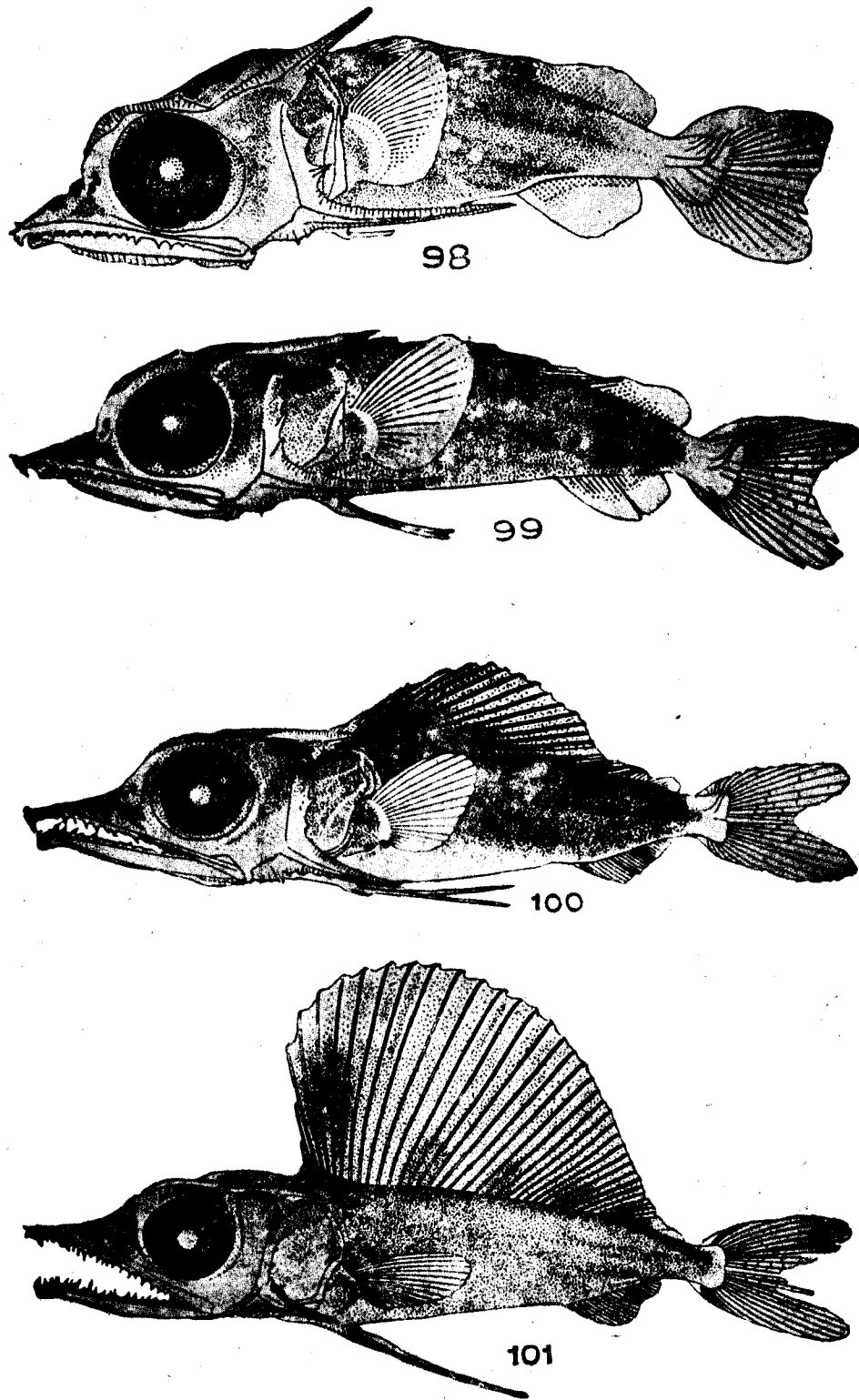
The black marlin, *Istiompax indicus* (= *Marlina marlina*) is found in comparative abundance in the Western Pacific. Its western limit in the Indian Ocean, is Tanganyika coast and Pemba.



Figs. 95-97. *Makaira mazara*. Fig. 95.—2.9 mm., Fig. 96.—3.3 mm., Fig. 97—6.0 mm. (Reproduced from Ueyanagi and Yabe, 1959).

Ueyanagi and Yabe (1960) have described a specimen of 26.5 mm. (Fig. 107) collected from the western Pacific. In addition four larvae including one from the southern waters off Ceylon have been collected (Ueyanagi, 1960a). Three larvae illustrated by him are reproduced in Figs. 104-106. 10 specimens collected by the Dana Expedition, 1928-30 from the Indo-Pacific have been examined by the authors.

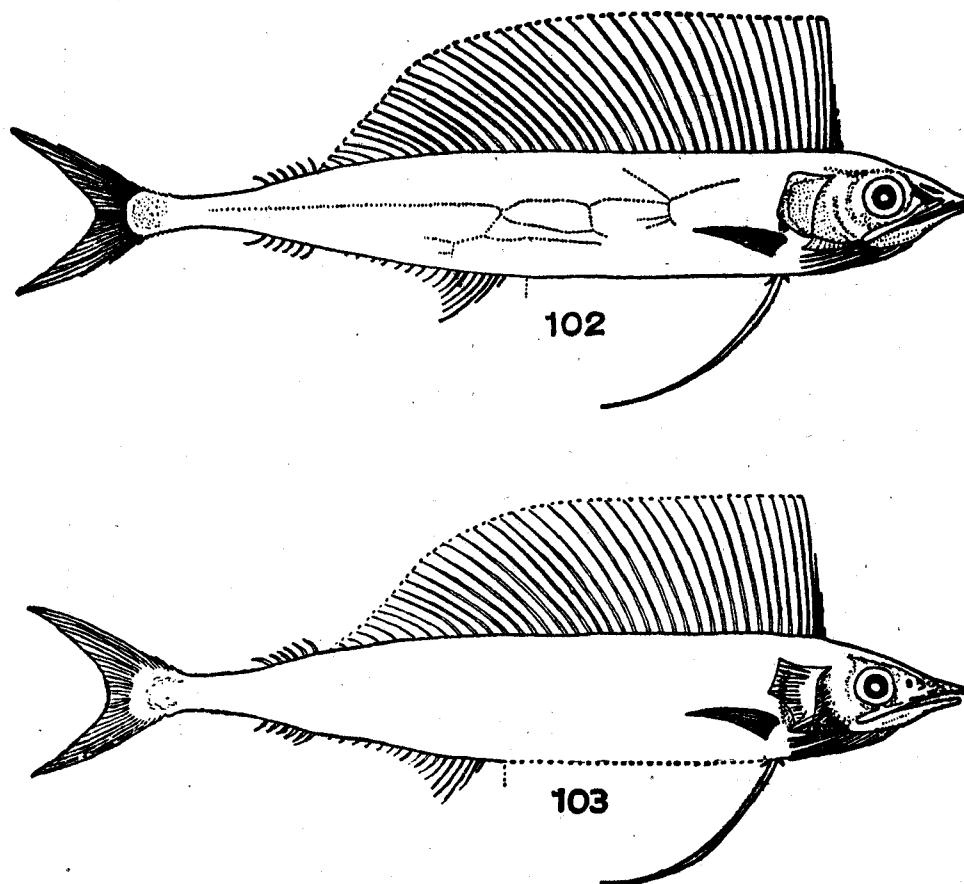
The larvae have characteristically short snout and the eye is large. Pectoral fin was found to be rigid even in postlarval stages. Centre of eye is at a higher level from the horizontal line from snout. Chromatophores are not developed in the middle portion of the body in specimen measuring 3.5 mm. and those near the urostyle are more prominent. In a specimen measuring 26.5 mm. minute spinous scales are found on the post-orbital portion, operculum and on the sides of the body.



Figs. 98-101. *Makaira mazara*. Fig. 98.—8.6 mm., Fig. 99.—11.6 mm., Fig. 100.—16.3 mm., Fig. 101.—23.2 mm. (Reproduced from Ueyanagi and Yabe, 1959).

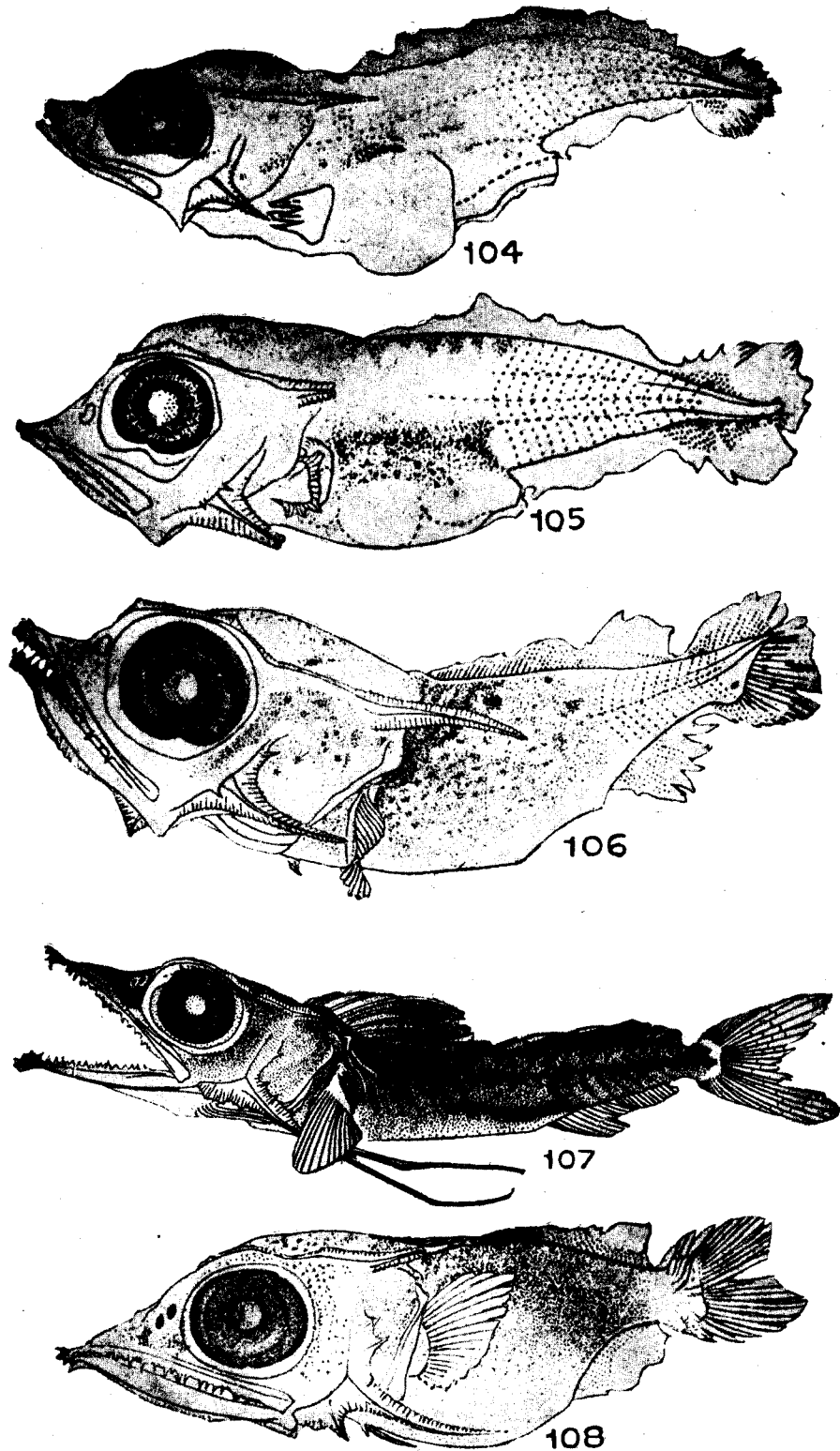
***Tetrapturus angustirostris* (Tanaka)**

Shortnosed spearfish which is reported to occur in appreciable numbers east of Formosa and the Philippines do not form a significant fishery anywhere. Its occurrence in the Indian Ocean was reported by Yabe *et al.* (1958). We have not come across any specimen of this species from Indian waters.



Figs. 102-103. *Makaira mazara*. Fig. 102.—177 mm., Fig. 103.—258 mm. (Reproduced from Ueyanagi, 1957).

Larval and postlarval stages of shortnosed spearfish from 3 to 50 mm. in total length have been collected from the Pacific and the one measuring 7.4 mm. illustrated by Ueyanagi (1960b) is reproduced here (Fig. 103) to facilitate identification of the larvae from our waters. Two larval specimens presumably of this species collected by the Dana Expedition from west of Sumatra were also examined by us. In larva measuring 7.4 mm. the snout length exceeds the diameter of eye. Centre of eye is at a higher level from the horizontal line from snout. The length of head is usually about 45% of total length in specimens ranging from 4-7 mm. The branchiostegal membrane is pigmented.



Figs. 104–108. *Istiompax indicus*. Fig. 104.—2.5 mm., Fig. 105.—3.6 mm., Fig. 106.—5.2 mm. (Reproduced from Ueyanagi, 1960a). Fig. 107.—26.5 mm. (Reproduced from Ueyanagi and Yabe, 1960).
 Fig. 108—*Tetrapturus angustirostris*, 7.4 mm. (Reproduced from Ueyanagi, 1960b).

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*Denotes important references on the subject though not cited in the text.