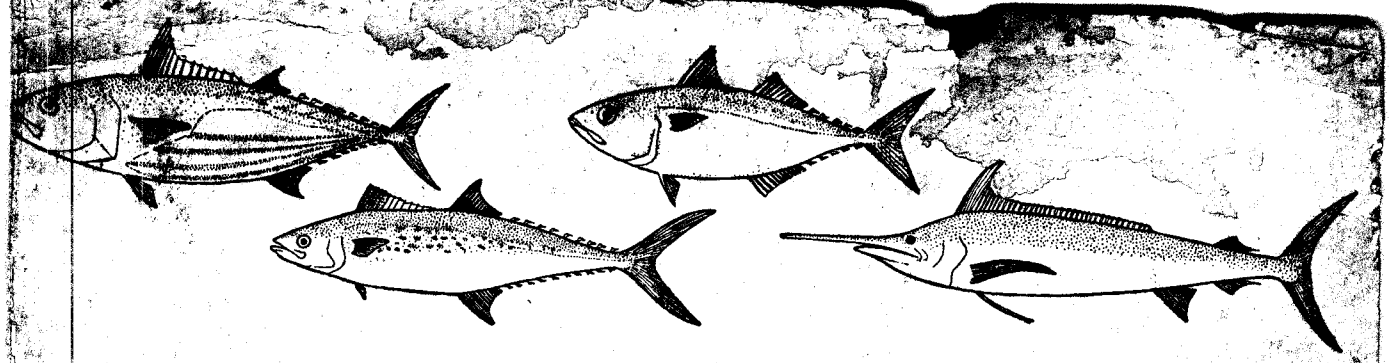
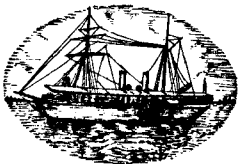
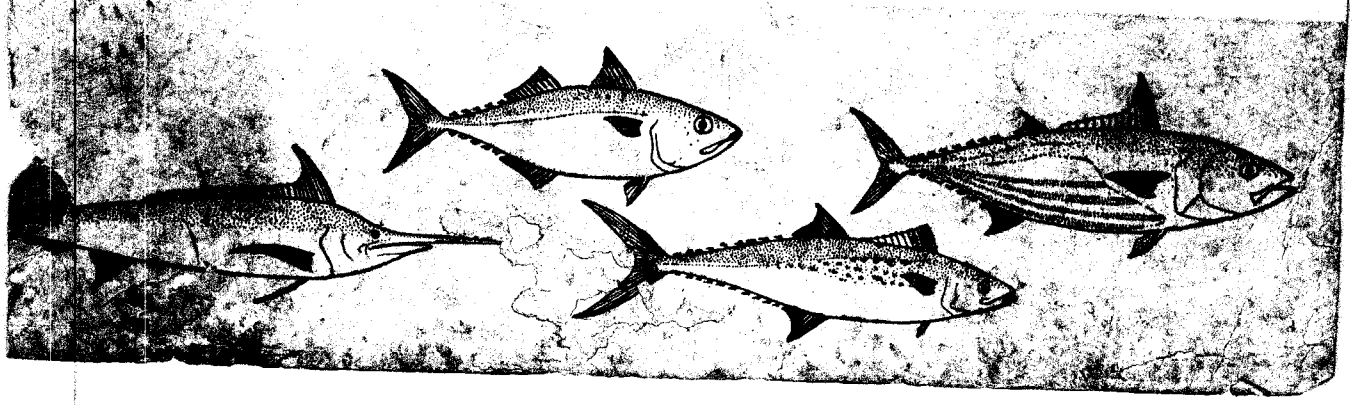


SYMPOSIUM ON SCOMBROID FISHES

PART I



MARINE BIOLOGICAL ASSOCIATION OF INDIA
MANDAPAM CAMP
S. INDIA

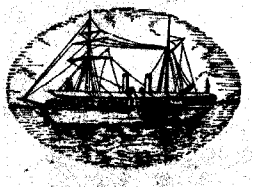


PROCEEDINGS OF THE

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

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PRINTED BY THOMPSON & CO PRIVATE LTD (MINERVA PRESS) 33 BROADWAY MADRAS 1

ACKNOWLEDGMENT

The Marine Biological Association of India acknowledges with profound thanks the *Van Camp Foundation,* San Diego, California, for the generous grant of $ 1500.00 towards this publication. The Association also wishes to place on record its gratitude to *Dr. W. M. Chapman,* Director of the Van Camp Foundation and Corresponding Member of the Association, for the very active interest he has taken in securing the funds for the publication of the Proceedings of the Symposium.

PREFACE

The present volume contains the first of the three parts of the Proceedings of the "Symposium on the Systematics, Biology and Fishery of Scombroid Fishes" held under the auspices of the Marine Biological Association of India at Mandapam Camp from 12th to 15th January, 1962.

The rapid development of the fishery for pelagic fishes around the world and the tremendous expansion of the fishery for certain scombroid fishes in particular have drawn attention to the need for intensive investigations on these important fishes. With the advent of more technically developed fishing fleets, the intensity of exploitation of pelagic stocks of scombroid fishes, especially the oceanic tunas and billfishes has reached new peaks, giving rise to anxiety in certain parts of the world as to the future of these resources. In the Indian Ocean, intensive exploitation of this natural resource is not apparent. Although data are scarce, those given by the Japanese Fishery Agency based on that country's fishing efforts indicate a decline in the yield and catch-per-unit of effort for tunas and billfishes from certain areas over the past decade. Any attempt to delimit and assess the populations and stocks of these fishes available to us for exploitation should be also backed by a sound knowledge of the taxonomy of the different species, the spatial and vertical distribution both in larval and adult stages, spawning areas, migratory habits, oceanographic conditions influencing these, etc. In this region there is a considerable void as regards this as the expansion of the fishery has not seen the same quantum of expansion in scientific research on problems connected with it.

Therefore, as far back as 1959 it was felt that there was an urgent need to highlight this drawback and at the same time bring together as much of fundamental information as is available on the systematics, biology and fishery of scombroid fishes from the Indian Ocean and adjacent seas. The oceanic habits of the fishes have made it imperative that international co-operation is essential in tackling many of the problems connected with scombroid fish and fisheries. The deliberations and recommendations at the two recent conferences on the biology of tunas, the first at Dakar in December 1960, and the second at Hawaii in August 1961, further emphasised the necessity for this. Again, this want had to be stressed so that the scope of the biological programme of the envisaged International Indian Ocean Expedition would be enlarged to include more intensive studies on pelagic fishery resources.

This background information would explain the urgent need for such a Symposium on the systematics, biology and fishery of scombroid fishes. By the publication of these three volumes, the main objective of the Symposium that as much of information as possible about these fishes from the Indian Ocean area and adjacent seas be made available to workers, has to a great measure been achieved. Contributions on scombroid fish and fisheries received from specialists from various parts of the world, while drawing attention to some of the pressing needs also summarise a fund of information on the taxonomy, methodology and principles which will be very useful to future planning of research as well as the more judicious exploitation of the resources from this area.

Just as the recent Dakar and Hawaiian Meetings, this Symposium to some extent may be considered a forerunner to the forthcoming FAO World Scientific Meeting on the Biology of Tunas and Related Species scheduled to be held at La Jolla, California in July, 1962. These meetings and Symposia besides helping in the pooling and exchange of information among workers engaged in research on these fishes and their fishery, aid in a better understanding of problems of mutual interest.

The term 'scombroid fishes' may denote a vast assemblage, but in this Symposium the mackerels, seerfishes, wahoo, tunas and billfishes are considered. The various contributions were categorised under different headings and sub-headings and it was felt that it would not be possible to publish the entire proceedings in a single volume without drastic curtailments on the length of the papers which undoubtedly may affect even the interpretations given by the authors. Since this was not the idea of the Symposium, the Proceedings is published in three volumes (Parts I–III), the first dealing with 'Taxonomy, morphology and distribution'; the second with 'Population studies, composition of stocks, bionomics, behaviour, baitfish resources, and plankton and productivity'; and the third with 'Parasites, fishery and statistics, bibliography and species synopsis, research and conservation'. Needless to say, some of the contributions deal with more than one subject-matter, but they are placed under the major field dealt with.

Several people have contributed to the success of the Symposium. But for the vision, untiring efforts, and enthusiasm of Dr. S. Jones, the President of the Association, it would not have been possible to hold this Symposium. From the time that the first suggestion came from him in 1959 to organise the Symposium, to its materialisation in January 1962, and since then in the efforts made in having the Proceedings published, his has been the active guiding spirit, and we are immeasurably indebted to him for this. The encouragement and whole-hearted co-operation we received from scientists from various parts of the world, many of whom could not attend the meetings, and the contributions that they have sent have added to the importance of the Symposium. The various papers and discussions contributed in no small measure to the Recommendations approved at the Symposium which are published at the end of this introductory chapter.

All facilities for conducting the meetings and the attendant functions at the Central Marine Fisheries Research Institute were kindly given by its Director, Dr. S. Jones.

A number of Institutions and individuals from various parts of the world kindly sent specimens of scombroid fishes and other materials for exhibition during the Symposium.

The Symposium was formally declared open on the evening of 12th January by Dr. S. Jones, who along with the Resident Secretary of the Association, Dr. R. R. Prasad, welcomed the participants on behalf of the Association. The vote of thanks was proposed by Mr. P. T. Thomas.

Dr. Jones was Chairman at all the sessions, and the Convener was ably assisted by Mr. P. T. Thomas and Mr. G. Raju who acted as Reporters. Dr. T. A. Mammen and Mr. P. V. R. Nair helped with the recording of the discussions. Considerable help was received from Dr. N. Balakrishnan Nair in the arrangements made for the printing of the abstracts of the papers presented at the Symposium.

The benefit that the Symposium derived from Dr. Wilber M. Chapman, Director, Van Camp Foundation, San Diego, California, both in counsel and otherwise is immense. A generous and timely grant of $1500 made by the Van Camp Foundation, California, which is specially acknowledged elsewhere, has been mainly responsible for the publication of these volumes without much delay.

As Convener, I wish to express my appreciation and thanks to all those who have so selflessly laboured to make this Symposium a success.

E. G. SILAS
Convener.

PROGRAMME

Friday, January 12:

4–30 p.m.	... Inaugural Meeting.
5–30 p.m.	... [redacted] Tea Party by the Marakayar of Mandapam.

Saturday, January 13:

9-00 a.m. — 1-00 p.m.	... Scientific session.
2-00 p.m. — 5-00 p.m.	... Scientific session.
7-30 p.m. — 9-00 p.m.	... Film show.

Sunday, January 14:

9-00 a.m. — 1-00 p.m.	... Scientific session.
2-00 p.m. — 5-00 p.m.	... Scientific session.
5-00 p.m.	... Tea Party by Dr. S. Jones, President, Marine Biological Association of India.

Monday, January 15:

9-00 a.m. — 10-30 a.m.	... Scientific session.
11-00 a.m. — 1-30 p.m.	... Concluding session.

INAUGURAL MEETING, 12th JANUARY, 1962

Welcome Address by Dr. R. R. Prasad, Resident Secretary, Marine Biological Association of India

Mr. PRESIDENT AND FRIENDS,

As the Resident Secretary of the Marine Biological Association of India, I deem it a great pleasure and privilege to welcome you all to the first Symposium that is organised by this young Association. As you all know, the Association is only three years old and I should think that in the history of the Association this Symposium will be a landmark. Well, looking at the persons who have assembled here, I think, with the exception of Dr. Whitley, the others who have come from outside had a taste of Mandapam at least once. So I do not think that I need explain the drawbacks and difficulties we have in the matters regarding accommodation, food, etc. We have tried our best to make your stay as comfortable as possible, but I am sure you will find certain deficiencies. I earnestly request you to overlook these. Thank you all.

Inaugural Address by Dr. S. Jones, President, Marine Biological Association of India

FRIENDS,

We have all assembled here for the formal inauguration of the Symposium on scombroid fishes organised by the Marine Biological Association of India. As the Secretary has rightly indicated, this infant Association within the last three years has been able to make great strides in promoting its main objective, namely, the promotion of the cause of marine sciences in this part of the world. This Symposium, the first of its kind is really a landmark in its history. We are dealing in this Symposium with a group of fishes of vital importance to man-kind. This group embraces the coastal pelagic fishes such as mackerels and seerfishes and oceanic fishes such as tunas and billfishes.

The response we have received by way of contributions from all parts of the world and the presence of participants from outside surely indicate the importance of the subject. We will be having amongst us in addition to Mr. Whitley, Mr. Jonklass and Mr. Myrland from Australia, Ceylon and Norway, respectively, and Dr. Chapman from U. S. A. who is now on his way from Madurai to join us this evening.

The tuna fishery is becoming increasingly important to us in view of the intense fishing activities of the Japanese in the seas around India. It is an open secret that they are all over in the Indian Ocean and enormous quantities are being caught by them and exported to foreign countries. Therefore, this Symposium, I am sure, will be helpful in not only rainging together all the available information on the subject but also in giving us ideas as in how the future investigations have to be directed.

I am sure that the participants in the Symposium by the high level of their deliberations will contribute to a very great extent to the development of the scombroid fisheries in this part of the world. It is my earnest request to all to extend your full co-operation to make the Symposium a success. I have great pleasure in declaring the Symposium open.

Vote of Thanks by Mr. P. T. Thomas

MR. PRESIDENT, FRIENDS,

On behalf of the Convener it is my pleasant duty to extend a very hearty vote of thanks to the distinguished guests who are present at this inaugural function and to the members of the Association who have come over to participate in the Symposium. I also wish to specially thank Mr. Rodney Jonklaas from Ceylon, Mr. Per Myrland from Norway and Mr. G. P. Whitley from Australia, for coming over here to take part in the deliberations of the Symposium. We shortly expect the arrival of Dr. W. M. Chapman who will be present for the sessions starting from 13th morning. We are thankful to Mr. Kassim Mohamed Marakayar of Mandapam, who is present here, for his keen interest in the activities of the Association. Thank you all.

RECOMMENDATIONS APPROVED BY THE SYMPOSIUM ON SCOMBROID FISHES, HELD AT MANDAPAM CAMP FROM 12th TO 15th JANUARY 1962

IT IS RECOMMENDED THAT :

Scientists in the countries of the world primarily concerned with the high-seas fishery for tunas and billfishes devise and publish a suitable system for gathering biologically useful statistics of yield and effort in these fisheries that will be capable of being employed on a world-wide basis that can be used uniformly by Fishery Officers and scientists everywhere, and that will be capable of yielding data useful in elucidating population dynamics of the several fish populations involved.

It is considered that the devising of this statistical system might be properly initiated at the World Conference on Tunas to be convened by FAO in La Jolla, California, in July 1962.

The authorities involved with the planning of the Indian Ocean Expedition give due consideration to gathering and collecting the following sorts of information which would be useful in aiding the development of the high seas fisheries for Scombroid Fishes in the Indian Ocean :

(*a*) Surface temperature charts on a monthly basis particularly from 20° South latitude to the Continent and Island chain on the North ;

(*b*) Variation in thermocline depth with monsoon change particularly within 200 miles of land in the Andaman Sea, Bay of Bengal, Arabian Sea, Persian Gulf and Gulf of Aden ;

(*c*) Variation in direction and flow of the mixed layer currents in the Indian Ocean, particularly North of 20° South latitude, and in particular as related to variation in monsoon period and strength ;

(*d*) Variation in basic biological productivity rate in the area North of 20° South latitude, and particularly within 200 miles of shore ; and

(*e*) Relationship of variations in these parameters to variations in the season and yield of the high seas fisheries of the areas.

IT IS RECOMMENDED THAT:

The system of defining the homogeneous stocks of different tuna species, particularly by blood typing as being developed by Japanese and American workers, be extended to a thorough coverage of tunas and billfishes of the Indian Ocean.

It is suggested that the collection, care, and shipment of the required samples might be an appropriate function for the Biological Centre to be established at Cochin, in connection with the Indian Ocean Expedition.

IT IS RECOMMENDED THAT:

Appropriate international agency or agencies provide sufficient finances and facilities to permit a competent review on a world-wide basis of the systematics of the Scombroid fishes, together with the publication of the results with all species illustrated in colour.

CONCLUDING REMARKS OF THE PRESIDENT

We have come to the close of the session and can no doubt look back with satisfaction on the wide range of scientific papers read, fruitful discussions held and objective recommendations made. The scombroids constitute a group of fishes of great importance and as Dr. Chapman rightly pointed out, in none of the major water-masses, the oceanic species have hitherto been exploited to the optimum level. It is gratifying that the tunas of the world ocean, the most important among the scombroids, have begun to receive the attention of international bodies on a global basis. It is needless to say that the latent fishery resources of the high seas around us have yet to receive the attention they deserve and it is my earnest hope that this Symposium will help to change the picture and influence the scientific and economic aspects of oceanic fisheries in this part of the world. I am even inclined to doubt if any symposium on fisheries, so comprehensive and of such far-reaching importance has ever been held in the Indian region and service rendered in this regard to the cause of fishery science by the Marine Biological Association of India deserves special mention. It has to be admitted that though it was with utmost optimism that the arrangements were initiated in view of the encouraging response received from scientists all over the world, it was not smooth sailing all through and there was ground for misgivings also. The results have however more than justified the worthiness of the cause and let us hope that this Symposium will be a forerunner to others to be organised in future by the Association.

We are now faced with the colossal task of getting the proceedings published, without which all our labours will be wasted. The Association has not received any grant or subsidy so far from any quarters for conducting this Symposium. We should not allow lack of funds to deter us but should resolve to go forward with faith, courage and unity of purpose. In this I am sure that we will have the co-operation of all the members in general and particularly of those present here. I would however make a special mention in this connection that the presence here with us of Dr. Chapman, whose dynamic and indefatigable personality we are now familiar with, is most encouraging and it is our earnest hope that he would do his best to see us through the crisis. His presence with us is unique in another respect also. He is the only person here who has participated in the two regional meetings on tunas held previously, *viz.*, in Dakar in 1960 and in Honolulu in 1961, and we have seen here how this background has been helpful in the discussions. He would also probably be the only person among those present here who will be attending the World Tuna Meeting to be held in San Diego in July this year under the auspices of the FAO of the United Nations. Let us hope that he would give on behalf of the Association a firsthand appraisal there of this meeting.

Before requesting the Convener to tender the formal vote of thanks I wish to say in my official capacity that it has been a pleasure to have you all here and that we look forward to your revisit. I am grateful to the Ministry of Food and Agriculture, Government of India, for according permission to conduct the Symposium in this Institute. Finally let me record here on behalf of the Association and on my own behalf appreciation and thanks to Dr. E. G. Silas who so ably discharged his responsibilities as Convener of the Symposium. I thank you all.

VOTE OF THANKS BY Dr. E. G. SILAS, CONVENER

CHAIRMAN, FRIENDS,

We have just concluded a series of sessions dealing with some of the aspects of the systematics, biology and fishery of scombroid fishes. My sincere thanks are due to the Chairman, Dr. S. Jones, for ably conducting the sessions.

I would also like to thank those who sent papers for the Symposium and the well-wishers. In the absence of some of the contributors the papers were read by some of those present at these sessions. A number of you present here have contributed towards making the discussions lively and useful. These discussions and the contributions read here have led to the formulation of recommendations that have been unanimously approved at the Symposium. I wish to thank all those who have assisted in this endeavour.

The holding of a Symposium of this nature entails several preliminary arrangements and in this connection I wish to thank all those who have helped in the preparation and also for the arrangements made in conducting the Exhibition. It is also a pleasure to thank Janab PR. M. K. M. Mohamed Abdul Kader Marakayar and Janab PR. M. K. M. Kassim Mohamed Marakayar of Mandapam and Dr. S. Jones, President of the Marine Biological Association of India who were kind enough to be hosts at tea parties held for the participants on 12th and 14th evening respectively. Our special thanks are due to Dr. T. A. Mammen for arranging the Film Show on 13th evening.

Once again I wish to thank each and every one of you who have helped in one way or other for the success of the Symposium.

Thank you.

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A SYSTEMATIC REVIEW OF THE SCOMBROID FISHES OF INDIA

BY

S. JONES AND E. G. SILAS
Central Marine Fisheries Research Institute, Mandapam Camp

INTRODUCTION

From the standpoint of marine fishery resources there can be no doubt that scombroid fishes constitute the most important single element. Large scale exploitation of a greater part of this natural resource, especially of the truly pelagic species comprising tunas and billfishes has been in vogue for the past several decades, mainly by Japan and the United States of America. The importance of this potential wealth in the Indian Ocean has been forcefully drawn attention to by the extensive fishing operations carried out by the Japanese longline fishery fleets in the high seas of the Indian Ocean, and by exploratory offshore fishing operations carried out by some countries bordering the Indian Ocean.

Both at the symposium and conference on the biology of tunas and related fishes held recently at Dakar (Nov. 1960), and Honolulu (Aug. 1961) attention was drawn by workers to the urgent need for knowing more about the species occurring in the different geographical areas to help understand the precise distribution of the species, the occurrence of populations if any, etc. While regional reviews of scombroid fishes have been carried out in the Pacific and Northern Atlantic by several workers, the Indian Ocean has till recently remained a veritable blank. The recent regional works from this area (Munro 1943 ; Serventy 1941, 1956 ; Deraniyagala 1952 ; Fourmanoir 1957 ; Williams 1959 ; and Jones and Silas, 1960, 1961) ; a review of scombroid fishes of the world by Fraser-Brunner (1950); and the work on Pacific scombroid fishes mainly by Kishinouye (1923); Nakamura (1938, 1949); Godsil and Byers (1944); Godsil (1954) ; Royce (1957) ; Robins and de Sylva (1960), etc., have helped us in our knowledge about the species of scombroid fishes occurring in the Indian Ocean.

In this review we have covered the mackerels, tuna and related species, seerfishes, wahoo, and the billfishes occurring in Indian seas. Along with nomenclatorial discussions, meristic and morphometric data for the different species are given wherever possible. The key for the identification of the species has been made comprehensive and includes all species recognised as valid from the Indian Ocean. Since our knowledge of the precise distribution of the different species in the Indian Ocean itself is far from complete, this course has been adopted to aid future investigators in their field identification. An outline of the classification followed is also given and all the species are illustrated.

The discussion includes comparison of scombroids of the Indian Ocean and those occurring in the Pacific and Atlantic.

KEY TO THE IDENTIFICATION OF MACKERELS, TUNAS, SEERFISHES AND BILLFISHES FROM INDIAN OCEAN

1*a*. Upper jaw strongly produced into a rounded 'spear' or a powerful flat 'sword'; no finlets behind second dorsal and second (soft) anal ; pelvics when present reduced to one, two or three spines (Istiophoridae and Xiphiidae) ... 28

1*b*. Upper jaw not produced into a 'spear' or 'sword'; finlets present behind second dorsal and anal; pelvics present, with one spine and five rays (Scombridae) ... 2

2*a*. A deep groove midventrally along abdomen in which the pelvic fins can be concealed (moderately large cycloid scales covering body, about 50 along lateral line; pelvic fins black and enormous in young, normal in adult; two small lateral caudal keels developed only in very large specimens).
...*Gasterochisma melampus* Richardson

2*b*. No deep groove along abdomen ... 3

3*a*. Caudal peduncle on each side with a median keel and two smaller lateral keels ... 6

3*b*. Caudal peduncle on each side with only two small lateral keels ... 4

4*a*. Teeth present on vomer and palatines; total number of gill rakers on outer gill arch of each side less than 50; gill rakers of moderate length and not visible when mouth is opened; an osseous and moderately stiff anal spine present.
...*Scomber japonicus* Houttuyn

4*b*. Vomer and palatines edentulous; total number of gill rakers on outer gill arch of each side exceeds 50; gill rakers elongate, "feather-like" and conspicuously visible when mouth is opened; osseous anal spine absent ... 5

5*a*. Length of head distinctly greater than depth of body; latter 23% to 27% in fork length; snout pointed; dark stripes or rows of dusky spots along upper half of body; outer margin of first dorsal dusky.
...*Rastrelliger kanagurta* (Cuvier)

5*b*. Length of head distinctly shorter than depth of body; latter 28.5% to about 34% in fork length; snout short and bluntly rounded; no dark stripes or regular rows of dusky spots along upper half of body; outer margin of first dorsal black.
...*Rastrelliger brachysoma* (Bleeker)

6*a*. Two lateral lines, an upper and a lower, latter commencing from former in a line below anterior part of first dorsal and deeply decurved following lower contour of body, eventually joining upper lateral line near peduncular keel; vertebrae 31.
...*Grammatorcynus bicarinatus* (Quoy and Gaimard)

6*b*. Lateral line single, running straight, decurved or slightly undulating; vertebrae 38 to about 54 ... 7

7*a*. Teeth in jaws slender, conical, scarcely or not compressed; corselet scales well developed ... 8

7*b*. Teeth in jaws strong, compressed, subtriangular or knife-like; corselet obscure ... 22

8*a*. First and second dorsal fins widely separated by distance exceeding length of base of first dorsal 9

8*b*. First and second dorsal fins contiguous or separated by only a narrow interspace not exceeding diameter of orbit ... 10

9*a*. Corselet scales abruptly taper immediately below end of first dorsal and continue as a very narrow band having not more than four or five rows of scales in a line below origin of second dorsal ; total gill rakers about 39-42 (mean 39.8).

...*Auxis thazard* (Lacépède)

9*b*. Corselet scales gradually taper behind first dorsal and continue as a wide band with 7 to 12 rows of scales in a line below seventh dorsal finlet (counting from base of caudal) ; total gill rakers about 40–47 (mean 44.8).

...*Auxis thynnoides* Bleeker

10*a*. Distance from tip of snout to end of maxilla 50% or more of head length ; end of maxilla surpasses vertical below middle of orbit ... 11

10*b*. Distance from tip of snout to end of maxilla considerably less than 50% of head length ; end of maxilla does not surpass vertical below middle of orbit ... 13

11*a*. Vomer with villiform teeth ; dorsal and anal finlets 9 or 10/7 or 8.

...*Cybiosarda elegans* (Whitley)

11*b*. Vomer edentulous ; dorsal and anal finlets 6 to 8/5 or 6 ... 12

12*a*. Dorsal with 18 or 19 spines ; end of maxilla surpassing vertical below posterior border of orbit ; 6 to 9 horizontal dark stripes on upper half of body appear as short broken bars in juveniles.

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

12*b*. Dorsal with 12–14 spines ; end of maxilla reaching to vertical below posterior third of orbit ; no dark stripes on body.

...*Gymnosarda unicolor* (Rüppell)

13*a*. Body completely scaled ; those of corselet and lateral line usually larger ... 14

13*b*. Body naked except for corselet and lateral line (exception *Allothunnus*) ... 19

14*a*. Anterior insertion of second dorsal nearer to posterior end of caudal keel than to posterior margin of orbit ... 15

14*b*. Anterior insertion of second dorsal nearer posterior margin of orbit than to posterior end of caudal keel ... 17

15*a*. Pectoral short, not exceeding length of head excluding snout and falling short of vertical below anterior insertion of second dorsal by distance equalling almost its own length ; preoperculum distinctly rounded along posterior margin.

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

15*b*. Pectoral elongate, one to one half times length of head and surpasses vertical below anterior insertion of second dorsal ; preoperculum more or less angular at lower posterior margin. ... 16

16*a*. Gill rakers on lower limb 19–21 ; surface of liver markedly striated ; vent rounded ; distance between tip of pectoral and end of caudal keel much less than head length.

...*Thunnus* (*T.*) *alalunga* (Bonnaterre)

16*b*. Gill rakers on lower limb 16–18 ; liver marked with faint striations on margin only ; vent elliptical ; distance between tip of pectoral fin and end of caudal keel greater than head length.

...*Thunnus* (*Parathunnus*) *obesus mebachi* Kishinouye

17*a*. Total gill rakers 19–26 of which 13–19 on lower limb, (generally 15–17) ; air bladder absent; finlets with hardly any yellow being predominantly dusky.
...*Thunnus* (*Kishinoella*) *tonggol* (Bleeker)

17*b*. Total gill rakers 27-32 of which 19 to 22 on lower limb, (generally 20–22) ; air bladder present ; finlets lemon yellow with narrow dusky edging. ... 18

18*a*. Pectoral surpassing vertical below anterior insertion of second dorsal ; anal and second dorsal not elongate and shorter than pectoral.
...*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)

18*b*. Pectoral falls short of vertical below anterior insertion of second dorsal ; anal and second dorsal greatly elongate, being considerably longer than pectoral.
...*Thunnus* (*Neothunnus* ?) *itosibi* (Jordan and Evermann)

19*a*. First dorsal with 17 spines ; body outside corselet uniformly scaled ; total gill rakers 73–75 (24–25+48–51) ; sides of body devoid of any conspicuous colour pattern.
...*Allothunnus fallai* Serventy

19*b*. First dorsal with 15 spines ; body outside corselet naked ; total gill rakers not exceeding 60 ; body with conspicuous colour pattern ... 20

20*a*. Four to six conspicuous longitudinal stripes on lower half of body ; palatine edentulous ; gill rakers 15–17+33–42.
...*Katsuwonus pelamis* (Linnaeus)

20*b*. No dark stripes on lower half of body, instead a few conspicuous black spots may be present on each side of body behind corselet below pectoral base ; palatine with teeth ; gill rakers 7–12+22–30. ... 21

21*a*. Teeth present on vomer ; gill rakers 7–10+22–25.
...*Euthynnus affinis affinis* (Cantor)

21*b*. Teeth absent on vomer ; gill rakers 10–12+29–30.
...*Euthynnus alletteratus* (Rafinesque)

22*a*. First dorsal with XIII–XXII spines ; gill rakers present ; gill lamellae not reticulated ; lateral line slightly undulate or with a deep inflection behind second dorsal ... 23

22*b*. First dorsal with XXIII–XXVII spines ; gill rakers absent; gill lamellae reticulated; lateral line with a deep inflection beneath X–XV first dorsal spines.
...*Acanthocybium solandri* (Cuvier)

23*a*. First dorsal with XIX–XXII spines ; posterior margin of pectoral deeply excised forming two distinct lobes.
...*Scomberomorus niphonius* (Cuvier)

23*b*. First dorsal with XIII–XVII spines ; posterior margin of pectoral not deeply excised. ... 24

24*a*. Lateral line with a deep inflection below posterior end of D_2 to second or third dorsal finlet behind it; gill rakers 2 to 6 (generally 3 or 4) on lower limb of outer arch ; side of body of juveniles with large black blotches merging to form distinct dark vertical irregular stripes in adult.
...*Scomberomorus commerson* (Lacépède)

24*b*. Lateral line not deeply inflected along its course. ... 25

25*a*. Body marked with few broad vertical bands on its upper portion ; D_1 with XIII–XV (generally XIV) spines.

...*Scomberomorus semifasciatus* (Macleay)

25*b*. Body marked with diffuse rounded blotches, spots, or dark short longitudinal streaks or bars ; D_1 with XV–XVII (generally XVI or XVII) spines ... 26

26*a*. Distance from anterior insertion of second dorsal to caudal fork shorter than or rarely equalling second predorsal length ; sides of body with irregular rows of horizontal black streaks or broken bars ; caudal keel conspicuously broad.

...*Scomberomorus lineolatus* (Cuvier)

26*b*. Distance from anterior insertion of second dorsal to caudal fork distinctly longer than second predorsal length ; sides of body with diffuse rounded blotches or dark rounded or oval spots ; caudal keels not conspicuously broad. ... 27

27*a*. Gill rakers 4–7 (generally 6) on lower limb of outer gill arch, length of maxillary distinctly more than half head-length ; lateral line simple, devoid of any branching ; side of body with about three rows of large diffuse blotches.

...*Scomberomorus queenslandicus* Munro

27*b*. Gill rakers 7–10 (generally 8–9) on lower limb of outer gill arch ; length of maxillary hardly half length of head ; lateral line with short wavy posteriorly directed pseudo-branches (tracts of cutaneous mucous canals) ; sides of body with more than three rows of round or oval black spots.

...*Scomberomorus guttatus guttatus* (Bloch and Schneider)

28*a*. Upper jaw conspicuously elongated into a long flattened spear or 'sword'. elliptical in cross-section ; pelvic fins absent ; caudal peduncle with a single large keel on each side (Xiphiidae).

...*Xiphias gladius* (Linnaeus)

28*b*. Upper jaw elongated into rounded spear ; pelvic fins present ; caudal peduncle with a pair of a lateral keels on each side (Istiophoridae). ... 29

29*a*. First dorsal fin remarkably high and 'sail-like' with anterior rays markedly shorter than middle rays ; longest middle ray two or more times as long as greatest depth of body.

...*Istiophorus gladius* (Broussonnet)

29*b*. First dorsal fin of moderate height never exceeding in height 1.5 times greatest depth of body. ... 30

30*a*. Anterior lobe of first dorsal higher than depth of body at dorsal fin origin ; vertebrae—12 precaudal and 12 caudal ; size small, generally, much less than 160 kg. (*Tetrapturus*). ... 31

30*b*. Anterior lobe of first dorsal low, less than depth of body and more so in larger individuals ; vertebrae—11 precaudal and 12 caudal ; size large, attaining about 900 kg. (*Makaira*). ... 33

31*a*. Bill short, length from anterior margin of eye to tip equal to or hardly greater than length of mandible ; premandibular length of bill contained three times or more in preorbital distance (orbit to tip of mandible).

...*Tetrapturus angustirostris* Tanaka

31*b*. Bill long, length from anterior margin of eye to tip distinctly more than (atleast 1.5 times) length of mandible ; premandibular length of bill almost equal to or greater than preorbital distance. ... 32

32*a*. Height of middle rays of first dorsal fin less than 0.5 (about 0.25) height of anterior lobe of fin ; sides of body with vertical light stripes ; length of pectoral in young and adults greater than depth of body.

...*Tetrapturus audax* Philippi

32*b*. Height of middle rays of first dorsal fin more than 0.5 or equalling height of anterior lobe of fin ; sides of body devoid of vertical light stripes ; length of pectoral much less than or hardly equalling depth of body.

...*Tetrapturus* sp.

33*a*. Pectoral fin rigid forming a right angle with side of body and cannot be folded flat against side without breaking joint ; lateral line simple ; chambers of air-bladder arranged in several layers.

...*Makaira indica* (Cuvier)

33*b*. Pectoral fin not rigid and easily folds back against side ; lateral line complicated, forming hexagonal branchings not easily discernible in adults ; chambers of air-bladder arranged in a single layer.

...*Makaira nigricans* (Lacépède)

The scheme of classification adopted here is as follows :

Order PERCIFORMES

Suborder Scombroidei
- Family Scombridae
  - Subfamily Gasterochismatinae
    - Genus *Gasterochisma* Richardson, 1845
  - Subfamily Scombrinae
    - Genus *Scomber* Linnaeus, 1758
    - Genus *Rastrelliger* Jordan and Dickerson, 1908
    - Genus *Grammatorcynus* Gill, 1862
  - Subfamily Thunninae
    - Genus *Auxis* Cuvier, 1929
    - Genus *Cybiosarda* Whitley, 1935
    - Genus *Sarda* Cuvier, 1829
    - Genus *Gymnosarda* Gill, 1862
    - Genus *Thunnus* South, 1845
      - Subgenus *Thunnus* s. str.
      - Subgenus *Parathunnus* Kishinouye, 1923
      - Subgenus *Kishinoella* Jordan and Hubbs, 1925
      - Subgenus *Neothunnus* Kishinouye, 1923
    - Genus *Allothunnus* Serventy, 1948
    - Genus *Katsuwonus* Kishinouye, 1923
    - Genus *Euthynnus* Jordan and Gilbert, 1882
  - Subfamily Scomberomorinae
    - Genus *Scomberomorus* Lacépède, 1802
    - Genus *Acanthocybium* Gill, 1862

Family Istiophoridae
Genus *Istiophorus* Lacépède, 1802
Genus *Tetrapturus* Rafinesque, 1810
Genus *Makaira* Lacépède, 1802
Family Xiphiidae
Genus *Xiphias* Linnaeus, 1758

ORDER PERCIFORMES

Suborder *SCOMBROIDEI*

Family Scombridae

Subfamily Gasterochismatinae

Genus **Gasterochisma** Richardson, 1845

Gasterochisma Richardson, 1845. *Ann. Mag. Nat. Hist.*, (Genotype : *Gasterochisma melampus* Richardson).

Lepidothynnus Günther, 1889. *Challenger Rep.*, 31 : 15 (Genotype : *Lepidothynnus huttoni* Günther).

Chenogaster Lahille, 1903. *Ann. Mus. Nac. Buenos Aires*, Ser. 3, 2 : 376 (Genotype : *Chenogaster holmbergi* Lahille).

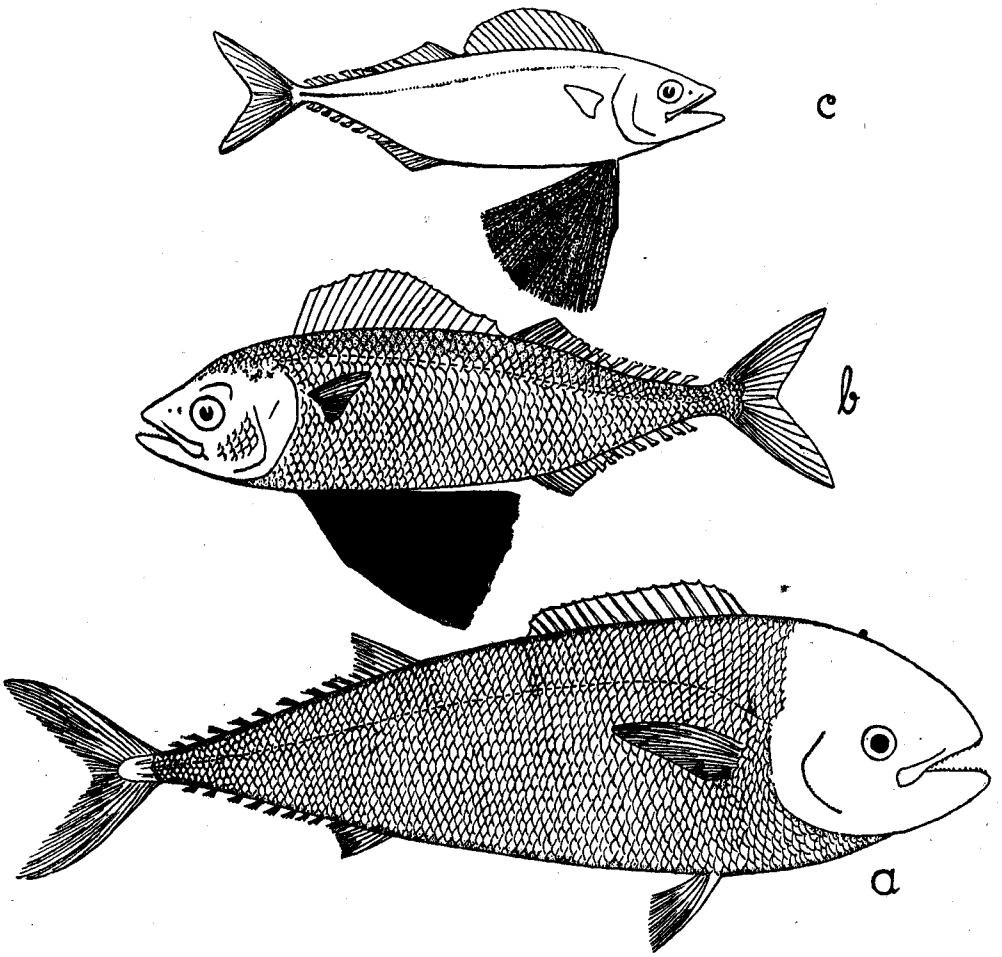
Body oblong to moderately elongate and compressed from side to side ; head with dorsal profile arched, compressed above into a ridge ; eyes lateral, rather small ; mouth horizontal, wide, cleft not extending behind level of eye ; maxilla not covered by preorbital ; in young, jaws with slender conical teeth in single row ; patches of strong teeth on palatines, vomer and tongue ; opercles not serrated ; dorsal fins contiguous in young, but distinctly separated in adults ; first dorsal with 17 to 19 flexible spines ; six to eight finlets present behind second dorsal and anal ; a deep intermuscular groove along abdomen in which pelvic fins can be completely concealed ; in young pelvic fins conspicuously large while in adults they are reduced and normal as in other scombroids ; interpelvic process separate, but minute ; anal low, shorter than second dorsal ; caudal keels wanting in young, but a pair of lateral caudal keels present on each side in adults ; caudal fin bilobed, lobes widely crescentic ; moderately large cycloid scales covering whole body, cheeks, and postorbital part of head ; lateral line well defined ; air bladder present ; gill arches with numerous small teeth ; pyloric caecae numerous and branched ; vertebrae 45.

DISTRIBUTION : Same as for species.

REMARKS : The genus is monotypic, and is thus far known only from the southern seas.

BUTTERFLY MACKEREL

Gasterochisma melampus Richardson, 1845



Text Fig. 1. *Gasterochisma melampus* Richardson. (*a*). Adult (after Günther 1889 given as *Lepidothynnus huttonii*) ; (*b* and *c*) Juveniles (after Fraser-Brunner, 1950 ; and Munro, 1958 respectively).

SYNONYMS :

Gasterochisma melampus Richardson, 1845 : 346 (Type locality : Port Nicholson, New Zealand) ; 1846. 60, pl. xxxvii, figs. 1–3
Stead, 1907 : 21, pl. 6
Waite, 1913 : 220, pl. 8
Barnard, 1927 : 804, pl. 30, fig. 3
McCulloch, 1934 : 78
Norman, 1937 *in* Norman and Fraser : *Giant Fishes, Whales and Dolphins*, 156
Smith, 1949 : 302, fig. 844
Fraser-Brunner, 1950 : 141, fig. 3, a and b
Graham, 1953 : 301–303, fig.
Whitley, 1956 : 56–71 (1955–56), fig.

Anon. 1958. *Fisheries Newsletter*, 17 (6) : 5 (Photo of juvenile from Victoria, Australia)

Munro, 1958 : 110, fig. 740 (2 figs.)

Lepidothynnus huttoni Günther, 1889 : 15, pl. vi, figs. A, A1 (type locality : New Zealand)

Chenogaster holmbergi Lahille, 1903 : 376 ; 1905, 461 (Argentina)

Chenogaster boulengeri Lahille, 1913 : 7, fig. 2, pl. 3 and 4 (Argentina)

Available information about this species is limited mainly to stray records of its occurrence in widely separated localities. Some idea as to the general variability and changes during growth may be had from the data given in the accompanying table (I), and figure 1.

TABLE I

Characters	Authors						
	Richardson* (1845)	Stead* (1907)	Günther (1889)	Barnard (1927)	Smith (1949)	Fraser-Brunner (1950)	Munro (1958)
Depth of body in length	...	...	ab. 3.5	3.5–3.75	3.5	...	3.9–4.1
Head in length	...	...	3.5	4.0	...	...	4.0–4.1
Eye in head	...	...	16.5	6.25–7.0	...	...	5.5–7.4
Eye in snout	...	...	...	2.5–3	...	...	...
Pectoral in head	...	...	1.5	1.3	ab. 2.0	...	...
Pelvic in length	2.5	2.8	8.75 (fig.)	6.0	...	3.0 8.25 (fig.)	3.0–9.3 (fig.)
Lateral line scales	...	...	78–80	80	...	50	64–70
L. tr.	...	...	6/13 (below D_2)	8–9/15–16	...	...	7/19
D_1	...	...	XVII	XVII	XVII	XVI–XIX (fig.)	XVII–XVIII
D_2 + finlets	...	...	2,7+7	10–11+6–7	10–11+6–7	–+8	1,9–10+6–8
A + finlets	...	...	2,9+7	II, 10+6–7	II, 10+6–7	–+8	I–II,9–10+6–8
Gill-rakers	...	...	?	?	?	7+18	Absent
Length	...	...	65.5 inches	43 inches	...	...	...

* Not seen in original.

The markedly large black pelvic fins so characteristic of young up to about 16 inches (40.7 cm.) (Barnard, 1927) becomes reduced to normal size as in other scombroids in adults, although Graham (1953) opines that this need not be the case. The first dorsal which is high and contiguous with the second in the young gets distinctly separated from it and in adults appears low. The scales are moderately large and in a specimen about 167 cm. long it is about 4.0 cm. broad. Most authors have given the lateral line count as between 64 and 80. Fraser-Brunner (1950) mentions 50 which is also depicted in the figure of the young fish illustrated by him, the count being low for the species. It is not known whether an increase in the number of scales is associated with growth.

Fraser-Brunner (1950) has also shown XIX spines in the first dorsal in the young fish illustrated, but XVII and XVIII appears to be the normal count. Most authors have

overlooked the gill-rakers, but Fraser-Brunner (1950) has given the count as 7+18, while Munro (1958) mentions that they are 'absent'. The caudal keels, a pair on each side are present in the adults.

The species is said to attain about two metres in length. Graham (1953) mentions of a fish 1.3 metres long weighing 56.6 kg. and a 1.67 metres long specimen weighing 90.7 kg.

The colour of *G. melampus* is given as : "……the head is steel-blue ; the upper surface above the lateral line is blackish, silvery below the belly. The pectoral fins are silvery, the ventrals black in some examples and in others almost transparent. The tail may be black or brown and sometimes tipped with white and here again the tail varies considerably and may be hyaline, *i.e.*, resembling glass" (Graham, 1953). Further he mentions that "Hutton……records one Butterfly-fish with six to eight vertical blackish bands. I have not seen a specimen with this ornamentation but one I saw did have a faintly marked blackish band past way along the body and below the lateral line".

G. melampus is considered an excellent sport fish. According to Graham (1953) it rarely takes dead bait or is hooked in deep water apparently preferring to chase fast-moving live fish or bait. In a 1.67 metre, 90.7 kg. specimen he has seen several smoothhound dogfish in its stomach, the largest weighing 3.6 kg. Further, red cod, barracouta, octopus and squid have also been observed as stomach contents. One fish weighing 13.6 kg. had its stomach crammed to capacity with surface forms of whalefeed (*Munida gregaria*) (Crustacea).

Little is known about the habits of this species. Along New Zealand coast occasional strandings of larger specimens are not uncommon.

DISTRIBUTION : New Zealand ; Australia (Queensland, New South Wales, Victoria and Tasmania) ; South Africa (Table Bay), and Argentina.

REMARKS : On account of its disjunct, though vide distribution in the southern oceans, and its occurrence in the southern colder waters of the Indian Ocean, (from where it has been recorded from the Australian and South African Waters) the species qualifies for inclusion in this account.

SUBFAMILY SCOMBRINAE

Genus **Scomber** Linnaeus, 1758

Scomber Linnaeus, 1758. *Syst. Nat.* Ed. 10: 297 (Type: *Scomber scombrus* Linnaeus. Designated by Gill, 1861: 125.)

Pelamys Klein, 1775. *Neuer Schauplatz der Natur*, 1: 176 (Type: *Scomber scombrus* Linnaeus : Designated by Jordan and Evermann, 1917: 37) (inadmissible)

Cordylus Gray, 1854. *Cat. Fish. Gronow.*, 163 (Type : *Cordylus scombrus* Gray) (*nec Cordylus* Gronow, in Reptiles).

Pneumatophorus Jordan and Gilbert, 1882. *Proc. U. S. Nat. Mus.*, 93 (Type: *Scomber pneumatophorus* De la Roche.)

Body elongate, fusiform, covered with very small thin scales ; similar scales on cheeks also, but corselet absent ; adipose eyelids well developed ; mouth wide, teeth small, slender uniserial in jaws ; similar teeth on vomer and palatines ; broad preorbital overlapping maxillary ; fleshy lobe on each side of lower jaw near junction with maxillary ; gill rakers

moderately long and slender, not visible when mouth is opened ; first dorsal with IX-XIV spines separated from rayed second dorsal by distance equal to about length of its base ; 5 or 6 detached finlets behind second dorsal and anal ; anal similar to second dorsal except first ray modified as short spine ; pectorals and pelvics small, former high or on level with eye ; caudal peduncle slender, median keel absent while two small lateral keels present on each side ; caudal forked.

DISTRIBUTION : Tropical and temperate seas.

REMARKS : For a long time the genus *Scomber* was also used to include species at present referable to *Rastrelliger* Jordan and starks (1908). However, both genera can be easily distinguished by the undermentioned key diagnosis given by Fraser-Brunner (1950) :

(i) " Teeth on vomer and palatines. Gill rakers long and slender less than 35 on lower limb of first branchial arch. Body robust, fusiform, the depth less than length of head.

...*Scomber.*

(ii) Vomer and palatines edentulous. Gill rakers long, feather-shaped, more than 35 on lower limb of first branchial arch. Body compressed, the depth about equal to the length of head."

...*Rastrelliger.*"

The genus *Scomber* thus separated would constitute a more or less natural grouping with the generic characters already given. However, some authors have recognised *Pneumatophorus* Jordan and Gilbert as a separate genus (Starks, 1921 ; Jordan and Hubbs, 1925 ; several Japanese workers) although it was originally described as a subgenus of *Scomber*, which some workers, (*e.g.*, Fowler, 1936) have adopted. The only important difference attributed between *Scomber* and *Pneumatophorus* is the absence or presence of the air-bladder respectively (Starks, 1922). All other characters show considerable overlap (*e.g. Scomber* thus restricted will have 11 or 12 dorsal spines while *Pneumatophorus :* 9–12). The importance of the presence or absence of air-bladder for causing generic distinction may be questioned on the basis of work carried out on other scombroid groups. For instance, in the genus *Scomberomorus* it is known (Munro, 1943) that the presence or absence of air-bladder may be useful in discriminating at the species level and even geographical races of species may or may not have the air-bladder ! Another instance may be cited among tunas, where but for the absence of air-bladder, *Kishinoella* Jordan and Hubbs shows no notable difference from *Thunnus* worthy of separate generic status.

Hence we are in agreement with Fraser-Brunner (1950) ; de Beaufort (1951) ; and other workers in considering *Pneumatophorus* a synonymy of *Scomber*.

Jordan and Hubbs (1925) while recognising seven species of *Pneumatophorus* remark that " A more extended comparison of these mackerel from various parts of the world has been needed. We have.....examined all the specimens at our disposal. These material seems to comprise seven species, of which two are represented in Japan, and so far as we know confined to the waters of that country. They are *P. tapeinocephalus* and *P. japonicus*. Besides these we have specimens from Australia, Hawaii, and Socorro Island, off the Coast of Mexico which seem to belong to a Polynesian species, which may be provisionally known by the old name *australasicus* of Cuvier and Valenciennes. The other species are nearer

japonicus. Each of them occupies a special faunal area : *P. colias* European ; *P. grex* Western Atlantic ; *P. peruvanus* sp. nov., Peru ; *P. diego* California."

The elaborate characters they have tabulated for separating the species draw attention to only the very close resemblance between the samples they had examined from the different faunal areas, although good series of specimens appear to have not been available to them for examination in all cases.

De Beaufort (1951) recognised two species under *Scomber*, *S. australasicus* and *S. janeseba* Bleeker. The material of the former species studied by him appeared to differ from the description of the so-called *australasicus* in the palate being practically without teeth and the anal spine being very feeble. The second species *S. janesaba* is considered by some authors to be the young of *S. japonicus*, but the latter has only IX dorsal spines, while the former is said to have X-XI. But, doubt as to whether this difference holds good has been raised by de Beaufort (1951) who remarks that ".....Steindachner and Doderlein (*Denkschr. Akad. Wien.* XLIX, 1884, p. 177) speaking of *S. colias* from Japan which is possibly identical with *janesaba*, say that the last dorsal spines sometimes disappear in older specimens without leaving a trace. If this is true, it adds to our difficulties in distinguishing between species of *Scomber*." The disappearance of the last one or two spines of the first dorsal in large adults cannot be ruled out as such a tendency is seen in certain other scombroids (*e.g. Scomberomorus* spp.) wherein the last one or two spines are stumpy and almost completely covered by the skin and hence liable to be overlooked. Besides, Abe and Takashima (1958) indicate that in the range of IX or X, the latter is the most frequent count met for the typical *Pneumatophorus japonicus japonicus* (=*S. j. japonicus*). However, their data are not tabulated size-wise and hence it is difficult to say whether the lesser count of IX is more characteristic of large adults. In the light of these, we fully support de Beaufort's (1951) following statement that " we are greatly in need of a revision of the Indo-Pacific species of *Scomber* and for that the whole genus too, but this can only be done at the hand of a very large material and on statistical basis."

Atleast one species of *Scomber* occurs in the Indian seas, although the specific identity of the species is not well established. Further, we are not quite sure whether the several species (of *Pneumatophorus*) described from various faunal regions represent only distinct populations or sub-populations of a single species. The position appears to be the same as in the case of the bluefin tuna (p. 35) discussed later on in this work. As such we feel that the course to follow at present in *Scomber* taxonomy would be to recognise only two species—*Scomber scombrus* Linnaeus and *S. japonicus* as was done by Fraser-Brunner (1950). The primary distinction between the two being the absence or presence of air-bladder, this character needs special checking for the Indo-Pacific forms at present lumped under *S. japonicus*, as *S. scomber* is at present recognised only from the Atlantic and the Mediterranean. If any of the Indo-Pacific forms lumped under *S. japonicus* lacks air-bladder the following are suggestive:

(1) Granting that the character is a dependable one, *S. scomber* has a wider distribution and quite likely some of the nominal species placed in the synonymy of *S. japonicus* may need reassigning under *S. scomber*, or may even have to be recognised as different species.

(2) Alternative would be that the presence or absence of air-bladder need not be of specific importance and as in the case of another scombroid, *Scomberomorus commerson* it may or may not occur in different geographical races of the same species. If so, the

other characters separating *S. scomber* from *S. japonicus* will need reappraisal. Fraser-Brunner's (1950) key to the species runs as follows:

"(i) Scales of shoulder enlarged as a more or less distinct corselet. Air-bladder present. Dorsal spines 9 or 10. Head larger, contained 3 to 3½ times in length of fish.

...japonicus

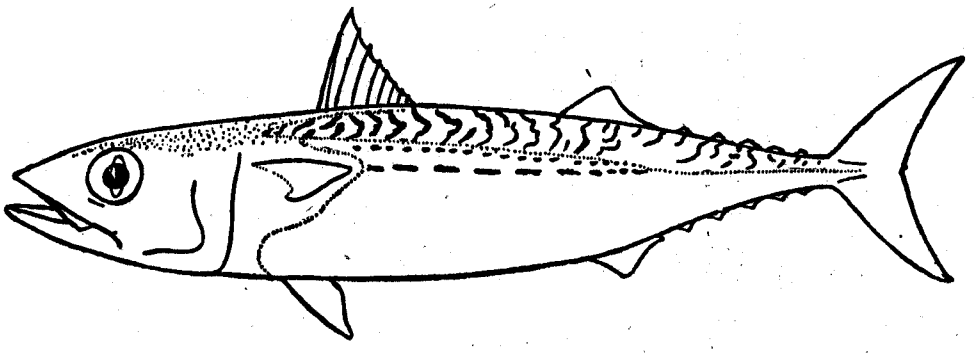
(ii) No corselet. No air-bladder. Dorsal spines 10 to 13. Head smaller, contained 3½ to 4½ times in length of fish.

...scombrus."

We are not in a position to comment on the nature of the corselet scales which may be a valid distinction between the two species. However, Fraser-Brunner (1950) was definitely wrong in giving the dorsal spines for *S. japonicus* as 9 or 10 while considering *P. tapeinocephalus* and *P. australasicus* (both with 11 or 12 dorsal spines) (Jordan and Hubbs, 1925) or the latter with 10–12 spines (Munro, 1958b) as junior synonyms. In fact Abe and Takashima (1958) show that the dorsal spines in *P. japonicus tapeinocephalus* is variable from 10–14! (most frequent count — 12). The ratio of length of the head in body length may also vary, for, in *S. australasicus*, Munro (1958b) gives it as 4–4·25 while for *S. japonicus* of which the former is considered a synonymy, Fraser-Brunner gives the ratio as 3–3·5. All these again point to the chaos and the need for a thorough reappraisal.

CHUB MACKEREL

Scomber japonicus Houttuyn, 1782



Text Fig. 2. *Scomber japonicus* Houttuyn (after Fraser-Brunner, 1950).

The following synonyms are listed by Fraser-Brunner (1950) under this species:

Scomber auratus Houttuyn, 1782 (not '1780' as given by Fraser-Brunner)
Scomber colias Gmelin, 1788
Scomber lacertus Walbaum, 1792
Scomber pneumatophorus De la Roche, 1809
Scomber macrophthalmus Rafinesque, 1810
Scomber grex Mitchell, 1815
Scomber capensis Cuvier and Valenciennes, 1831
Scomber australasicus Cuvier and Valenciennes, 1831
Scomber maculatus Couch, 1832

Scomber pneumatophorus major Temminck and Schlegel, 1842 (should be '1844')
Scomber pneumatophorus minor Temminck and Schlegel, 1842 (should be '1844')
Scomber saba Bleeker, 1854
Scomber janesaba Bleeker, 1854 (Species spelt as *janeseba* by de Beaufort, 1951)
Scomber diego Ayres, 1856
Scomber dekayi Storer, 1867
Pneumatophorus peruanus Jordan and Hubbs, 1925
Scomber gigas Fowler, 1935

The undermentioned scientific names given by Rosa (1950), and de Beaufort (1951) also are synonyms of *Scomber japonicus* as provisionally considered here.

They are :

(1) Under *Scomber colias* Gmelin-(Rosa, 1950)
Pneumatophorus colias de Buen, 1926
Pneumatophorus grex Jordan, Evermann, and Clark, 1930
Scomber gracilis Swainson, 1839
Scomber (Pneumatophorus) colias de Buen, 1930
Scomber undulatus Swainson, 1839

(2) Under *Scomber japonicus* Houttuyn-(Rosa, 1950)
Pneumatophorus japonicus Jordan and Jordan, 1922
Pneumatophorus tapeinocephalus Soldotov and Lindberg, 1930
Scomber delphinalis Richardson, 1846
Scomber uam Thiolliere, 1857

(3) Under *Scomber australasicus* Cuvier and Valenciennes-(Rosa, 1950)
Pneumatophorus australasicies Phillipps, 1927
Pneumatophorus australasicus Jordan, Evermann, and Clark, 1930
Scomber antarcticus Castelnau, 1872

(4) Under *Pneumatophorus diego* (Ayres)-(Rosa, 1950)
Pneumatophorus japonicus diego LaMonte, 1945

(5) Under *Scomber australasicus* Cuvier and Valenciennes-(de Beaufort, 1951)
Scomber australiensis Peters, 1876 (apparently an error in spelling)

Day 1888 (p. 790) and 1889 (p. 205) records *Scomber janesaba* Bleeker from Indian waters and gives the meristic counts as : "D. 9–10/1/11 + v–vi. A. 1/10–11 + v–vi. L. I. ca. 180." Vomer and palatine are said to have well developed teeth. *S. janesaba* is also recorded from the Red Sea by Klunzinger (1871 : 442 ; 1884 : 110), and de Beaufort (1951) from Java. The general distribution of *S. janesaba* is given by the latter author as ; " Red Sea, Persian Gulf, Coasts of India, China, Japan, Riu Kiu islands, Australia (Honson's Bay) ?, Hawaii ?" We have tentatively placed *S. janesaba* in the synonymy of *S. japonicus*. Other important references to *S. japonicus* from the Indian Ocean are : Barnard, 1927: 794 (*as S. colias*) ; Smith, 1949 : 300 (as *S. japonicus*), Fraser-Brunner, 1950 : (as *S. japonicus*) Rosa, 1950 : 87 – 92 (as *S. japonicus*, and *S. australasicus*) ; and Munro, 1958b : 19 (as *S. australasicus*).

It may be mentioned here that Rivas (1951) while recognising *Scomber colias* from North Western Atlantic, considered *S. lacertus, S. pneumatophorus, S. macrophthalmus, S. grex, S. maculatus, S. undulatus* and *S. dekay* as its synonyms.

Genus **Rastrelliger** Jordan and Starks in Jordan and Dickerson, 1908

Rastrelliger Jordan and Starks in Jordan and Dickerson, 1908. *Proc. U.S. Nat. Mus.*, 34 : 607 (Type : *Scomber brachysoma* Bleeker)

Body compressed from side to side ; body and cheek covered with small scales, eyes with well developed adipose eyelid, mouth large, maxillary reaching nearly vertical below posterior edge of eye ; teeth small, present in jaws ; vomer and palatines edentulous ; gill rakers long, numerous and feather-like and visible when mouth is opened. Spinous first dorsal and soft rayed second dorsal separated by distance equalling length of base of former ; anal devoid of spines ; five or six dorsal and anal finlets ; pectorals short with broad base ; pelvics with a spine and 5 rays ; caudal deeply forked.

Jordan and Hubbs (1925) place the genus *Rastrelliger* under a separate subfamily Rastrelligerinae as opposed to subfamily Scombrinae under which they include only *Scomber*, and *Pneumatophorus*.

DISTRIBUTION : Indo-Pacific (not recorded from Western Coast of North and South America or Eastern Pacific).

REMARKS : We recognise two species of *Rastrelliger*, *R. kanagurta* (Cuvier) and *R. brachysoma* (Bleeker) from Indian seas. A detailed study of these species is presented in a separate contribution by us at this Symposium (Jones and Silas, 1962*a*) to which reference is invited.

INDIAN MACKEREL

Rastrelliger kanagurta (Cuvier) 1817

(Plate I, Fig. A)

The following are considered synonyms of this species :

Scomber canagurta Cuvier, 1829
Scomber loo Lesson, 1830
Scomber moluccensis Bleeker, 1856
Scomber reani Day, 1870
Scomber microlepidotus Day, 1876
Scomber chrysozonus Peters, 1877

Detailed references, synonymy, morphometric and meristic characters, etc., are given by Jones and Silas (1962*a*). For an annotated bibliography on this species reference may be made to Jones and Rosa (1962).

DISTRIBUTION: Indian Ocean, Western and Central Pacific (eastwards upto Hawaii).

SHORT-BODIED MACKEREL

Rastrelliger brachysoma (Bleeker), 1851

(Plate I, Fig. B)

SYNONYMS :

Scomber neglectus van Kampen, 1907

For detailed synonymy, morphometric and meristic characters, and other details, reference may be made to Jones and Silas (1962*a*).

DISTRIBUTION: Andaman Sea, Indonesia, Philippines, and eastwards to Fiji.

Genus **Grammatorcynus** Gill, 1862

Grammatorcynus Gill, 1862. *Proc. Acad. Nat. Sci. Philad.*, 1862:125 (Type: *Thunnus bilineatus* Rüppell =*Thynnus bicarinatus* Quoy and Gaimard).

Nesogrammus Evermann and Seale, 1907. *Bull. Bur. Fish.*, 24 (1906), 1907:61 (Type: *Nesogrammus piersoni* Evermann and Seale)

Monotypic. The double lateral line on each side of the body is the most diagnostic character of this species which on the basis of osteological studies (Kishinouye, 1923) has been shown to be more related to the true Scombrinae than to Gasterochismatinae, Thunninae, and Scomberomorinae.

DISTRIBUTION: Indo-Pacific (not recorded from West Coast of North and South America-Eastern Pacific.)

DOUBLE-LINED MACKEREL

Grammatorcynus bicarinatus (Quoy and Gaimard)

(Plate IV, Fig. C)

SYNONYMS:

Thynnus bicarinatus Quoy and Gaimard, 1824 : 357 (Type locality : Sharks Bay, Western Australia)

Thynnus bilineatus Rüppell, 1835:39 (Type locality: Red Sea)

Grammatorcynus bilineatus Gill, 1862:125
Kishinouye, 1915 ; 1923
Hardenberg, 1935:137

Nesogrammus piersoni Evermann and Seale, 1907 : 61 (Type locality: Bulan, Sorsogen Province, Luzon, Philippines)

Grammatorcynus bicarinatus McCullouch, 1914 : 266 ; 1922 : 106; Silas, 1962e (See for synonymy)

Grammatorcynus bicarinatus (in part) Fraser-Brunner, 1950 : 156 ; de Beaufort, 1951 : 215

Nesogrammus thompsoni Fowler, considered by some a synonym of *G. bicarinatus* is in fact a gempylid, being a junior synonymy of *Lepidocybium flavobrunneum* (Smith) as shown by Munro (1949).

The species synopsis for the double-lined mackerel prepared by Silas (1962e) besides giving firsthand data about it based on material from the Andaman Sea, summarises existing information about the species.

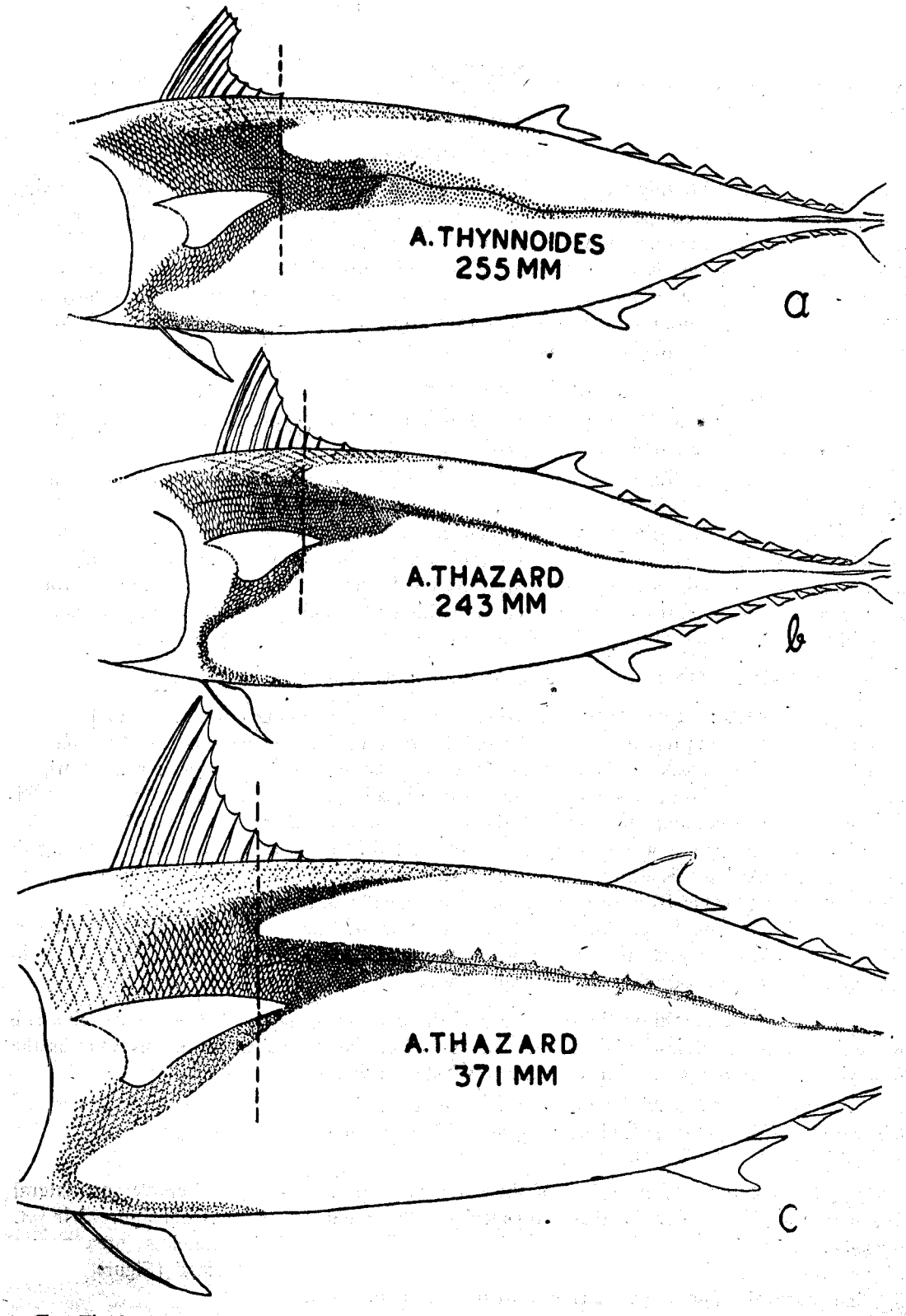
The finray and gill raker counts for specimens from the Andaman Sea are:

D_1. XI – XII; D_2. i – ii, 9 – 10 + 6 – 7; P_1. 23 – 35;
A. i – ii, 10 – 11 + 6 – 7; gill rakers 2 – 4 + 1 + 15 – 16.

The known range for the species is given by Silas (1962e) as :

D_1. XI – XII; D_2. i – iii, 6 – 11 + 6 – 7;
P_1. i – iii, 21 – 24; P_2. I, 5; A. i – iii, 8 – 11 + 6 – 7;
Gill rakers 19 – 21 (2 – 4 + 1 + 15 – 16). Vertebrae 31 (13 + 18).

References to the species from the Indian Ocean and contiguous seas besides those given under synonymy are: Günther (1860), Roux-Estevi and Fourmanoir (1955); Munro (1958b), Jones, Silas and Dawson (1960) Jones and Silas (1960, 1962b), Silas (1962e).



Text Fig. 3. Forward extent of the scaleless portions above lateral line in relation to pectoral fin in specimens of *Auxis thazard* and *Auxis thynnoides*.

DISTRIBUTION: In Indian Ocean and contiguous waters: Red Sea, Andaman Sea, West Coast of Java, and West Coast of Australia. In Pacific Ocean; East Coast of Australia, New Guinea, Marshall Islands, Sulu Sea, Philippines and Riu Kiu Islands, Japan.

SUBFAMILY *THUNNINAE*

Under this Subfamily we (Jones and Silas, 1960) recognised twelve genera comprising tunas and closely related species. Of these twelve genera, *Orcynopsis* Gill is the sole genus not represented in the Indian Ocean. Three of the genera then recognised, *Parathunnus* Kishinouye, *Neothunnus* Kishinouye and *Kishinoella* Jordan and Hubbs are relegated in this work as subgenera of *Thunnus* South. The remaining genera of the subfamily are: *Auxis* Cuvier, *Cybiosarda* Whitley, *Gymnosarda* Gill, *Sarda* Cuvier, *Allothunnus* Serventy, *Euthynnus* Lutken and *Katsuwonus* Kishinouye.

Genus **Auxis** Cuvier, 1829

Auxis Cuvier, 1829. *Regne Anim.* 2nd Ed., 2:199 (Type: *Scomber rochei* Risso, 1810 Type designated by Gill, 1861:125).

Body elongate, fusiform and robust; caudal portion remarkably short; snout short and hardly compressed; mouth small, jaws equal; teeth minute, mostly uniserial on jaws; palatine edentulous gill rakers long, slender numerous; scales forming well developed corselet; body outside corselet naked; first and second dorsals separated by a wide gap; second dorsal and anal markedly short and followed by six to nine finlets; caudal, pectorals, and pelvics small; lateral line slightly curved with small undulations; tongue flat, smooth and silvery, air-bladder absent. Vertebrae 39.

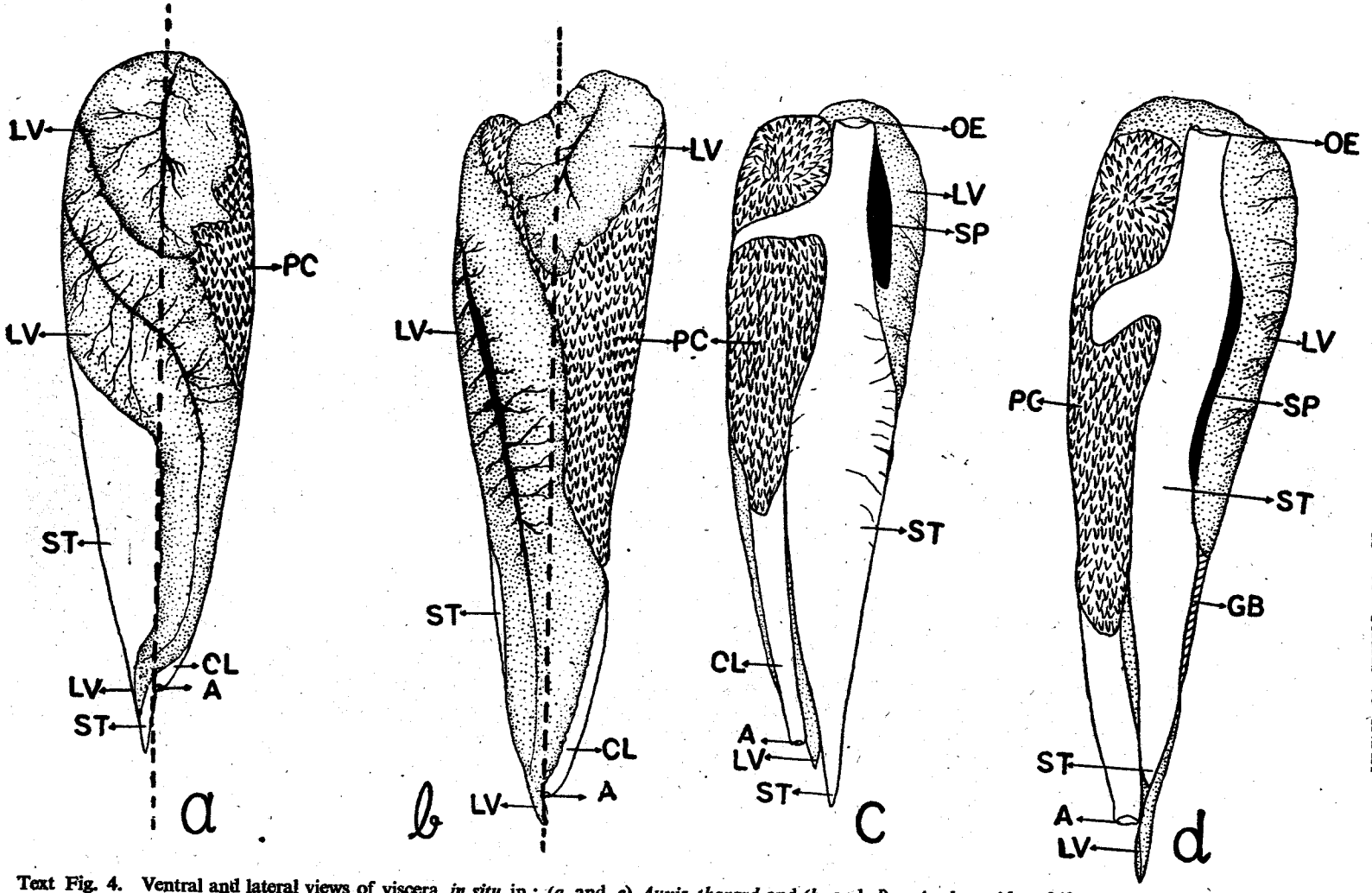
DISTRIBUTION: Indo-Pacific, Atlantic, and Mediterranean.

REMARKS: Two forms of frigate mackerels, a short corseletted and a long corseletted one are at present recognised from the Indo-Pacific and denoted as *Auxis thazard* (Lacépède) and *A. thynnoides* Bleeker respectively. The Atlantic and Mediterranean frigate mackerel appears to be the short corseletted form for which the name *A. thazard* has been used, although detailed comparison between the typical *A. thazard* from the Sunda Sea (from near New Guinea from where the species was first described) and those from the mediterranean and Atlantic is wanting. It is also surprising that while the two forms mentioned above are recognisable from throughout the Indo-Pacific distributional range of the genus, only one type should be known from the Atlantic and Mediterranean. However, Matsumoto (1959) suggests the likelihood of the occurrence of the long corseletted form in the Atlantic as well, but this needs confirmation.

Intermediate conditions in the nature of the corselet in the two species may give rise to some doubts in species identification. In that case, the gill raker counts as well as the following characters not mentioned in the 'key' should facilitate identification:

(1) For *A. thazard* the gill rakers number 9–10 and 29–32 in the upper and lower limbs of the outer arch giving a total of 39–42 while in *A. thynnoides* they are 8–12+ 31 – 36, and 40 – 47 respectively.

(2) The forward extension of the scaleless portion of the body above the lateral line was found to differ in the two species. As could be seen from figure 3 in *A. thynnoides* a vertical line drawn through the anterior end of the scaleless area passes downwards not touching the tip of the pectoral fin, while in *A. thazard* (Figure 3 b, c.) the line passes through the posterior third or fourth of the fin.



Text Fig. 4. Ventral and lateral views of viscera *in situ* in : (*a*, and *c*) *Auxis thazard* and (*b*, and *d*) *A. thynnoides*., 243 mm. and 255 mm. in length respectively (A = Anal opening; CL.=Colon ; GB = Gall bladder; LV = Liver ; OE = Oesophageal end ; PC = Caecal mass ; SP = Spleen and ST = Stomach).

(3) The viscera *in situ* in specimens of about the same length in both the species shows differences in the disposition of the organs (Figure 4). In *A. thazard* (Figure 4 a & c.) when viewed from ventrally, the right lobe of the liver takes a complete loop crossing over the mid-ventral longitudinal axis while in *A. thynnoides* the right lobe does not show such a curve and even the hepatic vein does not fall in line with the mid-ventral longitudinal axis. In the former, the stomach (whether containing food or empty) extends to slightly behind the level of the anal opening as the right lobe of the liver, while in *A. thynnoides* the stomach is shorter, the distal end hardly reaching the vent, though the right lobe of the liver may slightly extend backwards, but apparently not surpassing a line above origin of anal fin. The caecal mass in *A. thynnoides* is more developed and occupies a greater space than in *A. thazard* in which species the spleen unlike in the former is smaller. The left lobe of the liver in *A. thazard* is relatively longer than in *A. thynnoides*. In a lateral view, part of the gall-bladder can be seen in the latter species (Figure 4 d) while it is not so in *A. thazard*.

(4) In general body form, *A. thynnoides* is more rounded and robust while in *A. thazard* the body is more compressed from side to side (Figure 5). Six cross-sections (A–F) taken at almost identical locations of the body in a specimen each of *A. thazard* (243 mm.) and *A. thynnoides* (255 mm.) illustrate further differences between the two species. The shape of the visceral cavity is totaly different in the two species. Besides, in *A. thazard* (Figure 5-bottom) it appears to be slightly asymmetrical consequent probably to the looping of the liver ventrally, and accommodation in the form of narrow cavities for the liver and stomach above the origin of the anal fin is seen. There appear to be slight differences in the disposition of the coloured portion of the muscles in both the species. However, as the specimens are formalin preserved over a period of time, much of the latter details are not discernible. Sections through the origin of the second dorsal (fig. 5 d) in both the species show that in *A. thynnoides* the number of myotomes cut are slightly more than for *A. thazard*.

Godsil (1954) has drawn attention to certain other anatomical differences between the long corseletted and short corseletted forms. Godsil (1954) and Matsumoto (1959) comment that the gill raker counts for *A. thazard* from the Eastern Pacific are higher than are for specimens from the Central and Western Pacific, very closely approximating to the condition seen in *A. thynnoides*. This would need further investigation as Wade (1949) described two specimens from the Pacific coast of Central America (Schaefer and Marr, 1948 collection) showing higher gill raker counts as *A. thynnoides*.

The close similarity between the two species may be responsible for several discrepancies in species identity in earlier literature and there is a great need for a more detailed comparison between these two species as well as in the same species on a global basis.

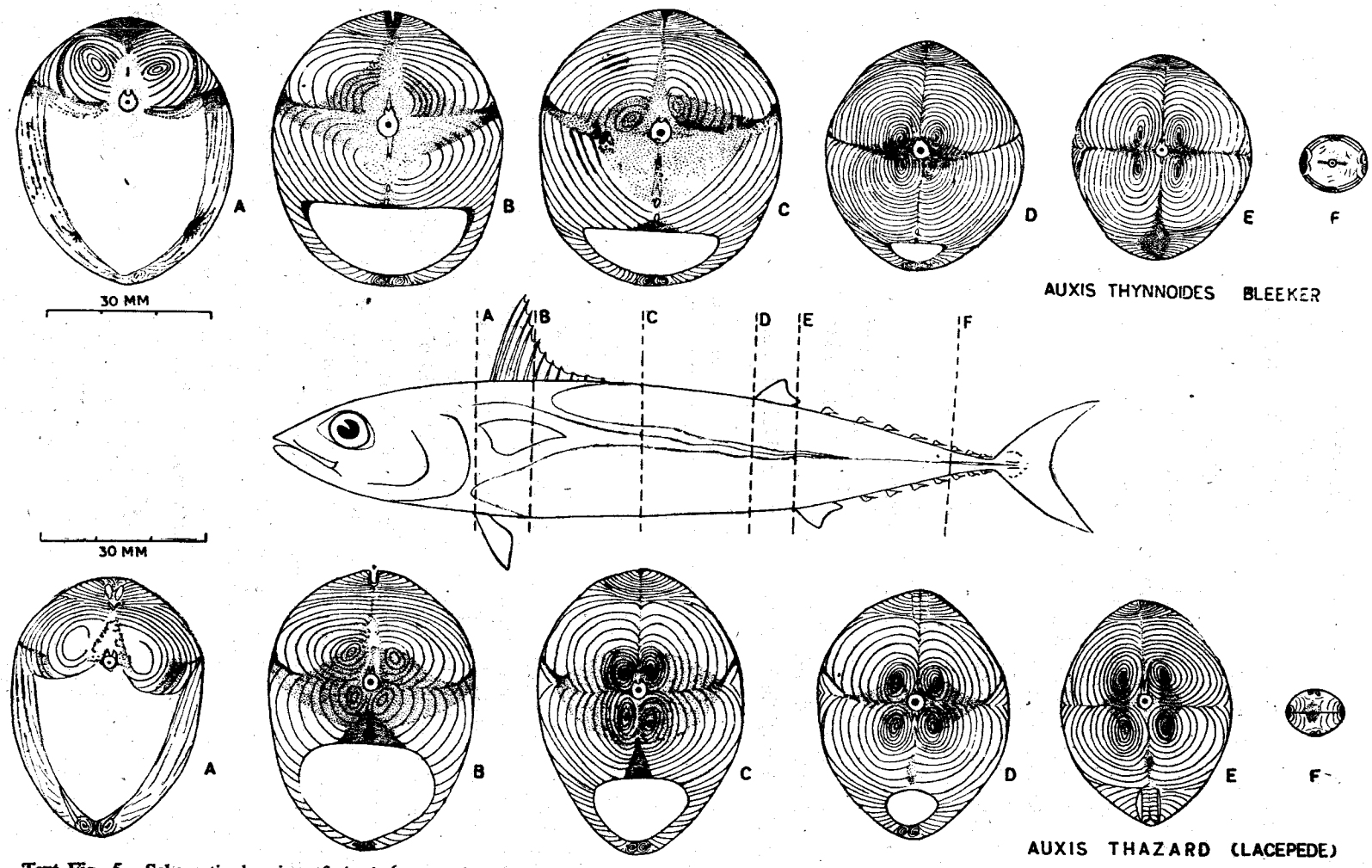
SHORT CORSELETTED FRIGATE MACKEREL

Auxis thazard (Lacépède), 1802

(Plate II, Figs. B & C)

SYNONYMS :

Scomber thazard Lacépède, 1801 : 9 (Type locality : New Guinea)
Scomber bisus Rafinesque, 1810 : 45 (Type locality : Palermo)
Scomber rochei Risso, 1810: 165 (Type locality : Nice)
Thynnus rocheanus Risso, 1826: 417 (Type locality: Nice)



Text Fig. 5. Schematic drawing of *Auxis* (central figure) indicating locations, from where 6 cross-sections of the body were made in *Auxis thynnoides*, and *A. thazard*, illustrated alongside showing differences in body shape and shape of abdominal cavity.

Auxis vulgaris Cuvier, 1831: 139 (Type locality : Mediterranean)

Auxis taso Cuvier, 1831 : 146 (Type locality : New Guinea)

Auxis tapeinosoma Bleeker, 1854 (Type locality: Japan)

Auxis rochei (in part) Günther, 1860: 369

Auxis rochei (in part) Steindachner, 1884: 180

Auxis thazard Jordan and Evermann, 1896: 867
Steindachner, 1896: 210
Meek and Hildebrand, 1923: 313
McCulloch, 1922: 104
Fowler, 1928: 132 ; 1934: 416
Smith, 1949: 298
Rivas, 1951: 215
Herre, 1953: 247
Munro, 1955: 219 ; 1958 b: 18
Jones and Silas, 1960: 377 ; 1962*b* (MS.)

Auxis tapeinsoma (*nec* Bleeker) Herre, 1931: 33

Auxis hira Kishinouye, 1915: 23 (Type locality: Hokkaido to Kyushu, Japan Sea, Ogasawaras and Ryukyus ; South Seas?) ; 1923: 462
Jordan and Hubbs, 1925: 221

Auxis thazard (in part) Fraser-Brunner, 1953: 152-53

Most of the data for the species are given under the genus. Additional references pertaining to the species from the Indian Ocean and contiguous Seas are : Williams (1960) ; Ranade (1961).

A. thazard is a seasonal visitor to the coastal waters, and is usually caught in shore seines, drift nets and in trolling. It is the more common of the two species of the genus and collections have been examined by us from various parts along the West Coast of India from Gujarat to Cape Comorin, from the East Coast from Tuticorin and from the Laccadive Sea, but no appreciable difference has been noticed. The fin rays and gill raker counts are D_1. X–XI ; D_2. 11–13+8 ; P_1. 24 ; A. 13+7 ; Gill rakers (total) 39-42 (as 9–10+29–32). Rivas (1951) gives the counts for *A. thazard* from the Western North Atlantic as : D IX–XI ; dorsal finlets 8 or 9 ; anal finlets 7, gill rakers 29 to 33 on lower limb of first arch.

It may be mentioned here that de Beaufort's (1951) description of the species given under *A. thazard* actually refers to *A. thynnoides* Bleeker. A question which may be difficult to settle is whether Lacépède's type of *A. thazard* from New Guinea actually refers to the short corseletted form, although it is currently believed to be so.

In view of the very close similarities between *A. thazard* and *A. thynnoides*, and the way in which both have been confused in the past, it will be an extremely difficult task to unravel all references pertaining to one or the other species to be listed under the section 'Synonymy.' Hence only the more important works are referred to.

DISTRIBUTION : In Indian Ocean and contiguous waters : East Coast of South Africa from Natal Coast northwards ; Gulf of Aden ; West and East Coasts of India, Laccadives ; Ceylon, South West Sunda Sea? ; West Coast of Australia. The general distribution also includes Atlantic, Mediterranean and the Pacific.

LONG CORSELETTED FRIGATE MACKEREL

Auxis thynnoides Bleeker, 1855

(Plate II, Fig. A)

SYNONYMS :

Auxis thynnoides Bleeker, 1855: 301 (Type locality : Ternate)
Munro, 1958b: 18
Jones and Silas, 1960: 378 ; 1962b (MS.)
Jones, 1962f (MS.)

Auxis thazard (*nec* Lacépède) Jordan and Evermann, 1900
de Beaufort, 1951: 226–27.

Auxis thazard (in part) Fraser-Brunner, 1950: 152-53
Rosa, 1950: 69-74
Rivas, 1951: 215-16

Auxis rochei (in part) Günther, 1860: 369

Auxis tapeinosoma (*nec* Bleeker) Herre and Herald, 1951
Jones, 1958: 189-94 ; 1960: 357-47
Williams, 1960
of Japanese workers.

Auxis maru Kishinouye, 1915: 24 ; 1923: 463-64

For long a problematic species, its position in the system is now better defined. Jones (1962f) summarises our knowledge about this species from which it would appear that much more has been written about it in literature than one would expect.

Unlike *A. thazard*, this species is rarely seen in the commercial catches, but when it occurs it is seen in very large shoals and considerable quantities are landed by shore seine. We have measured specimens upto about 300 mm. from the West Coast of India, but much larger specimens have atleast on one occasion been noticed in the fish curing yard at Vizhingam on the South West Coast of India.

Body proportions expressed as percentages of total length (to fork) for 13 specimens from the South West Coast of India are as follows :—

Head 23.7–26.8 ; snout 6.0–7.6 ; eye 4.2–5.2 ; snout to end of maxilla 8.2–9.1 ; height of body 17.1-21.0 ; first predorsal distance 21.9-31.1 ; second predorsal distance 61.0–63.7 ; preanal distance 66.7–69.4 ; prepelvic distance 25.0–29.5 ; prepectoral distance 25.0–28.3 ; distance between pelvic and anal origins 39.4–42.3 ; height of longest (first) dorsal spine 11.0–16.0 ; height of second dorsal 4.3–5.1 ; length of pectoral 11.9–13.3 ; length of anal 4.0–5.1 ; and width of body at pectoral base about 16.0 18.0 per cent in total length.

The fin ray and gill raker counts for specimens we have examined from South West Coast of India are :

D_1. X–XI, D_2. 13+8 ; A. 13+7 ; Gill rakers 8–12+31–36 (=40–47) (See Tables II and III for more details.)

This may be compared with the following counts given for the species from other areas (Table–II).

TABLE II

	D1	D2 + finlet	A + finlet	Gill-rakers
Japan (Kishinouye, 1923)	IX - X	10 - 12 + 8	13 + 7	10 + 36
Philippines (Wade, 1949)	X - XI	10–12+7–8	2, 10 - 12 + 7	10 - 12 + 1 + 31 - 35 (= 42 - 48)
Indonesia (de Beaufort, 1951)	X	11 + 6 - 9	14 + 6 - 8	...
Hawaii (Matsumoto, 1960)	X - XI	10 - 11 + 8	12 - 13 + 7	10 - 11 + 1 + 32 - 36 (= 43 - 48)

TABLE III

Range and mean gill raker counts for specimens of *Auxis thazard* and *A. thynnoides* from Indian waters

Species	No. of specimens	Range (R) Mean (M)	Gill rakers		
			Upper limb	Lower limb	Total
Auxis thazard	10	R	9 - 10	29 - 32	39 - 42
		M	9.6	30.2	39.8
Auxis thynnoides ...	13	R	8 - 12	31 - 36	40 - 47
		M	9.5	34.5	44.8

While there is considerable overlap in the number of gill rakers on the upper limb of the first branchial arch in both the species, the range on the lower limb is low for *A. thazard*. The total number of gill rakers also consequently shows a similar trend with the mean for *A. thazard* being about 40 and for *A. thynnoides* about 45.

In a few larger adults of *A. thazard* from South West Coast of India it has been found that the corselet instead of abruptly tapering, gradually narrows somewhat as in *A. thynnoides* to a vertical below mid-distance between posterior end of base of first dorsal and second dorsal origin from whence it is narrow with hardly one or two scales on either side. These conditions are shown in Plates II C and VI C and Fig. 3 a & b. Such intermediate conditions as also slight overlap in gill raker counts could evidently give rise to difficulties in specific determination. In such eventualities, additional characters discussed under the genus should facilitate identification.

DISTRIBUTION : Records from the Indian Ocean are rather few. Along the Indian coast we have collected the species from Malpe near Mangalore (S. Mysore) ; Calicut, Quilandy, Vizhingam (Kerala State) ; and Colachel and Cape Comorin (Madras State). In the Pacific Ocean it has a much wider distribution. Its occurrence in the Atlantic is suspected (Matsumoto, 1959).

Genus **Cybiosarda** Whitley, 1935

Scomberomorus (*Cybiosarda*) Whitley, 1935. *Rec. Aust. Mus.*, 19 (4):? (Proposed as a subgenus of *Scomberomorus*, but later (Whitley 1936) elevated to generic status. Type species : *Scomberomorus* (*Cybiosarda*) *elegans* Whitley).

The genus is placed under the subfamily Scombrinae as a synonym of *Gymnosarda* by Fraser-Brunner (1950). Munro (1958) has included it under the family Sardidae, while Jones and Silas (1960, 1962b) consider it a genus of subfamily Thunninae of family Scombridae.

We feel that *Cybiosarda* should be retained as a distinct genus, although Fraser-Brunner (1950) relegated it to the synonymy of *Gymnosarda* Gill. The presence of villiform teeth in the vomer, the greater number of dorsal and anal finlets (9 or 10/7 or 8), and XV or XVI dorsal spines in *Cybiosarda* should differentiate it from *Gymnosarda* in which genus the vomer is edentulous, the dorsal and anal finlets fewer (6 or 7/6 or 7), and the dorsal spines number XII–XIV.

The genus is monotypic and additional details are given under the species.

LEAPING BONITO

Cybiosarda elegans (Whitley), 1935

SYNONYMS :

Scomberomorus (*Cybiosarda*) *elegans* Whitley, 1935. 19 (4) :? (Type locality : New South Wales, Australia).

Cybiosarda elegans Whitley, 1936
Serventy, 1941: 43
Ogilby and Marshall, 1954: 89
Munro, 1958b: 17
Jones and Silas, 1960: 379 ; 1962b (MS.)

Gymnosarda elegans Fraser-Brunner, 1950: 149;
Rosa, 1950: 53

By its occurrence along the West Coast of Australia, this species qualifies for inclusion in this account. Munro (1958b) gives the following body proportions and meristic counts for the species. Depth 3.7 to 4, head 3.5 to 4.5 in length without tail. D_1. XV–XVI, D_2+finlets 17–18+9–10 ; A.+finlets 15–16+7–8 ; P_1. 22–24 ; gill rakers 3–4+8–10.

Jaws composed of curved conical teeth arranged uniserially ; palatines with 3 rows of fine sharp teeth ; pear shaped patch of villiform teeth on vomer. Corselet developed, lateral line almost straight joining peduncular keel ; a pair of lateral caudal keels on each side present.

According to Serventy (1941) it is said to be an excellent sport fish and specimens between 3/4 and 2 lbs. are usually taken in trolling, and shoals of many hundreds are often seen. Serventy further remarks that it " ..... is the one tuna whose flesh is appetizing in the fresh condition. The meat is white and may be smoked quite well ".

DISTRIBUTION : In Indian Ocean and contiguous waters : along the West Coast of Australia atleast as far south as Fremantle. In the Pacific Ocean : East Coast of Australia as far south as Sydney or Shell Harbour, New South Wales.

Genus Sarda Cuvier, 1829

Sarda Cuvier, 1829. *Regne Anim.*, 2 : 199 (Type : *Sarda pelamys* = *Scomber sarda* Bloch)

Pelamys Cuvier, 1831. *Hist. Nat. Poiss.*, 8 : 149 (Type : *Pelamys sarda*=*Scomber sarda* Bloch) (*nec Pelamys* Daudin, a genus of snakes).

Palamita Bonnaparte, 1831. *Giruale Arcadio*, P. 107 (Type : *Scomber sarda* Bloch).

Creotroctes Gistel, 1848. *Naturg. Thierr.*, p. 10 (Type : *Scomber sarda* Bloch) (*Creotroctes* Gistel proposed to replace *Sarda* Cuvier)

The generic diagnosis would be : Body elongate, compressed from side to side, covered with scales, corselet well formed, caudal slender, strongly keeled ; mouth large, maxilla extending to or surpassing vertical below hind border of eye ; teeth in jaws strong, conical and very slightly compressed ; vomer edentulous, palatines with a single row of strong conical teeth, gill rakers well developed, first dorsal with XVIII – XXII spines ; both dorsal and anal short followed by 7–9/5–9 finlets respectively. Vertebrae 44 or 45.

DISTRIBUTION : Warm and temperate waters of the Indo-Pacific, Atlantic and Mediterranean.

ORIENTAL BONITO

Sarda orientalis (Temminck and Schlegel), 1844

(Plate VIII, Fig. A)

SYNONYMS :

Pelamys orientalis Temminck and Schlegel, 1844 : 99 (Type locality : Japan)

Scarda chiliensis var. *orientalis* Steindachner and Doderlein, 1885 : 11 (typographic error for *Sarda*)

Pelamys chiliensis (*nec* Cuvier) Day 1876–78 : 253 ; 1889 : 208

Sarda chilensis (in part) Barnard, 1927 : 801

Sarda velox Meek and Hildebrand, 1923 : 320 – 21 (Type locality : Panama City, Panama – Specimen purchased from Market)

Sarda orientalis serventyi Whitley, 1945 : 41 (Type locality : Albany, W. Australia)

Sarda orientalis Kishinouye, 1915 : 12
Fraser-Brunner, 1950 : 147
Rosa, 1950 : 44–45
Jones, 1960 : 337–47
Jones and Silas, 1960 : 378–80 ; 1962b (MS.)
Smith, 1961 : 299
Silas 1962a (MS.), 1962f (MS.)

Available information about the oriental bonito may be had from two recent contributions on the species by Silas (1962a; 1962f) wherein, detailed synonymy, description, aspects of the biology of the species, etc., are dealt with. The meristic counts for the Indian specimens given by Silas (1962a) are : D_1. XVII–XIX ; D_2 + finlets. 14–16 + 7–8 (exceptionally 9) P_1. 23–25 ; A + finlets. 13–16 + 5–7 ; gill rakers 1–4 + 8–10.

For typical Japanese specimens, Kishinouye (1923) gives the counts as : D_1. XIX, D_2 + finlets 15 + 7–8 ; A + finlets 15 + 5–6 ; gill rakers 4 + 9 ; vertebrae 25 + 20 = 45.

Some of the earlier workers have confused both *S. orientalis* and *S. chilensis*, but the position has now been clarified (Godsil, 1955 ; Silas, 1962a, f)

DISTRIBUTION : " East Coast of South Africa, Seychilles, Somalia and Gulf of Aden, West Coast of India, South West Coast of Australia, Philippines, Japan, Hawaii, Pacific Coast of Central America and Galapagos Islands besides two records from the Atlantic". (Silas, 1962f).

Genus **Gymnosarda** Gill, 1862

Gymnosarda Gill, 1862 *Proc. Acad. Nat. Sci. Philad.*, 125 (Type : *Thunnus unicolor* Rüppell) (*nec Scomber unicolor* Geoffroy St. Hilaire, 1809 which is the type of *Orcynopsis* Gill 1862–syn. *Pelamichthys* Giglioli 1880)

Fraser-Brunner (1950) treated *Cybiosarda* Whitley as a synonym of *Gymnosarda*, but as already mentioned, we consider these two as distinct genera. Diagnostic characters include : " Body elongate, fusiform, anteriorly robust with large head.....maxilla extending to vertical below anterior third of eye ;.....teeth in jaws large slightly curved, but nearly conical in shape, villiform teeth present on tongue and palatines ; vomer edentulous ; eyes large ; body appearing naked except for greatly reduced corselet and lateral line ; scales in corselet elongate and concealed under skin which is usually drawn into longitudinal furrows on either side of dorsals ; lateral line conspicuous and undulating posteriorly ; two dorsal fins more or less contiguous.....first dorsal with XII–XIV spines of which 3rd spine longest ; dorsal finlets 6 or 7 and anal finlets mostly 6 ; pectorals not exceeding head length; interpelvic process developed, simple or bifid posteriorly ; caudal relatively slender, with a well developed median keel and a pair of low lateral keels on either side ; caudal lobes more or less vertical, posterior margin being a wide arc, gill rakers few, strong ; gill membranes free, operculum slightly undulating at hind margin ; vertebrae 38 (19+19)" (Silas, 1962 a).

The genus is monotypic.

DISTRIBUTION : Indo-Pacific.

REMARKS : The systematic position of the genus has been subject to varied treatment as Kishinouye (1923) placed it among the Cybiidae ; Fowler (1942) under subfamily Sardinae ; Fraser-Brunner (1950) under subfamily Scombrinae ; Munro (1960b) under family Katsuwonidae, and Jones and Silas (1960) under subfamily Thunninae.

DOGTOOTH TUNA

Gymnosarda unicolor (Rüppell), 1838

(Plate IV, Fig. D)

SYNONYMS :

Thynnus (*Pelamis*) *unicolor* Rüppell, 1838: 40 (Type locality : Djedda, Red Sea)
Pelamys nuda Günther, 1160: 368 (Type locality : Red Sea) (Species name proposed to replace *T. unicolor* of Rüppell which was considered to be preoccupied by *Scomber unicolor* Geoffroy. 1809)
Gymnosarda nuda Kishinouye, 1915: 13
Scomber vau Curtiss, 1938: 57 (Type locality : Ocean outside reef, off Tautira)
Gymnosarda unicolor Fowler, 1949 73
Jones, Silas and Dawson, 1960: 136
Jones and Silas, 1960: 380-81 ; 1962b
Silas, 1962g (MS.)

For detailed synonymy reference may be made to Silas (1962g) who also gives the body proportions for the species (for specimens from Indian seas) expressed as percentages of total length as follows :

" Head 24.8—28.1 ; first predorsal distance 28.1—31.8 ; second predorsal distance 54.3—58.8 (in one instance 62.1) preanal distance 61.0–67.0 prepelvic

distance 27.0—31.7 ; greatest depth of body 19.6—24.8; length of pectoral 16.6—19.9 ; height of second dorsal 9.9—11.8 ; height of anal 9.7—11.6 ; diameter of iris 3.8—6.0 per cent in total length."

For a redescription of the species, and information on aspects of the biology of it reference is invited to Silas (1962g).

DISTRIBUTION : In Indian Ocean and contiguous seas : East Coast of Africa off Mafia, South of Zanzibar, Minicoy Island in the Laccadives, Maldives ; Bases reef South East of Ceylon ; off Port Blair Andamans ; St. Davis ; Reunion ; Maurice ; Madagascar ; Comeros ; Banes Castor et Leven ; Hawkins Bank ; Rodrigues ; North East Seychelles Plateau ; South Amirante Bank ; St. Brandon and Constant Bank, Mauritius, Seychelles, Aldabra. From the Pacific Ocean it has been recorded from several localities from Riu Kiu Islands (Japan) in the North to Tahiti in the South East (after Silas, 1962g).

Genus **Thunnus** South, 1845

Thynnus Cuvier, 1817. *Regne Anim.* 2nd Ed. 313 (Type species : *Scomber thynnus* Linnaeus–by absolute autonomy) (Preoccupied by *Thynnus* Fabricius, 1775, a genus of Hymenoptera, Insecta)

Orcynus Cuvier, 1817. *Regne Anim.* 2nd Edn : 314 (Type species : *Scomber germo* Lacépède = *Scomber alatunga* Gmelin [= *Thunnus* (*T.*) *alalunga*]. Designation by Jordan, 1888, *Proc. Acad. Nat. Sci. Philad.*, 180. (Preoccupied by *Orcynus* Rafinesque, 1815 as a substitute for *Scombroides* Lacépède in Fishes).

Thynnus South, 1845. *Encyclop. Metrapol.*, 5 : 620 (Type species : *Scomber thynnus* Linnaeus). (Proposed to replace *Thynnus* Cuvier which is preoccupied.

Orcynus Gill 1862. *Proc. Acad. Nat. Sci. Philad.*, 238 (Type species : *Scomber thynnus* Linnaeus) (*nec Orcynus* Cuvier).

Albacora Jordan, 1888. *Proc. Acad. Nat. Sci. Philad.*, 180 (Types species : *Scomber thynnus* Linnaeus) (Substitute name for *Thynnus* Cuvier which is preoccupied).

Germo Jordan, 1888. *Proc. Acad. Nat. Sci. Philad.*, 180 (Type species : *Scomber alatunga* Gmelin [= *Thunnus* (*T.*) *alalunga*] proposed as a substitute for *Orcynus* Cuvier, 1817, which is preoccupied by *Orcynus* Rafinesque, 1815).

Parathunnus Kishinouye, 1923, *J. Coll. Agric. Tokyo Univ.*, 8 : 442 (Type species : *Thunnus mebachi* Kishinouye, 1915 [= *T.* (*P.*) *obseus mebachi*].

Neothunnus Kishinouye, 1923. *J. Coll. Agric. Tokyo Univ.* 8 : 445 (Type species : *Thynnus macropterus* Temminck and Schlegel, 1844 [= *T* (*N.*) *albacares macropterus*]

Kishinoella Jordan and Hubbs, 1925. *Mem. Carnegie Mus.*, 10 (2) : 219 (Type species : *Thunnus rarus*, Kishinouye, 1915 [= *T.* (*K.*) *tonggol* Bleeker].

Semathunnus Fowler, 1933. *Proc. Acad. Nat. Sci. Philad.*, 85 : 163 (Type species : *Semathannus guildi* Fowler [= *T.* (*N. ?*) *itosibi* ? Jordan and Evermann, 1926].

Whitley (1955) resurrected the obscure name *Thinnus* S. D. W (ood?) 1837 to replace *Thunnus* South (18'5). Since the name *Thunnus* is so widely current and well known we would suggest a ruling suppressing *Thinnus* in favour of *Thunnus*.

Parathunnus Kishinouye, *Neothunnus* Kishinouye, and *Kishinoella* Jordan and Hubbs were originally proposed as genera and they have been accepted in this sense by most recent workers (Jordan and Hubbs, 1925 ; Jordan and Evermann, 1926 ; Serventy, 1941a, 1942a.b ; Godsil and Byers, 1944 ; Fowler, 1949 ; Rosa, 1950 ; Godsil, 1954 ; Munro, 1957, 1958a ; Jones and Silas, 1960 ; and others). However, some (Fraser-Brunner, 1950 ;

and others) treat them as sub-genera of the genus *Thunnus*. Fowler (1936) considers them as synonyms of *Germo* Jordan. The salient differences between *Thunnus, Germo, Parathunnus, Neothunnus,* and *Kishinoella* are well covered in the 'key' to these genera given by Jordan and Hubbs, (1925) wherein, the first two genera are separated from the remaining three as the cutaneous blood vessel in these pass through the myotome of the fifth vertebra and the surface of the liver is straited with fine venules (*versus* cutaneous blood vessels passing through myotome of seventh vertebra and surface of liver not striated with venules). Further *Thunnus* is said to have short pectoral fins about half length of head and falling short of vertical below origin of second dorsal and anal with dorsal and anal lobes low while in *Germo* the pectoral fin is very long, ribbon-like, reaching to the anterior dorsal and anal finlets and the dorsal and anal lobes are moderately long. The remaining three genera were separated as follows :

" Posterior cardinal vein not contiguous with the cuverian ducts. Vascular plexus on the inner side of the liver ; pectorals long, reaching to near end of second dorsal, dorsal and anal lobes moderate, about half head.

... *Parathunnus*

Posterior cardinal vein contiguous with the cuverian ducts ; vascular plexus in the haemal canal.

Air bladder well developed, long and narrow ; pectorals long, extending beyond middle of second dorsal ; dorsal and anal lobes much elongated, as long as head ; gill rakers about 30.

... *Neothunnus*

Air bladder wanting ; gill-rakers about 26 ; pectoral fin shorter, reaching to near end of spinous dorsal ; head shorter ; mouth smaller.

... *Kishinoella.*"

Fraser-Brunner (1950 p. 142) who treats these as subgenera, mentions in addition that in *Parathunnus* the origin of the anal fin is midway between the hind margin of the gill cover and the end of the caudal keels or "very slightly anterior" while in *Neothunnus*, and *Kishinoella* the origin of the anal fin is distinctly anterior to the point midway between hind edge of gill cover and end of caudal keels, the tail being longer than in *Parathunnus* and subgenus *Thunnus*.

Godsil (1954) in his key to the genera of the family Thunnidae draws attention to the fine peripheral markings on the ventral surface of the liver in *Parathunnus* (in *P. mebachi*) which "..... may disappear in stale specimens."

However, additional information on these true-tunas given by de Sylva (1955), Rivas (1961) and others indicates that the differences between the species have been unduly magnified resulting in the recognition of a number of monotypic genera. No doubt, phylogenetically the species recognised under these genera or subgenera form a close-knit group and as such we feel that it will be desirable to place all these under a single genus *Thunnus* as advocated by Fraser-Brunner (1950). As will be evident from the discussions under the species given below, stability of nomenclature below the species level and in one or two instances at species level has not been attained. It is not yet clear whether populations recognised from different faunal areas should be given recognition as distinct species. A great and urgent need is the comparison of good series of samples both morphometrically as well as biochemically (blood

typing, etc.) from the different faunal areas to get a clearer picture. Until such time, we propose retaining *Parathnnnus*, *Neothunnus*, and *Kishinoella*, as subgenera of genus *Thunnus*. Here again, Rivas (1961) opines that *Parathunnus* and *Neothunnus* may be synonyms. We propose the following grouping under the genus *Thunnus*.

Genus **Thunnus** South

Subgenus *Thunnus* S. str.
T. (*T.*) *thynnus thynnus* (Linnaeus)-Atlantic, Mediterranean.
T. (*T.*) *thynnus orientalis* (Temminck and Schlegel)—Indo-Pacific.
T. (*T.*) *alalunga* (Gmelin)—Atlantic, Mediterranean, Indo-Pacific.

Subgenus *Parathunnus* Kishinouye
T. (*P.*) *obesus obesus* Lowe—Atlantic.
T. (*P.*) *obesus mebachi* Kishinouye—Indo-Pacific.
T. (*P.*) *atlanticus* (Lesson)—Atlantic.

Subgenus *Neothunnus* Kishinouye
T. (*N.*) *albacares albacares* (Bonnaterre)—Atlantic.
T. (*N.*) *albacares macropterus* (Temminck and Schlegel)—Indo-Pacific.
T. (*N.*) *itosibi* (Jordan and Evermann)—Indo-Pacific.

Subgenus *Kishinoella* Jordan and Hubbs
T. (*K.*) *tonggol* (Bleeker)—Indo-Pacific.

ORIENTAL BLUEFIN TUNA

Thunnus (Thunnus) thynnus orientalis (Temminck and Schlegel), 1844

(Fig. 6 a, b)

SYNONYMS :

Thynnus orientalis Temminck and Schlegel, 1844 : 94 (Type locality : Nagasaki, Japan).
Boeseman, 1947 : 91 (on the type specimen in Leiden Museum)

Thunnus maccoyii Castelnau, 1872 : 104 (Type locality : from Melbourne market caught off coast of S. Australia)

Orcynus schlegelii Steindachner and Doderlein, 1885 : 11 (Type locality : Southern Japan)

Orcynus thynnus Kitahara, 1897 : 1

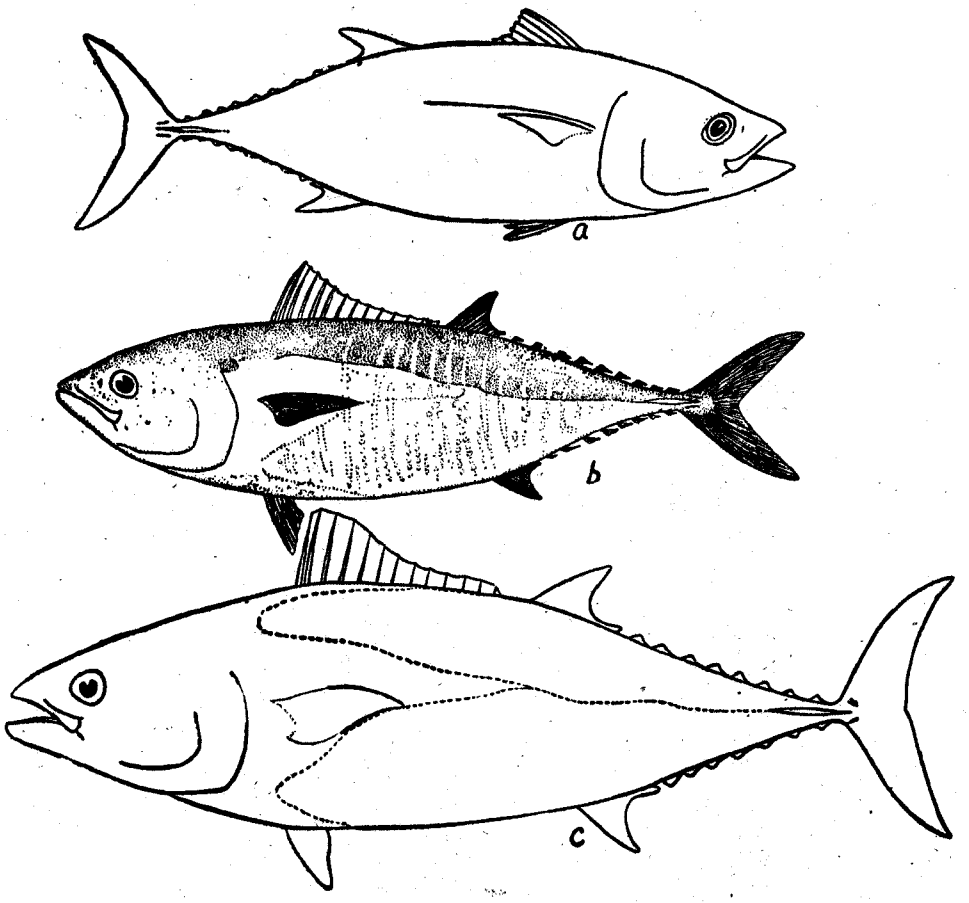
Thunnus schlegelis Fujita et al., 1905 : 21

Thunnus orientalis Kishinouye, 1915 : 17 ; 1923 : 437
Jordan and Evermann, 1926 : 14
Rosa, 1950 : 11–12

Thunnus saliens Jordan and Evermann, 1926 : 10–11 (Type locality : Catalina, California)
Roedal, 1953 : 88

Thunnus phillipsi Jordan and Evermann, 1926 : 13 (Type locality : Bay of Islands, New Zealand)

Thunnus maccoyii Jordan and Evermann, 1926 : 13
Serventy, 1941 a : 27 ; 1941b : 1–2
Rosa, 1950 : 13–14



Text Fig. 6. (*a*). *Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel) (after a photograph of *Thunnus maccoyii* Castelnau kindly sent by C.S.I.R.O., Australia); (*b.*) *T* (*T.*) *thynnus orientalis* (after Kishinouye, 1923); (*c*). *T.* (*T.*) *thynnus thynnus* (Linnaeus) from the Atlantic (after Fraser-Brunner, 1950).

Thunnus thynnus (in part) Barnard, 1927 : 798
Godsil and Byers, 1944 : 89–102
Molteno, 1948 : 16
Smith, 1949 : 298
Rosa, 1950 : 1–8
Herre, 1953 : 252
Thunnus Thunnus thynnus (in part) Fraser-Brunner, 1950 : 143
Thunnus (*Parathunnus*) *obesus* (in part) Fraser-Brunner, 1950 : 144
Thunnus thynnus maccoyii Serventy, 1956 : 1–43
Munro, 1958 b : 19
Thunnus thynnus orientalis Jones and Silas, 1960 : 381–82

The nomenclature and status of bluefins from various parts of the world are in a state of chaos. *Thunnus thynnus* (Linnaeus) is recognised as the typical bluefin from the Eastern Atlantic and Mediterranean, while the Western Atlantic (off North American Coast) bluefin is considered by some workers to be a distinct species *T. secundodorsalis* (Storer).

Serventy (1956) opined that *T. coretta* (Cuvier and Valenciennes) should replace *T. secundodorsalis*, but the former is now considered a synonymy of *Thunnus atlanticus*. At least three specific or subspecific names are currently in use in fishery literature to denote the bluefins from the Pacific and Eastern Indian Oceans namely, *T. orientalis* (from Japanese waters) ; *T. saliens* (from California coast) ; and *T. maccoyii* (from around Australia and New Zealand). The last said finds mention in Japanese fishery literature as the *Indomaguro*.

No attempts have been made to check the status of the bluefin from the Indian Ocean, although in the eastern part the *Indomaguro* and *T. maccoyii* may be considered identical. We have elsewhere (Jones and Silas, 1960) considered it best to denote the bluefin from the Indian Ocean as *T. thynnus orientalis* and would still advocate this course for the very reason that no comparisons of *T. maccoyii* or *T. saliens* have been made with *T. orientalis* from Japanese waters, the latter name being the oldest available for the Indo-Pacific bluefins, and thus having priority. The general body form, profile, short pectorals, etc., are very characteristic of bluefins throughout the world, while slight differences in gill raker counts, and a few body proport ons have been noted by Godsil and Holmberg (1950), Serventy (1956), and Mather (1959), between bluefins from the Atlantic, Pacific Coast of California, and Australia but with considerable overlap in ranges. It is highly questionable whether the said differences would suffice to denote bluefin from the geographical areas as distinct species as considered by some recent workers and also currently used in certain fishery literature in the Pacific.

The range of gill raker counts on the lower limb of outer arch which may vary from 22 to 31 would appear to show different modes for the different geographical areas which has led Serventy (1956) to recognise a single worldwide species of bluefin with at least 6 subspecies as follows :

Sub-species	*Area of occurrence*	*Gill-raker counts (Mode)*
Thunnus thynnus thynnus (L.) ...	European Seas ...	13/24–26 = 37–39
T. t. coretta (C. and V.) ...	North America, Atlantic Coast ...	
T. t. Sub sp. ...	South Africa ...	
T. t. saliens Jordan and Evermann ...	North America, Pacific Coast ...	12/23–24 = 35–36
T. t. orientalis (Temminck and Schlegel) ...	Asiatic Coast of North Pacific ...	12–13/24–26 = 36–39
T. t. maccoyii (Castelnau) ...	Australia and New Zealand ...	11/22–23 = 33–34

According to Serventy (1956) "The South African population has remained unnamed, but from a consideration of the morphological differentiation which has gone on in similar isolated populations (*vide* in particular the work of Godsil and Holmberg) it will probably require designation as a new subspecies when its characters have been worked out." Smith (1961), gives the meristic counts of *T. thynnus* from Cape Waters as "D. XII–XV, 12–14+8–10. A. I–II, 11–12+7–9. 26–31 slender gill-rakers." More information is required on the bluefin from Central and Western Indian Ocean.

The data given by Mather (1959) would suggest the following to be the modes for gill raker counts for bluefin from the Eastern and Western Atlantic.

Eastern Atlantic : 12/25–27 = 37–39
Western Atlantic : 13/25–27 = 38–40

TABLE IV.

Gill raker frequencies for *T. t. maccoyii* (after Serventy, 1956)

	Gill rakers																						
	Upper limb					Lower limb								Total									
No.	9	10	11	12	13	21	22	23	24	25	26	27	28	31	32	33	34	35	36	37	38	39	40
E. Australia	2	16	38	19	4	4	35	32	7	1	...	...	...	3	12	26	15	17	3	3	...	...	...
S. Australia	...	1	11	2	2	2	4	6	2	2	...	...	...	...	3	3	5	1	2	2	...	...	...
W. Australia	8	48	105	52	3	18	74	87	32	4	...	...	1	6	41	52	63	34	18	1	...	...	1
Total	10	65	154	73	9	24	113	125	41	7	...	...	1	9	56	81	83	52	23	6	...	...	1

The fin formula for *T. t. maccoyii* is given by Serventy (1956) as D.XII—XIV, 14–15+8–9 ; A. 14–15+7–8 ; P_1. 28–34, the most usual counts being : D.XIV, 15+8 ; A. 14+18 ; P_1. 32.

Fraser-Brunner (1950) relegated *T. maccoyii* and *T. phillipsi* as synonyms of *Thunnus* (*Parathunnus*) *obesus* Lowe, 1839. Serventy (1956) has shown that the first two are conspecific and has drawn attention to the fact that Fraser-Brunner had inadvertently placed *maccoyii* in the synonymy of *T.* (*P.*) *obesus*. The type of *T. phillipsi* (Jordan and Evermann, 1916, pl. 2, fig. 4) is considered to have facial abnormality, a kind which Serventy has also noticed in occasional specimens of '*Thunnus germo* Lacépède' from Australia.

As in the N. E. Atlantic tunny (fig. 6 c), the median lobe of the liver in *T. maccoyii* is more pointed, but the right lobe is less developed as in *T. orientalis* and *T. saliens*.

While regional differences in the bluefins are recognised by Serventy (1956), his examination of Australian specimens has led him to suspect that some of the detailed morphological differences such as the shape of the air-bladder between the Australian and Californian specimens of bluefins drawn attention to by Godsil and Holmberg (1950) could also be due to differences in the size of the specimens studied. "Supplementary findings of Godsil and Holmberg (1950, p. 45) suggest that some of these supposed differences, such as curvature of the dorsal wall, also vary with size. Examination of additional specimens suggests that their further diagnostic characters, concerning the arterial systems, be in this category, and that though there may be differences in the various regional groups the differences for the recognition of particular individuals are not decisive."

Few workers have commented on the colour of the bluefin from the Pacific and Serventy's (1956) observations show how easily this character could mislead one to identify a bluefin as an yellowfin. According to him "There are differences in colour between the various populations which deserve attention though they have not been fully studied by authors. Godsil and Holmberg draw attention to this character but were prevented from using it fully owing to their material having been in a frozen condition for sometime. The Australian fish have none of the rows of pale spots on the abdomen and flanks of the

California fish (*vide* Walford 1937, Plate 34) which also appear to occur on the Atlantic fish (Godsil and Holmberg 1950, p. 7) and on the Japanese (Kishinouye 1925, should be 1923, p. 438) where the belly is greyish with many pale transverse lines and rows of pale dots in alteration" (Fig. 6 b). There are also marked regional differences in fin colour. The Californian fish lack any marked yellow colour on the fins and finlets-hence the local common name of "bluefin." The Japanese fish differ from them in that the second dorsal fin has a yellow tip and the dorsal finlets are yellow. This yellow colouration is even more extensively developed in the Australian fish ; there is a yellow tinge on the second dorsal fin, both the dorsal and ventral series of finlets are yellow, and the caudal fin has a bright yellow stripe. This difference in fin colouration between Australian and Californian fish has been noted by fishermen with first-hand experience of both and has caused a great deal of confusion in identification (many local reports of yellowfin tuna have proved to be misidentification of the southern bluefin).

Large-scale fishing for the *Indomaguro* (*T. maccoyii* of Australia) is carried out at two centres in the Eastern Indian Ocean by the Japanese, the first 10°S to 17°S and 113°E to 120°E and the second 20°S to 30°S and 100°E to 110°E. Mimura (1961) suspects that although the fish in both these areas may belong to the same population, two spawning groups may exist as noticeable from differences in length/weight and gonad weight of specimens caught from these areas.

While evidence at present tends to picture the bluefins as six isolated populations or subspecies or species it may be mentioned that unlike the yellowfin, the bluefin occurs in waters with temperature as low as 12°C. Our knowledge is so inadequate as to even speculate whether there could be mixing between bluefin from Eastern Atlantic and Western Atlantic or between Eastern Atlantic and the Cape Seas (South Africa), or between the latter and that of the Eastern Indian Ocean. Little is known about the movements of the bluefin in the Pacific, though at present they are presumed to be localised.

The distinction between bluefin from these isolated areas is mostly very subtle and it is our contention that until good series from all these areas as well as from the Central and Western Indian Ocean are critically examined, it will be better to use the oldest name available for the bluefin from the Indo-Pacific, namely, *T. orientalis*, and on account of the considerable similarity between the bluefin, of the Indo-Pacific and Atlantic to consider those from the former as a subspecies of *T. thynnus*.

ALBACORE

Thunnus (Thunnus) alalunga (Bonnaterre), 1788

SYNONYMS :

Scomber alalunga Bonnaterre, 1788 : 139 (Type locality : Mediterranean)

Scomber alatunga Gmelin, 1789 : 1330 (on Alalonga Cetti, 1777, *Hist. Nat. Sardin*, 3 : 191, Locality : Sardinia (According to Jordan and Evermann, (1926). Species name misprint for *alalunga*)

Scomber germon Lacépède, 1800 : 598 (Type locality : unknown)

Scomber germo (Commerson) Lacépède, 1802 : 1 (Type locality : South Pacific Ocean-Lat. S. 27°, Long. 103°)

Orcynus germon Cuvier, 1819

Orcynus alalonga Risso, 1826 : 419 (also *O. alalunga*)

Thynnus alalunga Cuvier, 1831 : 120
Thynnus pacificus Cuvier, 1831 : 133 (Type locality : South Pacific Ocean—Lat. S. 26°-S. 27° Long. 103°)
Günther, 1860 : 366
Thunnus alalunga South, 1845
Orcynus pacificus Cooper, 1863
Albacora alalonga Dressler and Fesler, 1889 : 438
Germo alalunga Jordan and Evermann, 1896 : 871 ; 1926 : 15 (synonymy in part)
Meek and Hildebrand, 1923 : 316
Fowler, 1936 : 621 (synonymy in part)
Molteno, 1928 : 29
Smith, 1949 : 299
Orcynus germo Kitahara, 1897 : 1
Germo germo Jordan and Seale, 1905 : 175
Jordan and Evermann, 1926 : 16
Thunnus alalunga, Jordan, Tanaka and Snyder, 1913 : 120
Jones and Silas, 1960 : 382
Germo germon Waite, 1913
Thunnus germo Kishinouye, 1923 : 434
Serventy, 1941 : 23
Godsil and Byers, 1944 : 71–87
Thynnus germo Jenkins, 1925 : 65
Germo alalonga Barnard, 1927 : 799
Thunnus germon McCulloch, 1934 : 79
Germo germon steadi Whitley, 1933
Thunnus (*T.*) *alalunga* Fraser–Brunner, 1950 : 142 (synonymy in part)
Thunnus alalunga germo Munro, 1958 : 19

Besides the works listed above, the following may be consulted for aspects of the biology of the albacore from the Indian Ocean and contiguous waters : Ueyanagi (1955) ; Suda (1956) ; Mimura (1957) ; Yabe (1958) ; Kurogane and Hiyama (1959), and Hiyama and Kurogane (1961).

There are no definite records of this species from the Indian Coast. Apparently it is a southern species found more towards the southern latitudes, just south of the equator. However, Japanese tuna long-line fishery data (Anon, 1959) indicate that during certain months (March–May) albacore may occur in the catches a few degrees to the north of the equator also. Throughout the year the albacore was found to occur in appreciable abundance between latitudes 1°N and 12° S to 15° S and from 52° E of Gr. to 120°E. Even within this area, the seas south-west of Sumatra and south of Java were found to yield the maximum catches of albacore, in one sector the maximum rate of catch being over 11 per 100 hooks used. Some workers have treated the Atlantic albacore as *T. alalunga* and the Pacific as *T. germo*, but hitherto no detailed comparisons have been instituted and even so it is highly doubtful from available data whether more than one species of albacore exists.

Hiyama and Kurogane (1961) opine that in the Indian Ocean the albacore south of Sunda Islands belong to the same population as the ones from the equatorial areas of the Indian Ocean. They find marked differences between the albacore from the Indian Ocean and the Pacific in head length and relative position of the fins. Also the relative growth rate of the Indian albacore is more than that of the Pacific. The Indian Ocean albacore differ from those

of the northwest Pacific in having larger head and more posteriorly positioned fins and these differences along with their disjunct distribution have led them to consider albacore from both these areas as belonging to two distinct populations. Since samples from the Indian Ocean and the South West Pacific show greater agreement in morphometric characters, they suspect that albacore from these two areas may be the same with possibilities of regular mixing.

Mimura (1957) draws attention to two fishing grounds for the albacore in the Indian Ocean, one along the equator (April–September) and the second south of Lat. 8° S (January–March). From the southern waters off Sunda Islands (Indian Ocean) Ueyanagi (1958) obtained two albacores, one with ripe ovaries and the second with nearly ripe ones from an examination of which he deduces that the spawning of albacore takes place in that area. ".....in February atleast in part." Yabe *et al.* (1958) reported the occurrence of a juvenile albacore 258 mm. (vertebral length) from the stomach of a female short-nosed spearfish 130 cm. long collected on 20–3–1957 at 25° 13′ S and 90° 43′ E. Suzuki *et al.* (1958) give data on blood groups of albacore based on 20 specimens collected from Eastern Indian Ocean. Shimadu and Higasa (1960) have studied the Riboflavins in the liver and kidney of albacore from Eastern Indian Ocean, while Watanabe (1960) gives data regarding the composition of food in 21 specimens of albacore from the same area. For the results on exploratory fishing for the albacore in the mid-Indian Ocean reference is invited to Kataoka (1957).

The optimum temperature for albacore appears to be 18° C – 21° C, but the species may occur in waters with temperature range from 10° C – 28° C.

BIGEYE TUNA

Thunnus (Parathunnus) obesus mebachi Kishinouye 1915

(Plate III, Fig. A)

SYNONYMS :

? Thynnus sibi Temminck and Schlegel, 1844 : 97 (Type locality : Nagasaki, Japan).
Boeseman, 1947 : 93 (on the type specimen of *T. sibi* in the Leiden Museum, which he considers as belonging to the species *Germo alalunga* (Gmelin) (= *Thunnus* (*T.*) *alalunga*)

? Orcynus sibi (*nec* Temminck and Schlegel?) Kitahara, 1897 : 1–2

? Thunnus sibi (*nec* Temminck and Schlegel?)
Jordan and Snyder, 1901 : 64
de Beaufort, 1951 : 222–23
de Sylva, 1955 : 34–40

Thunnus mebachi Kishinouye, 1915 : 19 (Type locality : Ryukyu ; Formosa ; Japan Sea?)

Germo sibi Jordan, 1922 : 33

Parathunnus mebachi Kishinouye, 1923 : 442
Godsil and Byers, 1944 : 104–119
Munro, 1957 : 145–148

Parathunnus sibi Jordan and Hubbs, 1925 : 218
Jordan and Evermann, 1926 : 17.
Herre, 1953 : 251

Parathunnus obesus mebachi Jones and Silas, 1960 : 383

Thunnus obesus (in part) Collette, 1961 : 13–14

We agree with Fraser-Brunner (1950) : Rivas (1961) ; Collette (1961) and others that only one species of bigeye tuna may be recognised from the Atlantic and the Indo-Pacific. Although the specific names *sibi* and *mebachi* have been used to denote the Pacific bigeye tuna, we have elsewhere (Jones and Silas, 1960) used the name *mebachi*, as a subspecies of *T. obesus*. This may call for some explanation which we give below :

Günther (1860) considered *Thynnus sibi* Temminck and Schlegel as a dubious species, but Boeseman (1947) re-examining the type specimen definitely attributes it to the albacore *Germo alalunga* (Gmelin) (= *T.* (*T.*) *alalunga*). The reasons given by Kishinouye (1923) for considering his species *Thunnus mebachi* (= *Parathunnus mebachi*) as valid are that : " Kitahara 1897 identified this species with *Thynnus sibi* of Schlegel 1844, but the latter author writes that the species is very common, during summer months, and is caught in hundreds at a time by means of nets of large dimension. This statement is not adequate for the present species. Moreover there are no decisive characters in the description by Schlegel, except the long pectorals and remarkable height of the body. Probably Schlegel confounded this species with *Neothunnus macropterus*. Cunningham 1910 considers this species to be identical with *Thynnus obesus* Lowe of the Atlantic ; but our species differs from the latter in the colour of the second dorsal and the anal atleast. According to Cunningham these fins have ' some black at edges, but little or no yellow '. The descriptions of *Thunnus obesus* by Lowe 1889 as well as Cunningham are very incomplete. It is allied to the present species in having large eyes and a short, thick set figure. But as other important structures of *Thynnus obesus* Lowe are unknown, it is impossible to ascertain the relation between these two species."

Comparison of samples of the bigeye tuna from the Indian Ocean with those from the Atlantic is wanting. A specimen of bigeye we had examined (Jones and Silas, 1960) shows characters more akin to the Atlantic *T. obesus* than to *P. mebachi* figured by Godsil and Byers (1944). The latter appears to have a markedly larger pectoral. Roedel and Fitch (1961) have drawn attention to the desirability of making a comparative examination of the livers of the bigeye tunas from the Atlantic and the Pacific since the description of the nature of the striations of the liver for the Atlantic bigeye given by Mather (1959) and the Pacific bigeye given by Godsil and Byers (1944) indicates likely differences. Until such time that the position can be still further clarified, we advocate the use of the name *mebachi* in a subspecific sense instead of *sibi*.

Hiyama and Kurogane (1961) found that morphometrical comparison of the big eye tuna from the Indo-Pacific based on samples taken from various fishing grounds did not lead to any conclusive results since the samples were inadequate. However, certain trends are indicative, such as, " Among the bigeye tuna from the Equatorial area of the Indian Ocean, as well as the yellowfin tuna, the eastern fish differ from the western fish in having larger heads and more posteriorly positioned fins. The fish from the waters south of the Lesser Sundas differ greatly from those from the Equatorial area. The former have a shorter head and more anteriorly positioned fins than the latter. The differences between the fish from the area south of the Lesser Sundas and from the Banda Sea and also Palao area are not so great as we saw between the former and the Equatorial Indian Ocean ones."

Fujii and Higasa (1959), and Fujii, Mimoto, and Higasa (1959) have carried out biochemical studies on bigeye tuna based on material from the Indian Ocean. Serological studies have been attempted by Suzuki and Morio (1960) while Mimura (1957), Kataoka (1957), Nakagome (1959 *b*), and others have given data on bigeye tuna from parts of the Indian Ocean dealing with length frequencies in the catch, annual and periodic variations in fishing conditions for bigeye, etc. Reference may also be made to the following works for information on the

shoaling habits, food, etc. of bigeye from Indian Ocean : Maeda (1955) ; Yabe, Ueyanagi, Kikawa and Watanabe (1958), and Watanabe (1960).*

DISTRIBUTION : Warmer waters of Indo-Pacific.

NORTHERN BLUEFIN

Thunnus (Kishinoella) tonggol (Bleeker), 1852

(Plate IV, Figs. A & B)

SYNONYMS :

Thynnus argentivittatus Cuvier, 1831. Lectotype as selected by Schaefer and Walford, 1950 : (Type locality : Malabar Coast, India)
Thunnus tonggol Bleeker, 1852 : 356 (Type locality : Sea of Batavia) : 1852 : 89 ; 1861 : 52 ; 1866 : 356
Günther, 1860 : 364
Duncker, 1904 : 158
Thunnus thynnus (*nec* Linnaeus) Ogilby, 1908 : 24 ; 1912 : 58
Thynnus rarus Kishinouye, 1915 : 287 (Type locality : Nagasaki, Japan)
Neothunnus rarus Kishinouye, 1923 : 448
Deraniyagala, 1933 : 49
Thunnus maccoyii (*nec* Castelnau) McCulloch and Whitley, 1925 : 142
Kishinoella rara Jordan and Hubbs, 1925 : 219
Jordan and Evermann, 1926 : 26
Herre 1945 : 148
Thunnus maccoyii (in part) McCulloch, 1926 : 599 ; 1929 : 263
Neothunnus tonggol Jordan and Evermann, 1926 : 22
Thunnus (*Neothunnus*) *rarus* Delsman and Hardenberg, 1934 : 336
Thunnus nicholsoni Whitley, 1936 : 30 (Type locality : Lindeman Island, Queensland)
Thunnus tonggol Tortonese, 1939 : 326
de Beaufort, 1951 : 225–26
Mendes, 1954 : 148
Kishinoella tonggol Serventy, 1941*a* : 33 ; 1942*a* : 94–100 ; 1942*b* L : 101–112
Rosa, 1950 : 38-39 (Synonymy in part)
Herre, 1953 : 249–50
Munro, 1955 : 220 ; 1958*a* : 19
Jones and Silas, 1960 : 384
Thunnus (*Kishinoella*) *tonggol* Fraser-Brunner, 1950 : 145
Deraniyagala, 1952 : 103
Thunnus argentivittatus Rivas, 1961 : 131–32

The history of *Thynnus argentivittatus* Cuvier has been ably summarised by Rivas (1961) who following the suggestion put forward by Schaefer and Walford (1950) recognises it as the Indian yellowfin tuna. On the contrary, we find that Cuvier's *T. argentivittatus*, the lectotype of which was designated by Schaefer and Walford (1950) and examined and reported on by Rivas (1961) is closely akin to *Thunnus* (*Kishinoella*) *tonggol* than to the Indo-Pacific yellowfin

* Since this paper was sent to press we find that S. Kume (1962. *Rept. Nankai Reg. Fish. Res. Lab.*, No. 15: 79-84) has successfully carried out artificial fertilization of bigeye tuna (*Parathunnus mebachi*) from the Western Indian Ocean (between Lat. 3°-6° N., Long. 61°-64°E) in February 1961.

tuna designated here as *Thunnus* (*Neothunnus*) *albacares macropterus*. In fact, we consider *tonggol* and *argentivittatus* as being conspecific and have tentatively placed the latter as a senior synonymy of *tonggol*, our reasons for this action being :

(1) *T.* (*K.*) *tonggol* is quite common along the Malabar coast during certain seasons when it is caught in drift net and hook and line while the yellowfin is hardly ever caught in the coastal waters.

(2) The gill raker count of the lectotype, namely 8 + 18 = 26, fits in well within the range for *tonggol* from Indian waters as shall be presently shown, and the number is too low, for the yellowfin which has a total count of about 29 to 32 gill rakers on each side.

(3) Rivas (1961) has given additional gill-raker counts for three specimens (designated by him as topotypes) of *T. argentivittatus* from the Karachi coast as 6 + 17 = 23. Here again the total gill raker count is too low for a yellowfin. Actual examination of the lectotype and topotypes for characters such as (*a*) presence or absence of air bladder ; (*b*) body colouration ; etc., may aid in confirming our view-point regarding the conspecificity of *T. argentivittatus* and *T. tonggol*. If proven, the specific name *argentivittatus* will have priority over *tonggol*, but we would advocate the suppression of the former in favour of the latter widely current name.

The description of *Kishinoella zacalles* given by Jordan and Evermann (1923) is based on a single specimen out of about a dozen examined by them. Their photograph (plate 7) is of another specimen based on which the following key characters for the species were drawn up by them to distinguish it from *K. rara*. " Pectoral fin longer, 3 1/3 in length to base of caudal, reaching to below the first dorsal finlet, dorsal lobe a little lower than anal, its length about half pectoral ; caudal lobes long, 4 in body ; gill rakers 30 ; silvery markings in the form of about 20 narrow vertical cross streaks." The following diagnosis was given by them for the species : " Head $2\frac{1}{2}$ to base of caudal ; depth $3\frac{1}{3}$; head rather pointed, postorbital narrow ; body plump, the flesh rather soft ; pectoral $3\frac{1}{3}$ in body ; maxillary $2\frac{1}{2}$ in head ; eye 2 in snout, $6\frac{1}{2}$ in head ; dorsal lobe half pectoral, $7\frac{1}{2}$ in body, 2 in head ; D. XII, I, 12 ; A.1, 11 ; finlets small 9/9, the first very small, adnate to dorsal, caudal keel very large, pectorals pointed, reaching vent and to middle of soft dorsal ; gill rakers 9 + 21 = 30".

" Colour steel blue above, grey below, the 20 pale silvery cross streaks, each half to one-third the interspaces, fading anteriorly and posteriorly barely extending on corselet ; head silvery, pectoral silvery, tipped and edged with black ; spinous dorsal yellow ; soft dorsal yellow ; silvery at base and very slightly dark edged ; finlets above and below dull olivaceous yellow, slightly dark edged ; ventral short, silvery in front with yellow inside, shaded with pink and black, cross-streaks on body fainter in larger examples. No air-bladder." The above description has been cited to draw attention to 2 salient points in the description, namely:

(1) The gill raker count of 9 + 21 = 30 ; and

(2) The colouration, especially the vertical cross-streaks.

These two points are of importance as certain authors have treated *K. zacalles* as a doubtful synonymy of *T.* (*K.*) *tonggol*, (Rosa, 1950) or as a definite synonymy of the latter (Collette, 1961). We do not agree with either of these courses for several reasons. Serventy (1956) has given the total gill-raker counts for Australian specimens of *K. tonggol* as 19–25 with the mode at 22 and Silas (1962c) gives the counts for *T.* (*K.*) *tonggol* taken on troll line in the Gulf of Mannar

as 22–27 (6 — 8 + 16 — 19) with the mode at 7 + 18 = 25. These counts are much on the lower side when compared to that known for *K. zacalles*. The colour pattern of *tonggol* is totally different from that of *K. zacalles* given above, being present on the sides of the body as a number of rows of short silvery (whitish on preservation) bars or streaks.

Strangely enough there appear to be no records of *K. zacalles* after its original description to help to solve the problem as to whether there exists such a species at all. The absence of air-bladder is perhaps an important character which prompted Jordan and Evermann to place *zacalles* under the genus *Kishinoella* ; however, it may be worthwhile to re-examine fresh specimens approximating to *K. zacalles* for this character. Barring this, we see considerable similarity between the *K. zacalles* and the bigeye tuna *T. (Parathunnus) obesus mebachi* and to some extent to the yellowfin tuna. Although recognised as a distinct species, *Thunnus (Kishinoella) zacalles* by Fraser-Brunner (1950), for reasons given above we consider this, as a dubious species.

The meristic counts for *T. (K.) tonggol* given by de Beaufort (1951), Deraniyagala (1952), Munro (1955, 1958*a*), Serventy (1956), Ranade (1961), and Silas (1962*c*) indicate the following formulae for the species from the Indian Ocean :

D_1. XI — XIV ; D_2 + finlets 14–15 + 8 — 9 ;
P_1. 29 — 35 ; A + finlets 12 — 14 + 8 — 9 ; gill rakers 5 — 8 + 14 — 19 (= 19 — 27)

T. (K.) tonggol contributes to a minor fishery along the West Coast of India and in the Gulf of Mannar. For more information on aspects of the biology of this species from Indian Waters reference is invited to Silas (1962*c*) and Jones (1962*d*).

DISTRIBUTION : In Indian Ocean and contiguous seas. Somali coast of Africa ; Gulf of Aden ; Karachi coast of Pakistan ; West Coast of India from Kutch to Cape Comorin ; Gulf of Mannar and South East Coast of India ; Ceylon ; Laccadives ; Maldives ; Andamans ; Malay Coast ; Singapore, Java Sea and West Coast of Australia. In the Pacific Ocean it has been recorded from several localities from Western and Central Pacific.

YELLOWFIN TUNA

Thunnus (Neothunnus) albacares macropterus (Temminck and Schlegel), 1844

(Plate III, Fig. B)

SYNONYMS :

Thynnus macropterus Temminck and Schlegel, 1894 : 98 (Type locality : Nagasaki, Japan)
Boeseman, 1947 : 93 (on the type specimen in Leiden Museum)
Oreynus macropterus Kitahara, 1897 : 2
Germo macropterus Jordan and Seale, 1906 : 228
Thunnus macropterus Jordan, Tanaka and Snyder, 1913 : 121
Kishinouye, 1915 : 19
Mendes, 1954 : 148
Neothunnus macropterus Kishinouye, 1923 : 446
Serventy, 1941*a* : 25 ; 1941*b* : 5–6
Munro, 1955 : 219
Jones and Silas, 1960 : 385–87

Germo albacora (in part) Molteno, 1948 : 20
Smith, 1949 : 299
Fourmanoir, 1957 : 227

Thunnus albacora (in part) Fraser-Brunner, 1950 : 144–45

Thunnus macropterus (in part) de Beaufort, 1951 : 223–25

Thunnus (*Neothunnus*) *argentivittatus* Deraniyagala, 1952 : 102–103 (part synonymy and description) (*nec Thynnus argentivittatus* Cuvier, 1831, et Schaefer and Walford, 1950).

In addition to the references given under the ' synonyms ' other important works dealing with aspects of the biology and fishery of the yellowfin from the Indian Ocean and contiguous seas are : Hirano and Tagawa (1952) ; Wheeler and Ommanney (1953) ; Royce (1953, 1961) ; Maeda (1955) ; Tsuruta (1955, 1961) ; Kataoka (1957) ; Kurogane and Hiyama (1958) ; Jones (1959); Tsuruta and Tsunoda (1960) ; Watanabe (1960) ; Yabuta, Yukinawa, and Warashina (1960), Hiyama and Kurogane (1961) ; Jones and Kumaran (1962) ; Silas (1962c) (1962d) ; Silas and Ummerkutty (1962) and Thomas (1962).

On the basis of morphometric studies of the yellowfin from the Indo-Pacific Royce (1961) found that ".....the yellowfin from the Pacific show a continuous cline in morphology along the Pacific Equator, whereas, the samples removed from the Equator differ erratically from the equatorial cline. However, the dimensions are within the range of characters in the cline or are so close to one end or other of the cline that there appears to be no evidence of genetically isolated stocks in the Pacific." Further, from the Indian Ocean, Royce found his sample from off Somaliland (north-east Africa) to be the most diverse when compared to 23 other samples from various parts of the Indo-Pacific and one from Angola, Africa. According to him, " It is similar to one or more Central Pacific equatorial samples in head length, snout to second dorsal, but has very short pectoral, second dorsal and anal fins. Somaliland fish also have a very long distance from the snout to the insertion of the anal, an especially deep body and a long distance from the snout to the insertion of the ventrals. It is very different from the sample from the other side of Africa near Angola.....". However, the specimens having been drawn from a smaller size group and the sample itself inadequate, it is not known whether yellowfin from North East Coast of Africa constitute a distinct population.

Tsuruta (1961) found greater similarities in morphometrical characters between yellowfin from South West of Madagascar (south west Indian Ocean) and Angola (south-east Atlantic).

" Hiyama and Kurogane (1961) are of the opinion that there are a number of independent or semi-independent populations of yellowfin within each ocean distributed in rather localised waters, intermingling with each other, because of the positive difference of morphometrical features between the adjoining populations." They find that the yellowfin from the equatorial area of the Indian Ocean show differences as follows : ".....the eastern fish have a large head, more posteriorly positioned ventral and pectoral fins and longer fins than the western. The yellowfin tuna from the areas south of the lesser Sunda Islands differ from the Equatorial ones in having a shorter head and more anteriorly, positioned fins. The specimens from the lesser Sundas are rather similar to those from the vicinity of the Andaman Islands with respect to the length of the dorsal and anal fins. Accordingly it is probable that the yellowfin tuna inhabiting the waters adjacent to the Lesser Sundas belong to a population distinct from that of the Equatorial Indian Ocean, and that the Western Equatorial ones are somewhat different from the Eastern Equatorial ones, with some intermingling between them."

These observations draw attention to the need for more intensive study on populations of yellowfin tuna from the Indian Ocean as the picture is far from clear.

Reasons are given in this account (p. 39) for considering *T. argentivittatus* Cuvier (1831) *et* Schaefer and Walford (1950), *et* Rivas (1961) to be a senior synonymy of *T.* (*Kishinoella*) *tonggol* (Bleeker). However, the specific name *argentivittatus* has at one time or other been used to denote yellowfin from this area (Deraniyagala, 1952), the Atlantic (South, 1845 ; Rivas, 1951 ; Beebe and Tee-Van, 1936) and the Eastern Pacific (Nichols and Murphy, 1922).

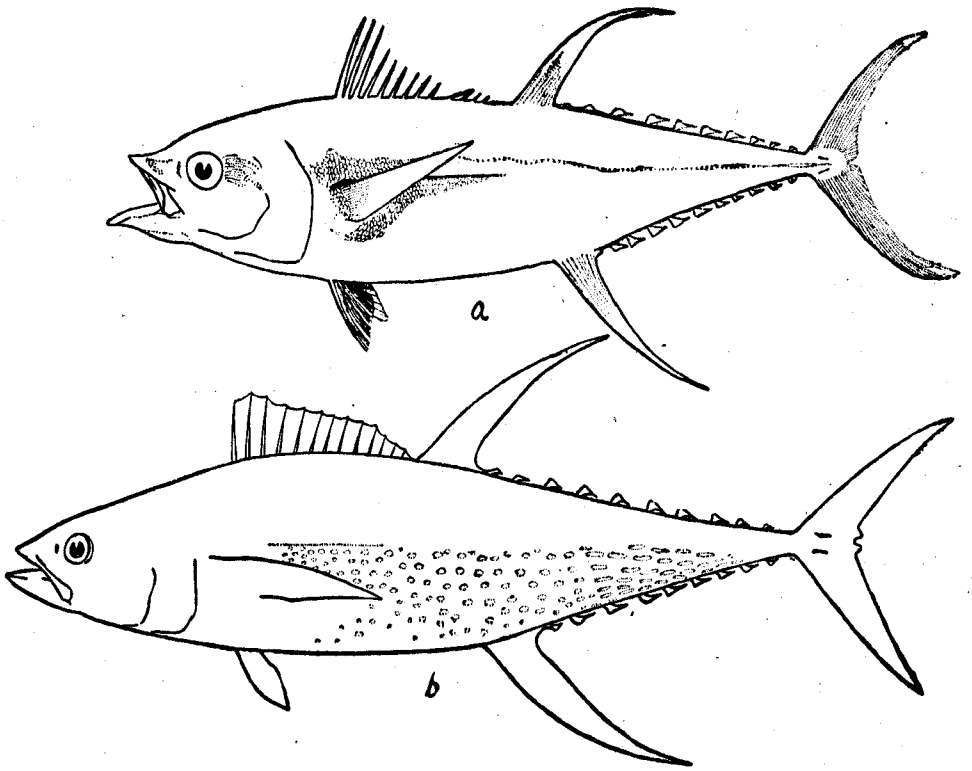
We consider the yellowfin as a single species *T. albacares* (Bonnaterre, 1788) having a world wide distribution, and tentatively recognise the Indo-Pacific form as belonging to a subspecies *T. a. macropterus* (Temminck and Schlegel).

DISTRIBUTION : Warmer waters of the Indo-Pacific. Oceanic, rarely occurring in coastal waters.

ITOSIBI

Thunnus, (Neothunnus?) itosibi (Jordan and Evermann), 1926

(Plate I c ; Text fig. 7)



Text Fig. 7. *Thunnus* (*Neothunnus*?) *itosibi* (Jordan and Evermann). (*a*). specimen from Madras, mounted in the Madras Government Museum and labelled *Thynnus macropterus* (after Jones and Silas, 1960) ; (*b*). Specimen from South Africa (after Barnard ; 1934).

SYNONYMS :

Neothunnus itosibi Jordan and Evermann, 1926: 22–23 (Type: a photograph of a specimen weighing 321 pounds in Honolulu market, Hawaii)
Molteno, 1948 : 33
Jones and Silas, 1960 : 387–88
Semathunnus guildi Fowler, 1933 : 163 (Type locality : Tahiti)
Thunnus macropterus (in part) Delsman and Hardenberg, 1934 : 339
de Beaufort, 1951 : 223–25
Scomber guildi Curtiss, 1938 : 60
Semathunnus itosibi Tinker, 1944
Neothunnus albacora (in part) Barnard, 1947 : 378–80
Neothunnus macroptorus (in part) Fowler, 1949 : 73
Germo itosibi Smith, 1949 : 299
Thunnus (*Neothunnus*) *albacora* (in part) Fraser–Brunner, 1950 : 144
Thunnus albacares (in part) Rivas, 1961 : 136–139

Contrary to general practice, we have not relegated *itosibi* to the synonymy of the Indo-Pacific yellowfin tuna since available data are not conclusive in showing that they are one and the same, merely representing different growth stages. Data obtained from Andaman Waters indicate that specimens of " yellowfin " 111.5 cm. show the excessively elongate second dorsal and anal fins, while yellowfin [*T.* (*N.*) *a. macropterus*] about 130 cm. still show the short second dorsal and anal. More information is needed and until such time this species is given tentative recognition. Since Jordan and Evermann (1926) made no remarks regarding internal anatomical features, its placement under subgenus *Neothunnus* is also tentative.

DISTRIBUTION : General—Indo-Pacific. In Indian Ocean from off the coast of South East Africa, Madras Coast, India, Andaman Sea, Seas around Sunda Archipelago.

Genus **Allothunnus** Serventy, 1948

Allothunnus Serventy, 1948, *Rec. Canterbury Mus.*, 5 (3) 131–135. (Type species : *Allothunnus fallai* Serventy).

Generic diagnosis : body more elongate than *Katsuwonus*, covered completely with minute scales, corselet well-developed, gill rakers more numerous than in any other genus of Thunninae being about 71–75 ; dorsal spines 17 ; vertebrae 41 (?).

Serventy (1948) showed that the affinities of *Allothunnus* was more towards *Katsuwonus* (*e.g.*, in the increased number of gill rakers ; 41 (?) instead of the usual 39 vertebrae etc.). However, Fraser–Brunner (1950) remarks that *Allothunnus* is " in effect, a *Thunnus* with greatly increased number of gill-rakers and reduced dentition (evidently a plankton feeder)."

DISTRIBUTION : As for species.

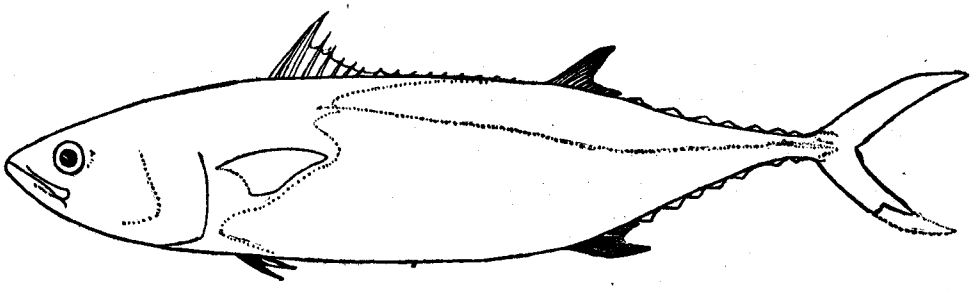
SLENDER TUNNY

Allothunnus fallai Serventy, 1948

(Text fig. 8)

SYNONYMS :

Allothunnus fallai Serventy, 1948 : 131–135 (Type locality : Timaru, South Island, New Zealand)
Fraser-Brunner, 1950 : 148
Rosa, 1950 : 49
Talbot, 1960 : 257–59
Smith, 1961 : 570



Text Fig. 8. *Allothunnus fallai* Serventy (outline taken from photograph given by Serventy, 1948).

Serventy (1948) gives the meristic formulae as : D. XVII, 12 + 7 ; A. 14 + 7 ; P_1. 25.; gill rakers 25 + 48 and 24 + 51 on left and right sides respectively of the type specimen. The tongue, vomer, and palatines are edentulous while teeth on jaws are very minute. Air-bladder is absent.

Talbot (1960) recorded *Allothunnus fallai* from South African waters and gives the gill raker counts as 22–23 + 48–53.

DISTRIBUTION : From South Western Pacific : New Zealand waters south of Lat. 43° S. From Indian Ocean and contiguous seas ; South Africa off Cape.

Genus **Katsuwonus** Kishinouye, 1915

Katsuwonus Kishinouye, 1915. *Sui. Gak. Ho.*, 1 : 21. (Type species ; *Katsuwonus pelamys* (Linnaeus) [= *Scomber pelamis* Linnaeus = *Katsuwonus pelamis* (L.)].

Generic diagnosis : Body fusiform and rounded in cross-section ; scattered scales on body outside corselet and lateral line present ; first and second dorsal more or less contiguous ; vomer and palatines edentulous ; gill rakers 14 to 18 + 34 to 40 ; vertebrae 20 + 21 (= 41) conspicuous dark longitudinal bands along lower half of body ; dark markings on back absent. Monotypic.

DISTRIBUTION : Atlantic, Mediterranean ; Indo-Pacific.

REMARKS : The genus *Katsuwonus* was proposed by Kishinouye (1915) on account of difference in osteology, circulatory systems, etc., evinced by the *Katsuo* (= *Scomber pelamis* Linnaeus) as compared to the genus *Euthynnus* under which it had been relegated till then. Later, additional differences were tabulated by Kishinouye (1923), and *Katsuwonus* and *Euthynnus* were separated as follows :

> " Both epaxial and hypaxial blood-vessels under the skin are equally well-developed, teeth in both jaws only, vertebrae 20–21—*Katsuwonus*. Hypaxial blood vessels under the skin are atrophied ; blood vessels run just above the lateral median line of the body, teeth in both jaws ; palatines and sometimes on the vomer too, epihaemal spines well developed, vertebrae 20–19—*Euthynnus*."

Detailed investigations of the osteology and other anatomical features of *K. pelamis* by Godsil and Byers (1944) and Godsil (1954) confirm Kishinouye's observations on *Katsuwonus* and also draw attention to more differences between this genus and *Euthynnus*.

Some authors (Deraniyagala, 1933 ; de Beaufort, 1951) consider *Scomber pelamis* Linnaeus as a species of *Euthynnus* while others (Fraser-Brunner, 1950 ; Fourmanoir, 1960) treat it as belonging to subgenus *Katsuwonus* of genus *Euthynnus*. However, we follow Kishinouye

(1923), Godsil and Byers (1944), Rivas (1951), and Godsil (1954) in considering *Katsuwonus* as a distinct genus more allied to *Euthynnus* than to *Thunnus*.

It is pertinent to mention here that Kishinouye (1923) and Godsil (1954) have placed *Katsuwonus*, *Euthynnus*, and *Auxis* under a separate family Katsuwonidae as opposed to Thunnidae, both families being distinguished by the following diagnostic characters given in Table V.

TABLE V

Differences between Families Thunnidae and Katsuwonidae

Family Thunnidae	*Katsuwonidae*
1. Body wholly covered with scales.	1. Body naked outside of corselet.
2. Second dorsal and anal high.	2. Second dorsal lower than the first.
3. Vertebrae 18 + 21.	3. Vertebrae generally 20 + 19.
4. Transverse process present, first vertebra short, anchylosed to the skull, alisphenoids meet at the ventral median line.	4. ?
5. ?	5. Some intermuscular bones are divided into two, distal and proximal, epihaemal spine developed between the centrum and haemal arch in most vertebrae, network of haemal processes well developed.
6. Air-bladder generally present.	6. Air-bladder wanting.
7. Intestine folded, spleen showing, totally or in part in ventral view.	7. Intestine straight without a fold in it and spleen dorsolateral to stomach so that it is entirely concealed in ventral view.

*Characters (1–6) are taken from Kishinouye (1923, p. 432) and (7) from Godsil (1954, p. 184).

Some of the characters given by Kishinouye (1923) for both families have exceptions. No doubt, *Katsuwonus*, *Euthynnus* and *Auxis* form a natural group, but we doubt whether such a group should be given family status.

OCEANIC SKIPJACK

Katsuwonus pelamis (Linnaeus), 1758

(Plate V, Fig. C)

SYNONYMS :

Scomber pelamis Linnaeus, 1758 : 296–7 (Type locality : " In pelago inter tropico ")
Scomber pelamys Bloch and Schneider, 1802 : 23
Scomber pelamides Lacépède, 1802 : 14
Thynnus vagans Lesson, 1828 : 279 (1829)? (Type locality : Tahiti)
Thynnus pelamys Cuvier, 1831 : 113
Temminck and Schlegel, 1844 : 96
Bleeker, 1856 : 41
Günther, 1860 : 364 ; 1876 : 151
Day, 1876–78 : 252 ; 1889 : 206–207
Macleay, 1881 : 191
Pelamys pelamys Bleeker, 1865 : 289
Gymnosarda pelamis Jordan and Evermann, 1896 : 868

Katsuwonus pelamys Kishinouye, 1915 : 21

Katsuwonus pelamis Kishinouye, 1923 : 453–56
Serventy, 1941 : 39
Rosa, 1950 : 63–68
Munro, 1955 : 219 ; 1958d : 18
Jones and Silas, 1960 : 383 ; 1962*c* (MS)

Gymnosarda pelamys Barnard, 1927 : 797–98

Euthynnus pelamis Fowler, 1928 : 132 ; 1936 : 616
Deraniyagala, 1933 : 50
Smith, 1949 : 298
de Beaufort, 1957 : 217–18
Steinitz and Ben-Tuvia, 1955 : 9
Fourmanoir, 1957 : 223

Katsuwonus vagans Fowler, 1949 : 73

Euthynnus (*Katsuwonus*) *pelamis* Fraser-Brunner, 1950 : 152
Deraniyagala, 1952 : 104
Williams, 1956 : 42–43

Euthynnus (*Katsuwonus*) *pelamys* Fourmanoir, 1960 (MS)

In an account entitled " Synopsis of biological data on skipjack *Katsuwonus pelamis* from the Indian Ocean ", by Jones and Silas (1962*c*) a reference to which is invited for further details the meristic counts for specimens from Indian Seas (Laccadive Sea) are given as :

D_1. XV–XVI ; D_2 + finlets 13–14 + 8–9 ;
A. + finlets 13–14 + 7–8 ; P_1. 26–28 ; gill rakers 14–18 + 34–39 (= 50–55).

The body proportions expressed as percentages of total length (snout to fork) for 10 specimens ranging from 283–458 mm. are as follows :

Head 29.6 to 30.7 ; first predorsal distance 33.6 to 34.9 second predorsal distance 60.5 to 62.9 ; preanal distance 64.2 to 67.5 ; prepelvic distance 32.9 to 35.6 ; greatest depth of body 23.0 to 26.3 ; length of pectoral 13.1 to 16.7 distance between origin of pectoral and first dorsal 13.1 to 15.5 ; base of first dorsal 24.5 to 28.4 ; base of second dorsal (excluding finlets) 7.4 to 9.1 ; base of second dorsal including finlets 31.8 to 34.9 ; caudal spread 25.6 to 26.5 ; longest (first) dorsal spine 13.0 to 15.6 ; length of second dorsal 6.0 to 9.3 ; length of anal 4.6 to 8.4 ; length of pelvic 10.3 to 11.9 ; least depth of caudal peduncle 1.9 to 2.2 ; greatest width of caudal peduncle at keel 3.5 to 4.5 ; length of maxilla 10.2 to 11.9 ; diameter of iris 4.3 to 5.9 ; longest gill filament 6.7 to 7.4, per cent in total length.

Some workers have used *K. vagans* to denote the Pacific representatives of *Katsuwonus*, but it is now well recognised that in all the oceans, *K. pelamis* shows no marked variations to enable separation into different species. However, there can be no doubt that eventual analysis may throw light on the existence of different populations.

DISTRIBUTION : General : Atlantic, Mediterranean and Pacific. In Indian Ocean and contiguous seas ; off South and East Coast of Africa, Gulf of Aden ; Red Sea ; Laccadives ; Maldives ; Gulf of Mannar ; Seychelles, Mauritius ; Reunion ; Madagascar ; Seas around Sunda Archipelago ; Western Australia. Larvae have been collected in the open seas from several localities.

Genus **Euthynnus** Lütken in Jordan and Gilbert, 1882

Thynnichthys Giglioli, 1880. *Cat. Pesci. Ital.*, p. 25 (Type species: *Thynnus thunnina* Cuvier = *Scomber alletteratus* Rafinesque). (Name preoccupied by *Thynnichthys* Bleeker, 1859 — a genus of Cyprinidae, Pisces).

Euthynnus Lütken, *in* Jordan and Gilbert, 1882. *Bull. U.S. Nat. Mus.* No. 16 : 429 (1883). (Type species : *Thynnus thunnina* Cuvier = *Scomber alletteratus* Rafinesque, Orthotypic. (Genotype wrongly given by Jordan : Genera of Fishes, pt. 4, p. 42, 1920, as " Orthotype *Thynnus pelamys* L.")

Wanderer Whitley, 1937. *Austral. Zool.*, 8 (4) : 229 (Type species : *Wanderer wallisi*, Whitley Orthotypic).

Body fusiform, elongate, corselet well developed ; lateral line single, rest of body naked ; teeth minute, uniserial on jaws ; present or absent on vomer and palatines ; pectorals short, hardly half head length, two dorsals more or less contiguous, second dorsal and anal lobes short, followed by 8 or 9 dorsal and 6 or 7 anal finlets ; gill rakers well developed ; gill membranes free.

DISTRIBUTION : Atlantic, Mediterranean, Indo-Pacific.

REMARKS : The genus *Euthynnus* has at one time or other been placed under the family Scombridae (Fowler, 1936 ; Smith, 1949 ; Fraser-Brunner, 1950 ; Rivas, 1951 ; Jones and Silas, 1960) ; or under family Katsuwonidae (Kishinouye, 1923 ; Jordan and Hubbs, 1925) or family Thunnidae (Fowler, 1949 — Subfamily Katsuwoninae) or under family Sardidae (Whitley, 1937). We consider *Euthynnus* as a distinct genus of subfamily Thunninae.

Fraser-Brunner (1949) recognised two species, namely *E. affinis* (Cantor) with the subspecies *E. a. affinis* (Cantor), *E. a. yaito* Kishinouye, and *E. a. lineatus*, Kishinouye ; and *E. alletteratus* Rafinesque with two subspecies *E. a. alletteratus* (Rafinesque) and *E. a. auro-littoralis* Fraser-Brunner. Later, in 1950 he treated *Katsuwonus* Kishinouye as a subgenus of *Euthynnus* recognising only *E. (E). affinis*, *E. (E.) alletteratus*, and *E. (K.) pelamis*. We consider *Katsuwonus* as a separate genus.

The differences between the Atlantic and Indo-Pacific representatives of *Euthynnus* appear to be relative and not clear cut. Fraser-Brunner (1950) distinguished the two species as follows :

" A. Vomerine teeth present. Gill rakers 7 to 12 + 22 or 23. Thoracic spots all below base of pectoral.....1. *affinis*.

B. No vomerine teeth. Gill rakers 10 to 12 + 29 to 30. Uppermost thoracic spots level with pectoral base.....2. *alletteratus*."

At the same time, the single species concept has led some authors to apply the specific name *E. alletteratus* (or *E. alleteratus*) for the Indo-Pacific forms of *Euthynnus* as well. We feel that Fraser-Brunner's review of the genus (1949, 1950) nor that by Kishinouye (1923) and Godsil (1954) give us a clear final picture. As in the case of other tunas, a lot more remains to be known and we may summarise some of these problems as under.

1. Fraser-Brunner's (1950) account would show that the differences between the Atlantic and Indo-Pacific forms in the number of gill rakers is very clear cut. This need not be the case for, Rivas (1951) gives the gill raker count in *E. alletteratus* from W. Atlantic as 25 to 29 on lower limb of the first arch. We have elsewhere (Jones and Silas, 1960) given the count for *E. affinis* as 22 to 25 on the lower limb of the first arch for specimens from Indian waters,

These suggest the possibility of overlap in the range between *Euthynnus* from the Atlantic and the Indo-Pacific. However, one interesting feature is, that as far as is known, in the typical *E. affinis* as well as in *E. yaito* recognised as its subspecies, the range of gill raker counts is almost identical. In *E. lineatus*, Godsil's data (1954) indicate that the number on the lower limb is higher, the range being 7–11 + 1 + 23–29, in which similarity is seen with the high count of 10–12 + 1 + 25–30 (combined data from Fraser-Brunner, 1950; Godsil, 1954; and Rivas, 1951) in *E. alletteratus*. It will be well worth obtaining more data on gill raker counts for *Euthynnus* from the different faunal areas.

2. The presence or absence of vomerine teeth is given considerable importance in separating *E. affinis* and *E. alletteratus*. In some specimens of *E. a. affinis* that we have examined from the Indian coast, the vomerine band of teeth is very poorly developed, especially in larger specimens. However, two specimens kindly sent to us by Mr. Soong Ming Kong from Malaya (the area from where Cantor, 1850, described *Thynnus affinis*) have the vomerine teeth very well developed as a distinct uniserial band. Kishinouye (1923) remarks that vomerine teeth are also present in *E. yaito* and *E. lineatus*, but absent in *E. alletteratus* from the Atlantic. According to de Beaufort (1951), Chabanaud (1925) found vomerine teeth both in *yaito* and *alletteratus*, but recorded other differences, such as the number and length of the gill rakers, the number of teeth in the jaws, the distance between the articulation of the first pectoral ray and the opercle, the form of emargination of the corselet and the relative development of the caudal keel. Steindachner (1896) found vomerine teeth present in *E. alleteratus* (*nec* Rafinesque) from Japan, but absent in specimens from St. Thomas (W. Indies) and Nice (Mediterranean). Godsil's (1954) detailed study also corroborates this view of the absence of vomerine teeth in the Atlantic *E. alletteratus*. De Beaufort (1951) remarks that "Klunzinger.....misses them, as well as palatine teeth, in two specimens of 750 mm. length from the Red Sea, and suggests that they are only present in young ones." Whitley (1937) described a new genus and species, *Wanderer wallisi* (= *Euthynnus affinis affinis*?) from Australian waters and remarks that his species lacks vomerine teeth. However, the gill raker count of 9 + 23 is in agreement with that of *E. affinis*. All these point to the uncertainty that still surrounds even a salient character used in species discrimination in *Euthynnus*.

3. Fowler (1934, 1936) and Smith (1949, 1961) have recorded *Euthynnus alletteratus* from South African waters including Natal Coast. They do not, however, recognise *E. affinis* from that coast. Fowler's (1936) description of *E. alletteratus* is based on material from St. Thomas, West Indies and not from South Africa, having gill rakers 8 to 10 + 24 or 25. These are low counts for *E. alletteratus* when compared to the figures given by Fraser-Brunner (1950) but is more in agreement with what Rivas (1951) mentions. However, the total count deduced from Fowler's data definitely is on the lower side as is the case for the Indo-Pacific *E. affinis*. Smith (1949) mentions "About 25 gill rakers" on the lower limb of the outer gill arch in *E. alletteratus* and since he apparently follows the single species concept, his specimens could either be *E. a.lletteratus* or *E. affinis*. His mention of "1–5 dusky spots below pectoral sometimes present, may all be absent" and the accompanying colour figure (pl. 65, fig. 830) wherein the spots below the pectoral are shown much below the pectoral base, suggest that he may be dealing with *E. affinis* and not *E. alletteratus*. All the same, as an element of doubt has been introduced as to whether one or both the species occur in South African waters (S.W. Indian Ocean) we have tentatively included *E. alletteratus* also in this account. It is not unlikely that in South African waters of Indian Ocean *E. alletteratus* may show overlap in distribution with that of *E. affinis*, similar to *E. affins affinis* and *E. a. yaito* in the Western Pacific and the latter and *E. lineatus* in the Eastern Pacific.

4. The number of vertebrae is another important character in separation of species in *Euthynnus*. Available data which on the whole is meagre indicate the range as 36 to 39 but generally 39. In *E. lineatus*, Godsil (1954) found that of 29 specimens examined 27 had 37 vertebrae and one each had 36 and 38 vertebrae. This character by itself is significant in separating *E. lineatus* specifically from other members of the genus, although Godsil has drawn attention to several other distinguishing features as well. In seven specimens of *E. alletteratus* and in eight specimens of *E. yaito* Godsil found the vertebrae to number 39. Delsman (1931) gives 19 + 19 = 38 as the count for *Euthynnus thunnina* (= *E. affinis*) from Indonesian waters, but 2 specimens we have examined from the Indian Coast (Tuticorin) have 39 vertebrae. Since this character happens to be of diagnostic value within the genus, there is a great need for making proper vertebral counts in *Euthynnus* from the different faunal areas.

5. Having examined a specimen of *E. yaito* kindly sent to us by Mr. J. C. Marr from Hawaii (Plate V, Fig. B) we are at a loss to distinguish the species from *E. affinis*. From existing literature also there is difficulty in separating *affinis* from *yaito*, and in the Western Pacific, it is hard to say where the distribution of *affinis* ends and that of *yaito* begins. It has been suggested that they may be synonymous, but until such time that this is proven, we consider it desirable to retain *yaito* as a subspecies of *E. affinis*. These preliminary observations lead us to recognise the following species and subspecies under the genus *Euthynnus*.

(1) *Euthynnus alletteratus* (Rafinesque)—Atlantic ; Mediterranean ; South Western Indian Ocean around South Africa (?).

(2) *Euthynnus affins affinis* (Cantor)—Indian Ocean ; Western part of Western Pacific.

(3) *Euthynnus affinis yaito* Kishinouye—Pacific Ocean.

(4) *Euthynnus lineatus* Kishinouye—Eastern Pacific.

ATLANTIC LITTLE TUNNY

Euthynnus alletteratus (Rafinesque), 1810

SYNONYMS :

Scomber alleteratus Rafinesque, 1810 : 40 (Type locality : Palermo, Sicily). (also given as *Scomber alletteratus* by Rafinesque, 1810 in *Caratteri Nuov. An. Sicil.*, pl. 2, fig. 3)
Thynnus leachianus Risso, 1826 : 414 (Type locality : Nice)
Thynnus thunnina Cuvier, 1831 : 104 (Type locality : Mediterranean)
Thynnus brasiliensis Cuvier, 1831 : 110 (Type locality : Brazil)
Thynnus brevipinnis Cuvier, 1831 : 112 (Type locality : Mediterranean)
Gymnosarda alletterata Jordan and Evermann, 1896 : 869
Euthynnus alletteratus Jordan, Evermann, and Clark, 1930 : 258
Fraser-Brunner, 1950 : 150–51
Rivas, 1951 : 216–17
Euthynnus alletteratus Fowler, 1936 : 616–17
Smith, 1949 : 298 (*E. alleteratus* — in part?)
Euthynnus alletteratus alletteratus, Fraser-Brunner, 1949 : 622–27
Euthynnus alletteratus aurolitoralis Fraser-Brunner, 1949 : 622–627 (Type locality : Accra, Gold Coast, W. Africa)

The specific name *alletteratus* has been spelt differently as *alleteratus, alliteratus, alleterata, alletterata,* and *alliyterata.* See Rosa (1950 : 56–57) for more detailed synonymy.

The salient characteristics and distribution of this species have already been mentioned in the 'remarks' under the genus.

LITTLE TUNNY OR MACKEREL TUNA

Euthynnus affinis affinis (Cantor), 1880

(Plate V, Fig. A)

SYNONYMS :

(?) *Scomber quadripunctatus* Geoffroy St. Hilaire, 1827, pl. 24, fig. 3 (Type locality : Red Sea, Egypt)

Thynnus affinis (Cantor, 1850 : 1088, (Type locality : Sea of Penang)
Günther, 1860 : 363

Auxis taso (*nec* Cuvier) Bleeker, 1850 : 8

Thynnus thunnina (*nec* Cuvier) Bleeker, 1852 : 36
Day ; 1876–78 ; 252 ; 1889 : 205–206
Günther, 1876 : 150 ; 1889 : 17
Klunzinger, 1884 : 111

Pelamys thunnina (*nec* Cuvier) Bleeker, 1865 : 289

Euthynnus alletteratus (*nec* Rafinesque) Deraniyagala, 1933 : 51
Serventy, 1941 : 104
Fourmanoir, 1957 : 222–23

Wanderer wallisi Whitley, 1937 : 229 (Type locality : off North Bother Mountain, New South Wales, Australia—Holotype purchased from Sydney Fish Market)

Euthynnus affinis affinis Fraser-Brunner, 1949 : 623
Williams, 1956 : 41–42
Jones and Silas, 1960 : 389

Euthynnus (*Euthynnus*) *affinis* Fraser-Brunner, 1950 : 150 (Recognises a typical subspecies and subspecies *yaito*, both figured)

Euthynnus affinis (in part) Rosa, 1950 : 58–62

Euthynnus alletteratus affinis (in part) de Beaufort, 1951 : 218–21

Euthynnus alletteratus affinis Mendes, 1954 : 147
Munro, 1958*b* : 18

Euthynnus affinis Wheeler and Ommanney, 1953 : 61–63
Munro, 1955 : 219
Steintz and Ben-Tuvia, 1955 : 9
Jones, 1960 : 101–106

Euthynnus alletteratus (in part ?) Fowler, 1934 ; 1936 : 617–619
Smith, 1949 : 298

Euthynnus yaito (*nec* Kishinouye) Blanc and Postel, 1958 : 369–370

The problem of nomenclature has not yet been fully settled in the case of the little tunny. As Whitley (1937) has drawn attention to, the name *Thynnus affinis* of Cantor [*J. Asiat. Soc. Bengal*, 18, 1849 (Dec. 1850) : 1058] is preoccupied by *Thynnus affinis* Guerin-Meneville, 1838, for a species of insects. This being so, according to the Rule of Zoological Nomenclature, the name *Thynnus affinis* is not available for the little tunny. However, we feel that it should stand as *Euthynnus affinis*, and being widely current, it will be desirable to retain the name. In case the name *affinis* has to be replaced, *yaito* has a better claim than *wallisi* which was characterised as not having vomerine teeth. The problem does not end there for de Beaufort (1951) shows that *affinis* may have to give way to *quadripunctatus* of Geoffory St. Hilaire, " who figured *Scomber quadripunctatus* (*Descr. Egypte, Poissons*, 1814, Tab. 24, Fig. 3) after a specimen from the Red Sea." Eventually if it is found that the present assumption that the little tunny from

the Indian Ocean is specifically distinct from *E. alletteratus* from the Atlantic, a special ruling to validate the specific name *E. affinis* and its retention in preference to *quadripunctutus* may be necessary.

Our observations and those of various authors who have reported on *Euthynnus affinis* from the Indian Ocean (Cantor, 1850 ; Day, 1878, 1889 ; Deraniyagala, 1933, 1952 ; Fraser-Brunner, 1949, 1950 ; Morrow, 1954 ; Munro, 1955, 1958*b* ; Steinitz and Ben-Tuvia, 1955 ; Williams, 1956 ; Blanc and Postel, 1958 ; and Jones and Silas, 1960) indicate the following meristic counts for *E. affinis* :

D_1. XIV ; D_2 + finlets 11–14 + 8–9 ; A. + finlets 12–15 + 6–8 ;
P_1. 24–28 ; Gill rakers 7–10 + 22–25.

In six specimens of *E. affinis* from the Gulf of Aqaba, Red Sea, Steinitz and Ben-Tuvia (1955) give the gill-raker counts as 23 (3) ; 24 (2) and 30 (1). Presumably these refer to the number of rakers on the lower limb of the outer gill arch and if so, the number of 30 for a specimen of *E. affinis* (403 mm. in length) is very unusual, unless by mistake in this particular instance the rakers on the upper limb have also been included.

The little tunny from the Reunion is recorded by Blanc and Postel (1958) as *Euthynnus yaito* with gill raker count of 8 + 1 + 24 = 33.

As regards the black spots below the pectoral, it is highly variable and we have examined specimens in which they are totally absent on both sides or some in which as many as 8 may be present.

DISTRIBUTION : General distribution is—Indian Ocean and Western Pacific. In Indian Ocean and contiguous seas it is widespread from the entire East Coast of Africa, Red Sea, Gulf of Aden, Karachi Coast of Pakistan ; East and West Coasts of India ; Ceylon, Andamans, Burma Coast ; Malaya, Indonesian waters south of Java, Western Australia and in between these areas from the Laccadives, Maldives, Scychelles, Aldabra, Madagascar, Mauritius, Reunion, etc.

SUBFAMILY *SCOMBEROMORINAE*

The Scomberomorinae includes the spanish mackerals or seerfishes coming under the genus *Scomberomorus*, and the wahoo under the monotypic genus *Acanthocybium*.

Genus **Scomberomorus** Lacépède, 1802

Scomberomorus Lacépède, 1802 *Hist. Nat. Poissons*, 3 : 296 (Genotype : *Scomberomorous pulmieri* Lacépède, 1802 : *Scomber regalis* Bloch, 1793).

Cybium Cuvier, 1829 *Regne Animal*, 2 (Ed. II) : 99 (Genotype : *Cybium Commersonii* Cuvier).

Other generic synonyms are :

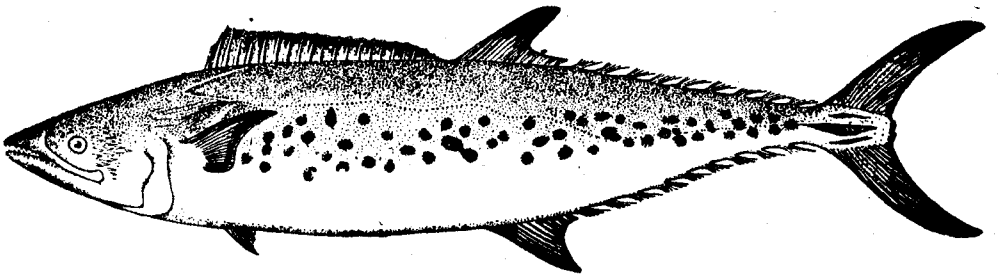
Polipturus Rafinesque, 1815
Apolectus Bennett, 1831 (*nec* Cuvier)
Apodontis Bennett, 1831
Cibium Troschel, 1849
Chriomitra Lockington, 1879
Sierra Fowler, 1904
Sawara Jordan and Hubbs, 1925
Indocybium Munro, 1943
Pseudosawara Munro, 1943

Lepidocybium Gill (1862) given as a synonym of *Scomberomorus* by Fraser-Brunner (1950) and as a subgenus of *Scomberomorus* by Munro (1943) is a Gempylid (Family Gempylidae) as later shown by Munro (1949).

The nomenclatorial status of the genus *Scomberomorus* Lacépède, which has priority over *Cybium* Cuvier, has been discussed in detail by us recently (Jones and Silas, 1961) and as stated therein we are not in favour of the splitting of the genus into subgenera as proposed by some of the previous workers. The characters at the generic level of all the species occurring in the Indian, Pacific and Atlantic Oceans are basically the same and therefore the seerfishes dealt with in this account are described under *Scomberomorus* without giving any subgeneric status.

SAWARA OR JAPANESE SPANISH MACKEREL

Scomberomorus niphonius (Cuvier), 1831



Text Fig. 9. *Scomberomorus niphonius* (Cuvier) (after Munro, 1943).

SYNONYMS :

Cybium niphonium Cuvier, 1831 : 180–81 (after a Japanese painting).
Kishinouye, 1923 : 42.
Cybium niphonicum Kner, 1869 : 144 (species name mis-spelt).
Cybium gracile Günther, 1873 : 378 (Type locality : Cheefoo, China).
Scomberomorus niphonius Tanaka, 1912 : 154–157.
Sawara niphonia Jordan and Hubbs, 1925 : 214.
Munro, 1958 : 20.
Scomberomorus gracilis Tortonese, 1939 : 321–322.
Scomberomorus gracileus Chu, 1931 : 107 (Species name mis-spelt).
Scomberomorus (*Sawara*) *niphonius* Munro, 1943 : 86.
Rosa, 1950 : 104.
Scomberomorus (*Scomberomorus*) *niphonius* Fraser-Brunner, 1950 : 159.

This species is included here on account of its recent record from Western Australia between Cape Leveque and Abrolhos Island (Munro, 1958). Better known from Japanese waters, the following combination of characters easily distinguishes it from other scomberomorinae from the Indo-Pacific :

(1) First dorsal with XX–XXII spines. An exception appears to be Kishinouye's (1923) mention of XIX spines.
(2) The posterior margin of the pectoral fin is deeply excised forming two distinct lobes.

(3) Swim-bladder absent.
(4) Gill rakers 2–3 + 9–11.
(5) As in the case of the pectoral, the postero-ventral margin of the preopercle is deeply excised, a feature more pronounced than in other species of *Scomberomorus*.
(6) Vertebrae 22 + 28 (= 50).
(7) Scales covering body comparatively large.
(8) Body covered with anastomosing spots about size of pupil of eye and confined to a band along middle of side.

Munro (1943, 1958) gives the fin ray counts for Australian examples as : D 20–22 + 16–19 + 9–10 ; A. 15—18 + 9 ; P_1 23. For specimens from Japan it is : D 22 + 16 + 8 ; A. 17 + 8 ; P_1 21 or 23 (Tanaka, 1912), and D 19 + 15 + 9 ; A. 15–17 + 8 (Kishinouye, 1923).

This species is of special interest on account of two reasons : First, due to its apparent disjunct distribution and secondly the difference of opinion of some of the earlier workers regarding the nature of its lateral line. On these, Munro (1943) comments that : " There may remain a little doubt as to whether Australian specimens belong to the same species as those from Japanese and Chinese waters. The break in the geographical distribution might suggest specific distinction, but making allowances for minor variations the morphological differences between Australian and Japanese examples are not great. Markings, colouration, gill raker counts, body proportions, shape of pectoral fin and preopercle indicate synonymy. It is possible that the nature of the lateral line may prevent these two species from being conspecific. Although the lateral-line is reported to be branched in oriental specimens, there is no evidence of such branching in examples caught in Queensland waters. This character apparently is of some importance since Jordan and Hubbs (1925) used this feature to separate their subgenus *Sawara*. At the same time it is well worth noticing that Tortonese (1939) reinstated Günther's name "*gracilis*" for application to an oriental specimen which lacked branching of the lateral line. As stated earlier, it is very probable that the branching of the lateral-line is not as noticeable or as regular as described by Kishinouye and followed by later authors. Australian examples fit well enough the descriptions and resemble in the main essentials the illustrations of Cuvier and Valenciennes (1831), Günther (1860, 1873), Temminck and Schlegel (1884), Tanaka (1912), Kishinouye (1923), Fowler (1936) and Tortonese (1939). As already suggested in the description of the subgenus *Sawara*, there appears to be insufficient justification for considering *S. niphonius* and *S. gracilis* separate species. Also, it is reasonable that the Australian form is similarly conspecific."

Jordan and Hubbs' (1925) definition of the genus *Sawara* (type *C. niphonium*) runs as follows : " This genus differs from *Scomberomorus* in lacking the air-bladder, and in the presence of sharp branch canals placed at right angles along the course of the lateral line." The branch canals of the lateral line are depicted in Kikkawa's drawing of *C. niphonium* published in Kishinouye (1923 : fig. 32) as being distinct and running antero-posteriorly, perhaps giving rise to some of the confusion. As mentioned by Munro (1943) the lateral line branches in *C. niphonium* are " apparently true ramifications as are seen well developed in *Acanthocybium* or vestigially in older age groups of *S. commerson*." The nature of the branching is definitely different from that seen in *S. guttatus guttatus*.

DISTRIBUTION : In Indian Ocean and contiguous seas : Western Australia between Cape Leveque and Abrolhos Island ; and along coast of Northern Territory of Australia.

In the South Pacific, North New South Wales, Queensland and Torres strait. In North Pacific Ocean according to Rosa (1950) " Coast of U.S.S.R. around Vladivostok, Coast of Korea, both coasts of Japan, on Honshu, Shikoku and Kyushu, a few stragglers found as far north as Hokkaido, Coast of China ".

SEERFISH OR BARRED SPANISH MACKEREL

Scomberomorus commerson (Lacépède)

(Plate VII, Fig. C)

SYNONYMS :

Scomber commerson Lacépède, 1800 : 598–603, pl. 20, fig. 1 (Based on MS. drawing by Commerson. Type locality : Mauritius as given by Cuvier)

Scomber commersoni Bloch and Schneider, 1801 : 545–46 (after Lacépède)

Scomber commersonii Shaw, 1803 : 589–590 (after Lacépède—' Pacific Ocean ')

Scomber maculosus Shaw, 1803 : 592 (based on *Konum* of Russell, 1803, *Fish. Vizag.*, 2 : 27, pl. 135 : Coromandal Coast, Bay of Bengal)

Cybium commersonii Rüppell, 1828 : 94–95 ; 1835 : 41
Cuvier, 1829 : 200 ; 1831 : 165–70
Bleeker, 1849 : 77 ; 1850 : 100 ; 1851 : 212 ; 1853 : 42 ; 1858 : 246 ; 1859 : 64
Pollen, 1850 : 5
Jerdon, 1851 : 136
Günther, 1860 : 370
Day, 1865 : 69–70 ;1876–78 : 255 ; 1889 : 211
Playfair and Günther, 1866 : 67
Klunzinger, 1871 : 444 ; 1884 : 112–13
Karoli, 1881 : 162
Sauvage, 1891 : 320
Gilchrist, 1902 : 128
Duncker, 1904 : 158
Gilchrist and Thompson, 1909 : 284
Maxwell, 1921 : 274
Gudger, 1929 : 517
Delsman, 1931 : 402, 407
Anon. (Agric. Marketing in India, Market. Ser. 24), 1941 : 37

Cybium commersoni Cantor, 1850 : 1090
Robinson, 1916 : 63
Jordan and Hubbs, 1925 : 214
Sorley, 1933
Munro, 1955 : 221 ; 1958*a* : 20 ; 1958*b* : 262
Fourmanoir, 1957 : 225
John, 1959 : 133

Cybium konum Bleeker, 1851 : 343 ; 1853 : 42 ; 1855 : 345 ; 1858 : 242, 246 ; 1859 : 64

Scomberomorus konum Bleeker, 1851 : 357 ; 1852 : 39

Cybium Konum Kner, 1865–67 : 144

Scomberomorus commersonii Swain, 1883 : 306
Gilchrist and Thompson, 1917 : 395

Cybium commersonii (in part) Saville-Kent, 1893 : 291, 311

Scomberomorus commersoni Jordan and Seale, 1906 : 288
Thompson, 1918 : 112
Barnard, 1927 : 802
Norman and Fraser, 1937 : 153
Munro, 1942 : 33–48
de Beaufort, 1951 : 230–32
Copley, 1952 : 166–67
Deraniyagala, 1952 : 97–98 (*S. commersonii comersoni* on p. 97 apparently an error)
Herre, 1953 : 244
Mendes, 1954 : 148

Scomberomorus commersonii (in part) Stead, 1908 : 98

Cybium multifasciatum Kishinouye, 1915 : 9 (Type locality : Off the coast of Yamaguchi Perfecture, Japan)

Cybium commerson Kishinouye, 1923 : 416
Whitley, 1936 : 32–38

Scomberomorus (*Cybium*) *commerson* Whitley, 1927 : 5
Munro, 1943 : 74–82
Rosa, 1950 : 97–100
Fraser-Brunner, 1950 : 161

Scomberomorus commerson Paradice and Whitley, 1927 : 82
Delsman and Hardenberg, 1934 : 340, 342
Marchand, 1935 : 77
Fowler, 1935 : 380 ; 1938 : 102
Herre and Myers, 1937 : 21
Tortonese, 1939 : 322
Smith, 1949 : 301
Herre, 1953 : 245–46
Wheeler and Ommanney, 1953 : 66
Williams, 1956 : 43–44
Anon 1960 (Rep. Aden Protectorate Fish. Dept. 1947–58) : 11
Jones, 1961 : 113–117
Jones and Silas, 1961 : 194–195

Scomeromorus (*Scomberomorus*) *commersoni* Deraniyagala, 1933 : 40

Scomberomorus commersonii Scott, 1959 : 113

For a discussion on the ' synonymy ' reference is invited to Munro (1943). The references listed above are not exhaustive, but the more important works pertaining to the Indian Ocean are listed.

The low gill raker count of 2 to 6 rakers on the lower limb of the outer arch (generally 3 or 4) and the deep infliction of the lateral line below the posterior end of the second dorsal to second or third finlet behind it, help in easily distinguishing this species from its congeners.

Jones (1961) has shown that the finlets in *S. commerson* get differentiated even at an early stage of 14.4 mm. The lateral line is discernible in juveniles about 42 mm. in length and as in adults shows the characteristic infliction below the posterior end of the second dorsal. We have noted abnormalities in the lateral line in more than one instance. This is seen mainly in the form of discontinuity in the line or in a second branching (up to 5 or 6 cm.) of the main lateral line below the second dorsal fin. As mentioned by Munro (1943) and depicted by Deraniyagala (1933, 1952) very large examples of *S. commerson* evince a type of vestigial branching of the lateral line (the branches running more or less at right angles to the main lateral line) as seen in *Acanthocybium solandri*. The scales along the lateral line in 3 specimens were found to number 228, 235 and 244.

The body colouration in juveniles and adults differs greatly. In the former generally several large dusky blotches are seen on the side of the body. In adults these merge to form dark irregular vertical stripes, their number differing, depending on the size of the specimen. In young about 400 mm. there may be as few as 20 bars while in a specimen 1.5 metres long about 65 have been counted.

The fin ray count for the species is : D_1 XIV—XVII ; D_2 14–19 + 9–11 ; A. 14–18 + 8-10 ; P_1 20–24. No marked deviation in fin ray counts is noticeable from place to place. The vertebrae are 20 + 25=45.

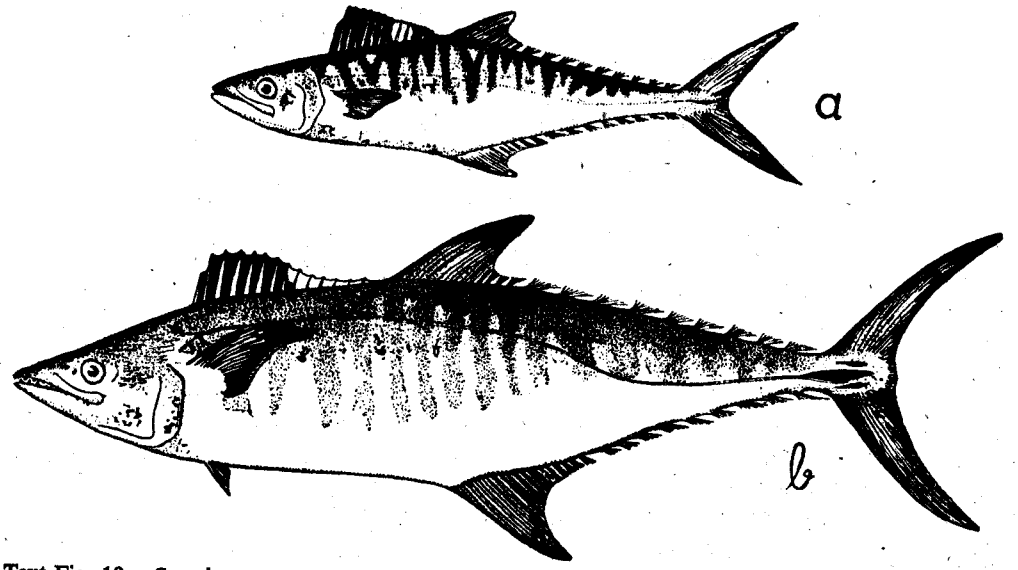
The gill-rakers though few are variable both with age as well as in specimens of the same size. Jones (1961) found the following combinations in specimens 54.5 to 278 mm. in length ; 0 + 2 ; 0 + 3 ; 1 + 3 ; and 1+4 ; in this case the larger number is apparently more characteristic of the larger examples. In specimens over 300 mm. it was invariably seen that one of the rakers was situated at the angle of the upper and lower limbs of the outer gill arch. In order to avoid confusion this raker is indicated separately as+1 and the following combinations have been encountered : 0 + 1 + 4 ; 0 + 1 + 5 ; 1 + 1 + 2 ; 1 + 1 + 3 ; 1 + 1 + 4 ; 1 + 1 + 5 and 1 + 1 + 6 ; but 0 + 1 + 4 ; 1 + 1 + 3 and 1 + 1 + 4 are the more frequent counts.

Munro (1942) and Jones (1961) have dealt with eggs, larvae and juveniles of *S. commerson*. Although important as one of our prime food fishes, little information is available about the biology of this species from Indian waters or far that matter from other areas. The collection of larvae and early juveniles less than 100 mm. (14.4 — 91.50 mm.) (Jones, 1961) from off Vizhingam along the South West Coast of India during the months January–March points to this area being one of the likely spawning areas of this species. No proper figures of landings of this species or for that matter any species of *Scomberomorus* are available from the Indian Coast. Earlier data listed under '*Cybium* sp. or *Scomberomorus* sp.' or ' Seerfish ' may be taken as being composite involving more than one species.

DISTRIBUTION : *S. commerson* is the most widely distributed species of the genus. In Indian waters it is caught all along the Indian Coast and Andamans and may also occur in the Laccadives. The general distribution of the species is from the Red Sea, East Coast of Africa as far south as Cape of Good Hope, and eastwards through Mauritius and the Coast of India, Ceylon, Burma, Malaya to the Australian coast and further eastwards to Fiji, New Caledonia, Solomon Islands ; and in Western Pacific along the Sunda Archipelago, Thailand Coast, Philippines, Taiwan and Japan.

BROAD-BARRED SPANISH MACKEREL

Scomberomorus semifasciatus (Macleay), 1883



Text Fig. 10. *Scomberomorus semifasciatus* (Macleay) (*a*) juvenile, and (*b*) adult (after Munro, 1943).

SYNONYMS :

Cybium semifasciatum Macleay, 1883 : 205–206 (Type locality : Lower Burdekin River, Queensland)

Cybium tigris De Vis, 1884 : 545 (Type locality : Cape York)

Scomberomorus semifasciatus McCulloch and Whitley, 1925 : 142
McCulloch, 1929 : 264

Scomberomorus tigris McCulloch and Whitley, 1925 : 142
McCulloch, 1929 : 264

Cybium commersonii Saville-Kent, 1893 : 291–311, Pl. 46, fig. 1 (*nec* Lacépède)

Scomberomorus commersonii Stead, 1908 : 98, Pl. 46 (*nec* Lacépède)

Cybium guttatum Rendahl, 1921 : 16 (*nec* Bloch and Schneider)

Scomberomorus (*Indocybium*) *semifasciatus* Munro, 1943 : 91–95
Rosa, 1950 : 107

Scomberomorus (*Scomberomorus*) *semifasciatus* (in part) Fraser-Brunner, 1950 : 150

Indocybium semifasciatum Munro, 1958 : 20

Munro (1943) has given reasons for considering *Cybium tigris* De Vis a synonym of *S. semifasciatus*. As shown by Silas (1962), Fraser-Brunner's action of synonymising *Cybium koreanus* Kishinouye, 1923 under *S.* (*S.*) *semifasciatus* was unwarranted as the affinities of *C. koreanus* are more towards *S. guttatus* in the nature of the lateral line, body colouration, vertebral counts, etc.

S. semifasciatus is characterised by the following fin ray counts (Munro, 1943) : D. 13 — 15 + 17–20 + 8–10. A. 20–22 + 8–10. P_1. 22–23: the average (*i.e.*, modal) fin formula

being : D 14 + 19 + 9. A. 21 + 9 ; P_1 23. The gill raker count is said to be 2 — 3 + 7 — 9 with the most usual count being 2 + 8. The vertebral count was found to be 44 (1 specimen) or 45 (3 specimens) in the following combinations : 19 + 25 and 19 + 26 respectively.

The distinctive features of this species are, the body colour, the shape of the pectoral, the great depth of the body between the origin of the second dorsal and anal fins, the head which appears to be relatively small, the large caudal lobes and the conspicuously broad fleshy lateral keels on either side of the tail.

The characteristic colouration in life for immature specimens less than 100 mm. is given by Munro (1943) as follows : " Cranial regions and upper regions of the back are pale green with a bronze sheen and marked with about twelve to twenty broad vertical bands of dark grey. These bars are confined to the region of the body above the lateral line and their number increases with age. The cheeks and belly are silvery white. The snout is a dark slate grey and there is a patch of green above the orbit. The spinous dorsal fin is jet black with contrasting areas of white in its central region. The second or soft dorsal fin is cream with yellow anteriorly. The anal fin and all the finlets are of a transparent white. The caudal flukes are creamy white at their margins and dusky or blackish near the hypural. The pectoral fins are dusky." With increase in size " the bronze-green colouration of the back turns to a greenish blue. The vertical bands on the back are most marked in specimens less than 500 mm. length and in larger fish there is a tendency for these markings to become less distinct, break into spots or fade out more or less completely. Above 700 mm. dead fish assume a drab greyish-yellow blotchy appearance with little or no evidence of markings."

The pectoral fin unlike most other scomberomorinae is not falcate. In larger specimens the margins of the fin are rounded. The anterior or upper margin is distinctly convex and lower or posterior margin is slightly concave or even sigmoid in outline.

DISTRIBUTION : In Indian Ocean and contiguous seas : Western Australia and Northern Territory of Australia. In South Pacific Ocean along the coast of Queensland, Australia.

STREAKED SPANISH MACKEREL

Scomberomorus lineolatus (Cuvier), 1831

(Plate VII, Fig. A)

SYNONYMS :

Cybium lineolatum Cuvier, 1831 : 170 (Type locality : Malabar)

Cantor, 1850 : 1092

Bleeker, 1852 : 22, 40

Günther, 1860 : 370

Day, 865 : 69 ; 1878 : 256 ; 1889 : 212

Cybium interruptum Cuvier, 1831 : 172 (Type locality : Pondicherry)

Jerdon, 1851 : 136

Günther, 1860 : 371

Day, 1878 : 254 (description and part synonymy) ; 1889 : 210 (description and part synonymy)

Scomberomorus lineolatum Gilchrist and Thompson, 1917 : 395
Thompson, 1917 : 395

Scomberomorus lineolatus Barnard, 1927 : 803
Fowler, 1934 : 415
Smith, 1935 : 210 (?)
de Beaufort, 1951 : 235–36
Scott, 1959 : 114
Jones, 1961 : 117
Jones and Silas, 1961 : 187–204

Scomberomorus (*Sawara*) *interruptus* Deraniyagala, 1933 : 41

Scomberomorus (*Indocybium*) *lineolatus* Munro, 1943 : 68

Scomberomorus (*Scomberomorus*) *guttatus* (in part) Fraser-Brunner, 1950 : 160
Rosa, 1950 : 111–112

Scomberomorus interruptus Deraniyagala, 1952 : 99–100
Mendes, 1954 : 148

Indocybium lineolatus Munro, 1955 : 221 (description and part synonymy)

Indocybium lineolatum John, 1959 : 134

Scomberomorus sp. Williams, 1956 : 44–45

Scomberomorus lineolatus Williams, 1960 : 184–191 (description and part synonymy)

The description and figure of *Scomberomorus leopardus* (Shaw) Smith, 1949 (p. 301) as shown by Silas (1962) are referable to *Scomberomorus guttatus* (Bloch and Schneider). Fourmanoir (1957) has followed Smith (1949) in his description of *Cybium leopardus* which consequently also becomes a synonymy of *S. guttatus*.

For specimens of *S. lineolatus* we have examined from the Indian coast, the meristic counts vary as follows :

D_1 XVI–XVII ; D_2 19–20 + 8–9 ; A. 18–20 + 8–11 (11 finlets exception) ; P_1 23–24 ; gill rakers 2–3 + 8–10 ; vertebrae 21 + 28 (= 49).

Munro (1943 and 1955) and de Beaufort (1951) have given the gill raker count as 2 + 9 = 11 ; while for East African specimens, Williams (1960) mentions 2 + 1 + 8–11 = 11–14 as the range.

Day (1865, 1878) and Munro (1943) give the pectoral count as 21, while others have mentioned 23 (Deraniyagala, 1952) ; 24 (de Beaufort, 1951 ; Munro, 1955) and 22–26 (Williams, 1960).

The dorsal and anal counts given by various authors (Table VI) differ but some of the differences atleast may be accounted for as due to the differences in the methods of counting used.

TABLE VI
FIN RAY COUNTS IN *S. lineolatus*

Author	Year	D_1	D_2 + finlets	A + finlets	Species
Günther ...	1860	XVI	16 + 9	16+10	*C. lineolatum*
Günther ...	1860	XVI	17 + 9	18+9	*C. interruptum*
Day ...	1865	XVI	16 + 9	16 — 20+10	*C. lineolatum*
Day ...	1873	XVI	18 + 9	18+9	*C. interruptum*
Day ...	1873	XVI	16 + 9	16+10	*C. lineolatum*
Day ...	1788	XVI	19 — 20 + 8 — 9	19+8 — 9	*C. interruptum*
Day ...	1878	XVI	16 + 9	19+10	*C. lineolatum*
Barnard ...	1927	XVI	16 + 9 — 10	16+10	*S. lineolatus*
Munro ...	1943	XV — XVII	18 — 20 + 8 — 9	19 — 21+8 — 10	,,
de Beaufort ...	1951	XV	15 — 17 + 9	19 — 21+9	*C. lineolatus*
Deraniyagala ...	1952	XV — XVII	18 — 20 + — 10	20+9 — 10	*C. interruptus*
Munro ...	1955	XV — XVII	18 — 20 + 9 — 10	20+9 — 10	*I. lineolatus*
Williams ...	1960	XV — XVII	19 — 21 + 8 — 9	18 — 21+8 — 9	*S. lineolatus*
Jones and Silas ...	1961	XVI — XVII	19 — 20 + 8 — 9	18 — 20+8 — 11	*S. lineolatus*
Total range ...	...	XV — XVII	15 — 20 + 8 — 10	16 — 21 + 8 — 11	...

The diagnostic characters of the species are :

(1) Body colouration consisting of blackish narrow streaks or broken bars along the sides of the body ;

(2) Both in young as well as adults a markedly rounded ridge runs from the side of the pointed snout to the end of the operculum in line with the base of the pectoral fin.

(3) When compared to the other Indian species of the genus, the caudal keels are conspicuously large. In this it probably shows affinities with *S. semifasciatus.*

(4) The lateral line is simple, with slight undulation in the posterior half and does not show branching as in adult *S. commerson* or " pseudobranching " as in *S. g. guttatus.*

(5) The gill rakers are better developed in *S. lineolatus* than in *S. g. guttatus* and *S. commerson.*

(6) The pectoral fin is scaled for a greater part as in *S. regalis* (Bloch) from the Atlantic.

(7) Invariably in most of the freshly caught juvenile and adult specimens of *S. lineolatus,* the ventral profile between the pelvic and anal fin is slightly concave.

It may also be mentioned that Silas and Ummerkutty (1962) have found that atleast four or five out of every ten *S. lineolatus* examined have the parasitic copepod *Brachiella thyni* Cuvier in the pectoral axil of one or both sides.

The air-bladder is wanting in *S. lineolatus.*

Hardly anything is known about the biology of this species. Jones (1961) has shown that the description and figures of post-larvae and juveniles of *S. lineolatus* given by Kuthalingam (1959) have nothing to do with that species or for that matter to any species of *Scomberomorus.* Consequently his observations on the food and feeding habits of post-larvae and juveniles are referable to some other non-scomberomorinae. Similarly his reference to adults of *S. lineolatus* measuring 100 mm. to 128 mm., is also doubtful as we have not come across fully mature adults although specimens upto about 700 mm. have been examined.

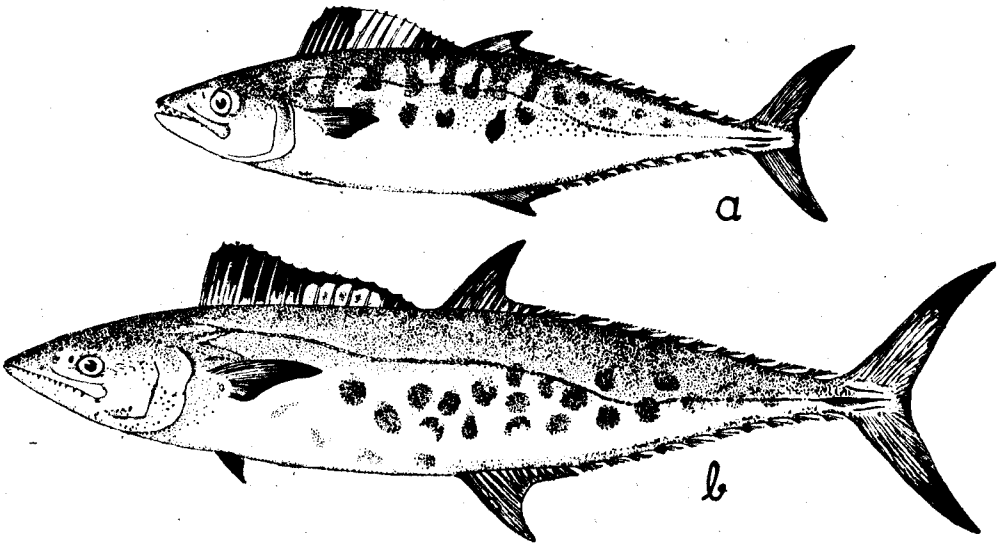
DISTRIBUTION : All along the Indian coast, but generally rarer than *S. g. guttatus* and *S. commerson.* The general distribution is given by Williams (1960) as : British East

African Waters ; Natal Coast of South Africa ; ? Mozambique channel and Madagascar ; Ceylon, India to the East Indies.

Although in the section on 'Synonymy' we have listed references to *S. lineolatus* from South African Waters (Gilchrist and Thompson, 1917 ; Barnard, 1927 ; Fowler, 1934 ; Smith, 1935) more information is needed on this species from that area. It is felt that *S. lineolatus* and *S. guttatus* both occur in S.E. African waters, but have been confused. For further discussion reference is invited to Silas (1962).

QUEENSLAND SCHOOL MACKEREL

Scomberomorus queenslandicus Munro, 1943



Text Fig. 11. *Scomberomorus queenslandicus* Munro. (*a*) juvenile and (*b*) adult (after Munro, 1943).

SYNONYMS :

? *Cybium guttatum* Macleay, 1881 : 193 (Port Jackson, Australia)
? *Scomberomorus guttatus* McCulloch, 1934 : 79 (N. S. Wales, Australia)
Scomberomorus (*Cybium*) *Queenslandicus* Munro, 1943 : 82 (Type locality : Cape Cleveland, North Queensland, Australia)
Rosa, 1950 : 101
Cybuim queenslandicus Munro, 1958 : 20

S. queensandicus qualifies for inclusion here on account of its occurrence along the Coast of Western Australia. Munro (1943) while describing this species, recognised its very close affinities to *S. commerson* from which he distinguished it as follows :

	S. queenslandicus	*S. commerson*
1. Vertebral count ...	20 + 28 = 48	20 + 25 = 45
2. Markings ...	Almost three rows of diffuse blotches	Numerous wavy vertical bands on belly
3. Lateral line ...	Not deeply inflicted	Deep infliction below 2nd and 3rd dorsal finlets
4. Anal fin count ...	17–20, mode at 19	16–18, mode at 17
5. Gill rakers ...	Normal = 1 + 6	Normal = 1 + 4

Slight differences between *S. queenslandicus* and *S. commerson* were also noted for the following characters :

(1) Snout is slightly shorter than in *S. commerson.*

(2) The eye diameter larger than in *S. commerson.*

(3) First dorsal fin inserted slightly further back than in *S. commerson.*

(4) The caudal fin very slightly larger than in *S. commerson.*

Munro (1943) has given the fin formula for *S. queenslandicus* as : D. 15–17 + 16–20 + 9–10. A. 15–20 + 9–10. P_1. 20–23 and the average fin formula (*i.e.* modal) as : D. 16 + 18 + 10 ; A. 19 + 10 ; P_1. 21-22. Gill-raker formula is 0 + 4 to 1 + 7 with 0 + 6 being most common. Of nine specimens examined for vertebral counts from East Coast of Australia, Munro (1943) found 8 to have 20 + 28 = 48 and one 20 + 29 = 49 vertebrae. A single specimen examined from Sharks Bay, Western Australia had lesser precaudal count namely 19 + 29 = 48 and according to Munro " This slight variation may be significant in that it might indicate the existence of two races of this species, one from the east coast and the other from the west. It would be foolish to conclude this from such little material."

The colour when freshly caught is as follows : " Cranial regions and upper part of the back are an irridescent bluish green and the cheeks and belly are a silvery white. In adult fish the sides are marked with about three rows of bronze-grey indistinct blotches, each a little larger than the orbit. The membrane of the spinous dorsal fin is jet black with large contrasting areas of intense white between the sixth and last spines. The second dorsal fin and the finlets are pearly grey with darker margins. The caudal fin is of similar colour. The ventrals, anal fin and anal finlets are white. The pectoral fins are greyish, being darkest on their inner surface." The body markings appear to alter with age as an example of 95 mm. is said to lack the bronze-grey blotches of the older fish.

The species also attains maturity at a small size and examples about half metre in length weigh 3 to 4 lbs. Munro (1958) remarks that this species which is found in coastal waters and estuaries is taken by trolling and in set nets.

DISTRIBUTION : In Indian Ocean and contiguous waters : Coast of Western and Northern Australia ; In South Pacific Ocean : Australia along the Coast of Queensland and New South Wales.

SPOTTED SPANISH MACKEREL

Scomberomorus guttatus guttatus (Bloch and Schneider), 1801

(Plate VII, Fig. B)

SYNONYMS :

Scomber guttatus Bloch and Schneider, 1801 : 23 (Type locality : Tranquebar, S.E. Coast of India).

For detailed synonymy reference may be made to Silas (1962) wherein the following species are also considered synonyms of *S. guttatus guttatus* :

Scomber leopardus Shaw, 1803.

Cybium kuhlii Cuvier, 1831.

Cybium croockewiti Bleeker, 1850.

Silas (1962) also considers *Cybium koreanum* Kishinouye a subspecies of *S. guttatus.*

Jones and Silas (1961) give the meristic counts for *S. guttatum* (= *S. g. guttatum*) from Indian waters as follows : D_1. XVI–XVII ; D_2. 20–21 + 7–9 ; P_1. 21–23 ; A. 19–20 + 7–9 ; gill rakers 1–3 + 7–10. The most frequent counts are : D_1 XVI ; D_2 finlets 8 ; P_1. 21 ; A. finlets 8 ; gill rakers 2 + 8–9. The total vertebral count varies and is 48 or 49, but the total range for the species is from 45 to 51 (Kishinouye, 1923 ; Delsman, 1931 ; Munro, 1943).

For further details regarding *S. g. guttatus* reference is invited to Silas (1962).

DISTRIBUTION : In Indian waters *S. g. guttatus* occurs all along the Indian Coast and the Andaman Islands. The general distribution of the species ranges from Iranian Gulf, Madagascar and South East Africa, Seychelles, Coast of India, Ceylon, Burma, Mayala, Indonesia, Philippines, China and Taiwan. Earlier references to its occurrence in Australian waters have been shown to be erroneous by Munro (1943).

Genus **Acanthocybium** Gill, 1862

Acanthocybium Gill, 1862. *Proc. Ac. Nat. Sci. Philad.*, 125 (Genotype : *Cybium sara* Bennett).

The genus is monotypic and has the following diagnostic characters : as in the sword-fish *Xiphias gladius* the lamellae of the gills are reticulated ; gill rakers are absent ; intermuscular bones are inserted on the ribs ; vertebrae 54–66. Additional characters are the elongate, more or less compressed body covered with minute scales ; beak-like long snout, large mouth ; jaws with strong trenchant teeth which are compressed, closely set in a single series and each slightly serrated ; vomer and palatine with villiform teeth ; spinous dorsal with XVII–XXIII spines ; second dorsal and anal small followed by 8 to 10 and 7 to 9 finlets respectively.

The reticulated nature of the gill lamellae led Jordan (1933) to elevate *Acanthocybium* to family status as Acanthocybiidae, a course which has been adopted by some workers (Munro, 1958*b*). Others (Jordan and Hubbs, 1925, Fowler, 1949) have placed *Acanthocybium* under a subfamily *Acanthocybinae* of the family Cybiidae and Thunnidae respectively. We (Jones and Silas, 1960, 1961) have elsewhere treated the genus as belonging to the subfamily scomberomorinae along with the genus *Scomberomorus* Lacépède, and herein also advocate the same system. External morphology, anatomy and osteology (Kishinouye, 1923 ; Conrad, 1938 ; Fraser–Brunner, 1950 ; etc.) show that although possessing certain specialised characters, the phylogenetic affinities of *Acanthocybium* are more towards *Scomberomorus* than to any other scombroid group. Hence, the need for a higher category to place *Acanthocybium* may not arise here and if used may tend to obscure the natural relationships.

DISTRIBUTION : Circumtropical. Details given under species.

WAHOO

Acanthocybium solandri (Cuvier), 1831

(Plate VI, Fig. A)

SYNONYMS :

Cybium Solandri Cuvier, 1831 : 192 (Type locality : unknown ; based on MS. of Solander)

Fourmanoir, 1957 : 226–27

Scomber lanceolatus (Solander) Cuvier, 1831 : 192 (name given in text)

Cybium sara Lay and Bennett, 1839 : 63 (Type locality : Loo Choo)
Cybium petus, Poey, 1860 : 234 (Type locality : Havana, Cuba)
Acanthocybium petus Poey, 1868 : 363
Cybium verany Doderlein, 1872 : 1 (Type locality : Palermo, Mediterranean)
Acanthocybium solandri Jordan, 1884 : 119
Jordan and Evermann, 1896 : 876
Boulenger, 1897 : 272
Kishinouye, 1923 : 411
Fowler, 1928 : 135 ; 1931 : 325 ; 1934 : 400 ; 1938 : 67 ; 1949 : 74
Deraniyagala, 1933 : 45 ; 1949 : Pl. 21, fig. D.; 1952 : 100–101
Hardenberg, 1934 : 292
Smith, 1949 : 301 ; 1956 : 721
Fraser-Brunner, 1950 : 162
Rosa, 1950 : 75–77
de Beaufort, 1951 : 228
Rivas, 1951 : 276–77.
Roughley, 1951 : 111
Herre, 1953 : 245
Wheeler and Ommanney, 1953 : 66
Mendes, 1954 : 147
Munro, 1955 : 220 ; 1958*a* : 263 ; 1958*b* : 17
Williams, 1956 : 45
Iversen and Yoshida, 1957 : 370–79
Jones and Kumaran, 1959 : 49
John, 1959 : 133
Jones, Silas and Dawson, 1960 : 134
Rao, 1960 : 132
Jones and Silas, 1961 : 192
Silas, 1962*c* (MS.)
Acanthocybium forbesi Seale, 1912 : 283 (Type locality : Coast of Leyte, Philippines)
Acanthocybium sara Kishinouye, 1915 : 9
Jordan and Starks, 1917 : 441
Jordan and Hubbs, 1925 : 213
Scomber amarui Curtis, 1938 : 58 (Type locality : open sea off Tautira, Tahiti)
Acanthocybrium solandri Copley, 1952 : 168 (generic name misspelt)

The meristic counts for this species are as follows : D_1. XXIII XXVII ; D_2. III, 9–10 + 8–10 ; A. III, 9–10 + 1–9 ; P_1. ii. 21 ; P_2. 1, 5. Vertebrae 23–33 + 31–34 (= 54–66).

Other external characteristics which may assist in distinguishing *A. solandri* from species of *Scomberomorus* are :

(1) The anterior two-thirds to three-fourths of the first dorsal is uniformly high when the fin is lifted erect.

(2) The pectorals are short.

(3) The lateral line decurves to the midlateral part of the body below the middle of the first dorsal. Short lateral branchings, at right angles all along the lateral line are seen.

(4) The caudal fin is lunate as in *Auxis* and not forked.

(5) Anterior insertion of second dorsal is midway between base of pectoral and base of caudal.

Hardly anything is known about the biology of this species except what has been given by Iversen and Yoshida (1957). Almost all works on the species listed pertain to the description of the species from different locations.

The ' World Record Marine Fishes ' published by the International Game Fish Association, gives the all tackle record for *Acanthocybium solandri* as 53 kg. (139 lbs.) the length of the specimen being 6 ft. 9 in. and girth 33 in. caught at Marathon, Florida, in May 1960. However, specimens usually taken by handlines or trolling are smaller in size. The seven specimens examined by Rao (1960) ranged from 1054 mm. to 1205 mm. weighing between 7.31 and 11.43 kg. The largest specimen, a spent female, taken in troll line fishery along the Tuticorin coast, Gulf of Mannar reported by Silas (1962*c*) is 1540 mm. weighing 16.8 kg.

DISTRIBUTION : In Indian Waters Jones and Silas (1961) record the species from " the west coast from Vizhingam, Colachel and Cape Comorin ; on the east coast from Tuticorin, Gulf of Mannar ; Minicoy Island in the Laccadive Archipelago ; and Port Blair, Andamans." From other parts of the Indian Ocean and contiguous seas it has been recorded from several localities, namely, the Gulf of Aden, Coast of East and South Africa ; Madagascar ; Mauritius ; Seychelles ; Maldives ; Ceylon ; Sunda Archipelago ; and Western and Northern Australia. It is also known from the tropical and temperate waters of the Pacific and the Atlantic and also from the Mediterranean.

FAMILY ISTIOPHORIDAE

The family includes the spearfishes and sailfishes in which the rostrum is shorter and cylindrical, the body covered with narrow, partly embedded scales ; caudal peduncle with two fleshy keels on each side ; air-bladder large, consisting of many separate divisions ; pelvics with 1 to 3 rays.

Genus **Istiophorus** Lacépéde

Istiophorus Lacépéde, 1802. *Hist. Nat. Poiss*, 3 : 374 (Genotype : *Istiophorus gladifer* Lacèpéde = *Scomber gladius* Broussonnet).

Notistium Hermann, 1804. *Observ. Zool.*, 304 (Type : *Guebuca Marcgrave* = *Histiophorus americanus* Cuvier (Type given as *Scomber gladius* by Jordan and Evermann, 1926).

Histiophorus Cuvier and Valenciennès, 1833. *Hist. Nat. Poiss.*, 8 : 213 amended spelling (Type : *Istiophorus gladifer* Lacèpède).

The genus can be easily distinguished from other members of the family by the very high dorsal fin in which some of the branched rays are higher than the unbranched rays of the anterior lobe ; pelvic fins with two or three rays which are not coalesced into one ; and pelvic fins 1.5 times or more length of pectoral.

Day (1878) recognised two genera, *Histiophorus* Lacépéde and *Xiphias* Linnaeus under the family Xiphiide. The genus *Histiophorus* as treated by him is composite as it was defined to include also a species at present referable to the genus *Makaira*. Two species of sailfish, namely, *H. gladius* (Broussonnet) and *H. immaculatus* Rüppell were recognised by him.

Jordan and Evermann (1926) in recognising nine species of *Istiophorus* viz., *I. gladius* (Broussonnet) (East Indies), *I. americanus* (Cuvier and Valenciennes) (Cape Cod to Brazil) *I. grey* n. sp., (Pacific Coast, Mexico), *I. wrighti* n. sp., (West Indies), *I. immaculatus* (Rüppell) (India), *I. maguirei* n. sp., (West Indies), *I. orientalis* (Temminck and Schlegel) (Japan), *I. volador* n. sp. (West Indies), and *I. eriquius* Jordan and Ball n. sp., (Hawaii), remarked that " The preliminary paper which makes up this paper is done almost entirely on a basis of photograph. No one knows what changes the sail fishes undergo in the process of development and it is quite possible that some characters used by us in the following key are matters of age not indicating specific distinction." During the last 35 years the position has not changed a bit in that no review of sailfishes on a global basis has been undertaken. However, contributions on billfishes published from various parts of the world indicate the following possibilities :

(1) The genus *Istiophorus* may be monotypic represented by one species *I. gladius* with subspecies.

(2) The genus *Istiophorus* is represented in the Atlantic by *I. americanus* and the Indo-Pacific by *I. gladius*. Subspecific categories may be recognised under these two species from these two different areas respectively.

(3) The genus *Istiophorus* is represented by several species.

As in the case of the tunas and seerfishes, here again, the concept of the different categories such as, species, subspecies, geographical races etc., is still in a nebulous state and until such time that these are studied satisfactorily based on reviews on a global basis, lack of agreement may exist.

We have examined sailfishes from different parts of the Indian Coast and Andaman Sea and are able to recognise only one species, *I. gladius*.

SAILFISH

Istiophorus gladius (Broussonnet)

(Plate VIII, Fig. C)

SYNONYMS :

Scomber gladius Broussonnet, 1786 : 454, pl. 10 (Type locality : " La Mer des Indes ". According to Jordan and Evermann (1926) " based on a specimen and a drawing by Sir Joseph Banks ") Bloch, 1793 : 81

Xiphias velifer Bloch and Schneider, 1801 : 93 (after Broussonnet 1786)

Istiophorus gladifer Lacépède, 1802 : 374 (after Broussonnet 1786)

Histiophorus indicus Cuvier and Valenciennes, 1831 : 293 (after Broussonnet 1786)

Histiophorus immaculatus Rüppell, 1835*a* : 116 (Type locality : Red Sea. Based on juvenile 18 inches long) ; 1835*b* : 71 ; 1835*c* : 42
Günther, 1860 : 514
Klunzinger, 1871 : 469
Day, 1878 : 199 ; 1889 : 132
Goode, 1883 : 21
Copley, 1952 : 172
Mendes, 1954 : 147

Histiophorus gladius Günther, 1860 : 513 (Synonymy—in part)
Playfair, 1867 : 865
Klunzinger, 1871 ; 468 ; 1884 : 122

Goode, 1883 : 21
Day, 1878 : 198 (Synonymy—in part) ; 1889 : 132
Duncker, 1903 : 155
Thompson, 1918 : 118
Maxwell, 1921 : 274
Barnard, 1927 : 807
Sorley, 1933
Copley, 1952 : 171
Munro, 1955 : 222
Fourmanoir, 1957 : 220
John, 1959 : 134

Histiophorus granulifer Castelnau, 1861 : 42 (Type locality : Cape of Good Hope, S. Africa).

Istiophorus gladius McCulloch, 1921 : 137 ; 1922 : 106 ; 1934 : 80
Jordan and Jordan, 1922–25 : 30
Jordan and Evermann, 1926 : 38
Deraniyagala, 1933 : 54 ; 1952 : 106
Fowler, 1936 : 80 ; 1938 : 105
Smith, 1949 : 315 (In part?)
Rosa, 1950 : 153
Munro, 1958 : 19
Jones, 1959 : 204 ; 1959 : 255
Scott, 1959 : 116
Jones, Silas and Dawson, 1961 : 136
Jones and Kumaran, 1962
Silas and Rajagopalan, 1962
Silas, 1962 (Helminth parasites)
Silas and Ummerkutty, 1962 (Copepod parasites).

Istiophorus immaculatus Jordan and Evermann, 1926 : 44.
LaMonte and Marcy, 1941.
Rosa, 1950 : 152.

We have examined sailfish landed at various fishing centres along the Indian Coast (Ratnagiri, Malpe, Calicut, Vizhingam, Colachel, Tuticorin) and from the Andaman Sea (Car Nicobar) and are able to recognise only a single species, *I. gladius*. Both *Xiphias velifer* Bloch and Schneider, and *Istiophorus gladifer* Lacépède are after Broussonnet's account of *Scomber gladius*, and as such are its synonyms. *Histiophorus indicus* Cuvier and Valenciennes is partly based on Broussonnet's account and partly on material studied by Cuvier form the type specimen in London. As commented by Jordan and Evermann (1926) the need for substituting a new name *H. indicus* for *S. gladius* did not arise firstly on account of the name *gladius* being preoccupied in *Xiphias* and not in *Scomber*. Secondly, even if a new name was required, *velifer* and *gladifer* were already available.

The same authors comment on *Histiophorus granulifer* Castelnau based on a mutilated skeleton cast ashore in a storm at Cape of Good Hope as follows : " Head well preserved in the Museum at Cape Town. Length m. 1.07 ; depth mm. 35 ; length of beak from eye mm. 67. Beak a little flattened above, pointed at tip, covered below and on sides with granulations, those below finer and more close-set than similar granulations on upper jaw. Skeleton resembles entirely that figured by Cuvier and Valenciennes (*Tetrapturus*) (Castelnau)."

" This may be *Istiophorus gladius* ; it is not likely to be *Makaira herscheli* ".

Day (1878, 1889) recognised *I. maculatus* (Rüppell) originally described from Red Sea. Jordan and Evermann (1926) based on Day's description of the species from Indian Waters (Madras) recognised this as one of their nine species of *Istiophorus*. We have here relegated *I. immaculatus* to the synonymy of *I. gladius* for the following reasons :

1. Rüppell's type of *H. immaculatus* is said to be a specimen of 18 inches in which " The dorsal fin is much higher than the body. The height of the body is one-tenth of the total length; the length of the head about one-third. Dermal production lanceolate. Colouration uniform ; dorsal blackish, immaculate." (Günther 1860—after Rüppell) Jones (1959) describing a specimen of *I. gladius* 432 mm. (17 inches) long remarks that " The dorsal fin is black and the characteristic blotches found in the fin of the adult fish are seen only in a few places". Deraniyagala's (1952) figure of a post larval sailfish slightly less than 13 cm. (5 inches) in length shows only five conspicuous blotches on the dorsal while the rest of the fin is colourless. It would thus appear that in juveniles and young, colouration of the dorsal fin may be a highly variable character. Added to this the likelihood of the few blotches disappearing in preservative would make reliance on this character for species determination in this instance useless.

Aside from this, the dorsal and anal fin ray counts of *H. immaculatus*, namely D. 47/7 ; A. 10/7, also show close agreement with Jones' specimen of *I. gladius* for which the counts are, D. 48/7 ; A. 11/7 besides which between the two anal fins, five small stub-like detached rays are present " which are not discernible in the adult ", and could be easily overlooked in juveniles of this size.

2. Day's (1878) description of *Histiophorus immaculatus* is based on a 5 feet 9 inches mounted specimen in the Madras Museum showing the following characters :

" B. vii., D. 47/7, P. 16, V. 3, A. 10–11/7, C. 17 ". " Length of head (including the snout 1/3, height of body 1/10 of the total length. *Eyes*—diameter about 1/3 in the postorbital portion of the head. A very slight ascent from the snout to the base of the first dorsal fin. The maxilla reaches to below the hind edge of the orbit. *Teeth*—generic. *Fins*—Length of base of dorsal fin about 1/3 of the total length, eleventh to the fifteenth* dorsal ray the longest, and atleast three times higher than the body ; the last few rays are low and reach to the base of the second dorsal fin. Ventral elongated. *Scales*—dermal production lanceolate. *Lateral line*—at first makes a very strong curve but becomes straight above the hind extremity of the pectoral fin. *Colours*—gray, dorsal and ventral blackish."

But for the colour characteristics, all other features mentioned by Day for his *H. immaculatus* agree fully with the characters of similar sized specimens of *I. gladius* we have examined. In the course of examining scores of specimens of sailfish in fresh condition from the east and west coasts of India, we have never come across one in which the dorsal fin is immaculate, although, slight variations in the disposition, size and number of spots are seen. Having not examined the type specimen at the Madras Museum, we are not sure whether the normal spots have been obliterated or painted over by the application of any preservative during the process of preparing the mount for exhibition.

In separating *I. gladius* and *I. orientalis*, the diagnostic character used by Jordan and Evermann (1926) was that in the former the " Interspace between dorsal fins with a series of

* Not " (11th to 13th) " as given by Jordan and Evermann (1926).

six to 12 short, stiff, stub-like spines....." Interspace between dorsals considerable almost equal to height of lobe and with no stubs or spines between the fins." "In addition, in *I. gladius* the sides of the body was said to have no pale bars " while in *I. orientalis* the " colour steel-blue, with numerous cross-bars each of four to six round blue spots." The number of dorsal spines in the two species is given as XLII to XLVIII and XLI respectively.

De Beaufort (1951) gave one more additional diagnostic character to distinguish the two species, namely, " Upper profile of head gradually ascending to dorsal " (*H. gladius*) and " Upper profile of head steeply ascending to dorsal " (*H. orientalis*). The dorsal counts were given as XLV and XLIV–XLVIII for the two species respectively. The distribution of *H. orientalis* was given by him as " Singapore ; Java (Bay of Jacarta, Wijnkoop's Bay) ; Banda ! —Japan, Siam ? Hawaii." A figure of a fish with a wide gap between the two dorsals equalling the distance from the origin of the second dorsal to fork or slightly more than half the length of the longest dorsal spine is shown, while adding the following remarks : " It is possible that this species is only a synonym of *H. gladius*, as has already been supposed by Klunzinger and Lütken. As I have seen no specimens besides the skull and some other parts of the skeleton, I abstain from giving an opinion."

Our acquaintance with the Indian sailfish which we consider to be a single species, *I. gladius* leads us to the following conclusions as regards the status of *I. orientalis*.

1. The gap between the two dorsal fins on which primary stress has been given in distinguishing certain sailfish species in highly variable, especially with age. Juveniles show the two fins to be continuous (Jones, 1961 ; Deraniyagala, 1952) while in adults, both immature and mature the gap may be of varying distances. In specimens at Tuticorin we have seen this gap to vary in width from that equalling almost eye diameter to slightly more than base of the second dorsal. Even so, it has been generally noticed that one or two of the last dorsal rays may be hidden in the deep groove between the two dorsals. In any case, the last exposed ray of the first dorsal is never elongate, as shown in the figure given by de Beaufort (1951), but the posterior rays are gradually reduced in length in a graded series as clearly illustrated for the typical *I. orientalis* by Temminck and Schlegel (coloured plate LX, reproduced in black and white by Jordan and Evermann (1926, pl. 15, fig. 1). In fact, in this feature, the similarity between the Japanese *I. orientalis* and the Indian *I. gladius* is well exemplified. Nakamura's (1938 : 1955) excellent figure of *I. orientalis* from Formosan Waters also shows the absence of this so-called wide gap and abrupt ending of the first dorsal. Illustrations of *I. orientalis* by Japanese workers, *viz.*, Tanaka (1911–14) ; Okada *et al.* (1938) and others show that the gap between the dorsals is less than or hardly equal to the distance of the base of the second dorsal.

The morphometric data for *I. orientalis* from the Central Pacific given by Royce (1957) also show the same trend of the free interspace between the two dorsals being extremely narrow. Thus while the narrow free interspace seems to be a widespread phenomenon in Indo-Pacific sailfishes we are unable to state whether there could be a valid species evincing the condition of wide interspace as observed by Jordan and Evermann (1926), and de Beaufort (1951).

2. While Jordan and Evermann (1926) gave the dorsal count of *I. orientalis* as XLI, later workers have shown that it is variable and number XLV–XLVII (Nakamura, 1938) ; XLIV–XLVIII (de Beaufort, 1951). This gives the range for this character as XLI–XLVIII, while it is XLII–XLVIII in *I. gladius*, the overlap being considerable.

3. *I. orientalis* is credited with having numerous cross bars each of four to six round blue spots. A majority of the freshly caught specimens of *I. gladius* we have examined clearly

showed this character while those subjected to long exposure after capture showed faint markings, but in all cases the round black spots on the dorsal fin were present. This again breaks down another supposed distinction between the sailfish from Indian Seas and the Pacific *I. orientalis.*

4. The degree of ascent of the dorsal profile of the head may show slight differences. In *I. gladius* we have examined the ascent is not abrupt and steep, as shown in the illustrations of *I. orientalis* by Temminck and Schlegel (plate LX), but is more like that figured by Nakamura (1938 : pl. 13, fig. 2) for *I. orientalis* from Formosan Waters. Variations in this character with size may be expected as in juvenile *I. gladius* the profile of the head is more or less straight (Jones, 1961) while in adults it shows a gradual slope to the origin of the dorsal.

5. Fowler (1928) and Royce (1957) have rightly synonymised *I. eriquius* Jordan and Ball (in Jordan and Evermann, 1926) from Hawaii with *I. orientalis* (= *I. gladius*). According to Royce (1957) " There seems little doubt that the species occurring in the Central Pacific should be *orientalis* which most authors have used. On the basis of a cast in the Bishop Museum, Jordan and Ball *in* Jordan and Evermann (1926), also describe *eriquius* from Hawaii in which the dorsal fin is subtruncated behind with only 34 dorsal spines. The photo in Jordan and Evermann (P. 101) suggests that the posterior part of the dorsal fin was missing from the cast. Further, there are no reports from Hawaiian fishermen of two species of sailfish. We, therefore, regard *eriquius* as a synonym of *orientalis.*"

6. Royce (1957) has also synonymised *Istiophorus brookei* Fowler (1934) with *I. orientalis* (= *I. gladius*) with no comments. Scrutiny of Fowler's description and figures indicates that besides the diagnostic colouration of the body (about 16 to 17 vertical light lines extending to the upper and lower edges of the body), the pectorals in *I. brookei* are more elongate. Much reliance cannot be placed on the colour characteristics in view of its variability with size and duration after capture. In view of our limited knowledge about the growth changes in the sailfishes from the Indo-Pacific, it is not possible to comment on the importance of the length of the pectoral in these specimens. In general *I. brookei* shows hardly any differences from *I. gladius* and both may be considered conspecific, although the possibility of racial differences could exist.

7. Jordan and Evermann (1926) speaking of their new species *I. greyi* remarked that " The species is apparently new to science. It is very close to the Japanese *Istiophorus orientalis* being distinguished by the shorter ventrals and by the absence of cross-lines of blue spots. The second dorsal and anal are, perhaps, smaller than in *I. orientalis.*" As type, a photograph copy of plate LXXVI of Zane Grey's " Tales of Fishing Virgin Seas ", of a specimen weighing 135 pounds and 10 feet 1 inch long taken by Grey near Cape San Lucas, Lower California, was designated. Unfortunately there is discrepancy between the description of the colouration of the species, and the type shown in the aforesaid photograph in the matter of body colouration. On p. 37 as Key character they mention that in *greyi* " color, plain steelblue " and on p. 2 for a specimen 10 feet (from tip of sword to centre of tail) caught near the tip of Baja California " in fresh (based on photographs) state as " color, dark, without markings on body....." However, the photographs of the type mentioned above and reproduced in their work on plate 14, very clearly show the cross-lines composed of light spots on the body ! In the absence of morphometric details, the supposed differences between *I. greyi* and *I. orientalis* in the length of the pelvics and size of the second dorsal and anal cannot be commented on and in our view will not merit distinction of species-status.

In view of these points raised, we feel that :

(*a*) For reasons given under items 1–4, that *I. gladius* and *I. orientalis* are conspecific.

(*b*) *I. brookei, I. eriquius* and *I. greyi* which are shown to be no way specifically distinct from the Japanese *I. orientalis* automatically become synonyms of *I. gladius.*

It is further held that only one species of sailfish may be recognised from the Indo-Pacific, but the possibilities of difference in sub-populations or regional differences as seen for tunas and seerfishes existing cannot be ruled out.

Finally, the validity of the specific name *Istiophorus gladius* for the Indo-Pacific sailfish is questionable. According to Fowler (1928) " The description and figure by Broussonnet are not accompanied by any specific name, simply being referred to *Scomber* (*Acad. Sci. Paris, Mem.* p. 450, pl. 10, 1786 (1788), type loc., sea of Indies). The *Scomber gladius* Bloch (*Nat. auslandichen Fische,* pt. 7, p. 81, pl. 345, 1793) the next name though composite is largely referred to *Xiphias* ". Since *I. gladius* is now widely current, it is hoped that proper ruling will be made to validate the specific name *I. gladius* Broussonnet for the sailfish by the Committee on International Zoological Nomenclature.

Some anatomical features of *I. gladius* from Indian Seas are given elsewhere (Silas and Rajagopalan, 1962) along with morphometric measurements and meristic counts.

For 10 specimens of *I. gladius* examined by Silas and Rajagopalan (1962) the first dorsal (total) counts are 46 (4) and 47 (6). The juvenile specimen examined by Jones (1961) had a dorsal count of 48. For Ceylon specimens Deraniyagala (1952) mentions IV, 40–44 (= 44–48) as the number. As already drawn attention to, the low count of 34 for *I. eriquius* may be on account of part of the fin missing from the cast. Barring this, the fin ray count for the *I. gladius* from the Indo-Pacific as recognised here may be given as follows :

D_1. XL–XLVIII ; D_2. 6–7 ; P_1. 15–19 ; P_2. I–1–2.
A_1. III, 10–11 ; A_2 6–7 ; Vertebrae 24 (12 + 12).

It may be mentioned that *I. gladius* is the most common of all billfishes caught along the Indian Coast.

Genus **Tetrapturus** Rafinesque, 1810

Tetrapturus Rafinesque, 1810 : 54 (Genotype *Tetrapturus belone* Rafinesque) (Spelling amended to *Tetrapturus* by Bonaparte, 1841 : 19 ; and *Tetrapturus* by Agassiz, 1843 : 7, 89–92, table E. Misprints *Tetrapturus* Verany, 1847: 492 ; and *Tetrapturus* Radcliffe, 1926 : 112).

Skeponopodus Nardo, 1832 : 99 (Nomen nudum) ; 1833 : 415 (Type : *Skeponopodus typus* Nardo (= *Tetrapturus belone* Rafinesque) ". Type species by virtue of the name *typus.*" (Robins and de Sylva, 1960). (amended spelling *Scheponopodus* Canestrini, 1872 : 112).

Pseudohistiophorus de Buen, 1950 : 171 (Genotype : *Tetrapturus illingworthi* Jordan and Evermann (= *T. angustirostris* Tanaka).

From the Atlantic, Robins and de Sylvia (1960) recognise three species of spearfishes under the genus *Tetrapturus*, namely *T. belone* Rafinesque, *T. albidus* Poey and *T. audax* Philippi. The last two species have been treated by several workers under the genus *Makaira* which Robins and de Sylva (1960) have restricted to include only the blue marlin, *Makaira* (*Makaira*) *nigricans* Lacépède and the black marlin, *Makaira* (*Istiompax*) *indicus* Cuvier. Among reasons given

are that species of *Tetrapturus* are small, generally much less than about 136 kg. while the two species of *Makaira* attain about 900 kg. If this course is adopted, the following additional synonyms of *Tetrapturus* (— after Robins and de Sylva, 1960) will have to be accepted :

Marlina Grey, 1928 : 47 [Genotype : *Tetrapturus mitsukurii* (= T. *audax* Philippi), type species by monotypy ; the use of *Marlina* at the Generic level is probably a slip].

Kajikia Hirasaka and Nakamura, 1947, 13–14 [Genotype : *Kajikia formosa* (= *Tetrapturus audax* Philippi), type species by monotypy].

Lamontella Smith, 1956: 32 [Genotype: *Tetrapturus albida* (*Sic*) Poey, type species by original designation and monotypy].

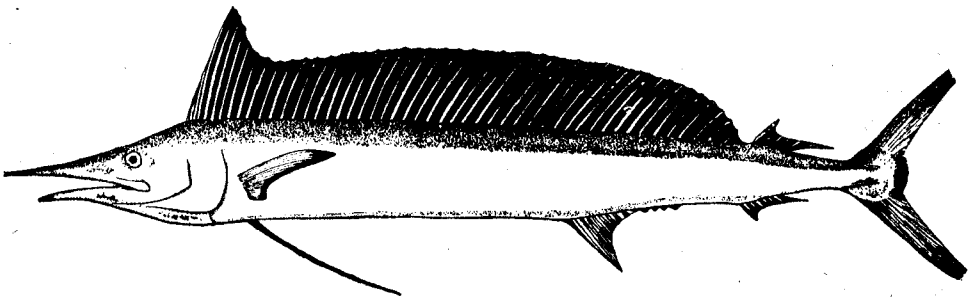
Thus reconstituted to embrace four species, the generic diagnosis of *Tetrapturus* as given by Robins and de Sylva (1960) is as follows :

" Anterior lobe of spinous dorsal fin higher than body depth at dorsal fin origin, the lobe portion of the fin rounded ; 12 precaudal and 12 caudal vertebrae ; flesh red (except in *audax*) ; size small, usually much less than 300 lbs."

La Monte (1955) had given importance to the relative length of the pectoral in separating the genera *Tetrapturus* and *Makaira*. Robins and de Sylva (1960) have shown that the pectoral fin shows marked allometry in the spearfish, and as the genus *Tetrapturus* as reconstituted by them includes *angustirostris* with the short pectoral, this character may not be considered as being of generic significance.

SHORTBILL SPEARFISH

Tetrapturus angustirostris Tanaka, 1914



Text Fig. 12. *Tetrapturus angustirostris* Tanaka (after Tanaka, 1935).

SYNONYMS :

Tetrapturus angustirostris Tanaka, 1914 : 324 (Type locality : Sagami Sea, Japan),
Nakamura (1938) 1955 : 24
Royce, 1957 : 520
Yabe *et al.*, 1958 : 32
Robins and de Sylva, 1960 : 405.

Tetrapturus illingworthi Jordan and Evermann, 1926 : 32 (Type locality : Coast of Hawaii)

Tetrapturus kruassi Jordan and Evermann, 1926 : 33 (Type locality : Hawaii)

Tetrapturus brevirostris Fowler, 1928 : 136 (in part) (*nec Histiophorus brevirostris* Playfair 1866 : 53, 145)
Day, 1878 : 199
Jordan and Evermann, 1926 : 33
de Beaufort, 1951 : 237

We agree with the synonymy and references given for *T. angustirostris* by Royce (1957) except that *Tetrapturus brevirostris* de Beaufort, 1951 : 238 (850 mm. specimen) in de Beaufort and Chapman (1951) should find a place elsewhere, the main reason being the low dorsal count (D, XXXIX).

There can be hardly any doubt that *T. illingworthi* and *T. kraussi* are synonyms of *T. angustirostris* as has rightly been shown by Royce (1957). Jordan and Evermann's (1926) dorsal counts of XLIV for *T. illingworthi* probably do not take into account the II or III shorter spines in front of the longest spine of the anterior lobe. So also their dorsal count for *T. kraussi* given as ' Dorsal XVII ' should be an error and is probably XLVII. Here again, we are not sure whether the anterior short spines have been taken into account.

The reason for the inclusion of this species in the present account is its record by Yabe *et al.*, (1958) from Eastern Indian Ocean from Lat. 25° 13'S., Long. 99° 83' E.

Meristic counts for the species based on previous works are given below :

D_1. XLVII-LIII + ; D_2 6 ; A_1. II, 12 ; A_2. 7 ; P_1. 18 ; P_2 1, 2 ; Vertebrae 24 (12 + 12).

For a descriptive account and morphometric measurements of the species reference is invited to Tanaka (1915 : 1935) ; Nakamura (1937 : 1955) ; and Royce (1957). However the salient characteristics of the species are : The moderately elevated dorsal fin which is high throughout, the posterior rays almost equalling the height of the anterior lobe ; the anterior dorsal lobe being higher than the depth of the body beneath it, the vent situated in front of the anal fin origin by a distance equal to or greater than anal fin height (about 9.6% body length) ; dorsal profile from tip of bill to dorsal fin origin more or less straight ; bill short, slightly exceeding length of lower jaw ; length of premandibular portion of bill contained three times or slightly more in preorbital distance and the pectoral fin which is short being markedly shorter than the pelvics.

As regards colour, Tanaka (1915) remarks that "……in life, back lead-black ; sides brownish, with fine whitish vermiculate maculations, and lower half silvery white ; two dorsals and ventrals blackish, without spots ; two anals whitish ; inner surface of pectoral blackish, but outer whitish ; caudal blackish proximally but whitish distally." Royce (1957) notes that " Immediately after death *T. angustirostris* is a brilliant, deep metallic blue on the back and first dorsal with silvery gray on the sides and white on the belly. In about an hour this rapidly fades to a dark, slate gray on the back and to black on the first dorsal. We have seen no evidence of stripes and, according to Nakamura (1949), it never has them."

DISTRIBUTION : Japan South of 35° N. latitude ; Formosa ; Philippines ; Eastern Indian Ocean (lone record from Lat. 25°13' S., Long. 99° 83' E). Eastwards, Baja California (Craig, 1958 : 275 — 280) and Chile (Robins and de Sylva 1960 : 404).

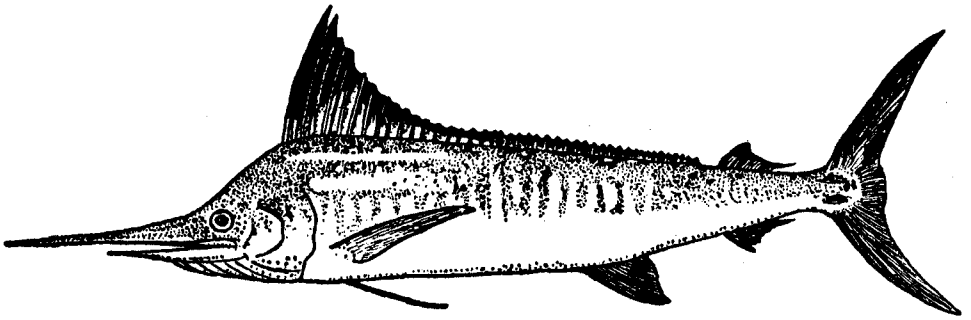
Size : On account of the small size, the species has been even suspected to be the young of marlins (LaMonte and Marcy, 1941). No doubt, it appears to be the smallest of known bill fishes as the maximum weight recorded for any specimen appears to be 114 lbs. (52 kg.) for a specimen from Central Pacific (Royce, 1957). The same author also mentions the modal weight for 177 specimens as approximately 38 lbs. (17 kg.). Nakumura (1937) has described a ripe female measuring 152 cm. weighing 27 lbs. (12 kg.) and also figured the ripe ovaries, eggs and tests of the species.

REMARKS : There still lurks the probability that the question of the correct nomenclature for the Pacific shortbill spearfish discussed here as *T. angustirostris* has not yet been

finally settled. Robins and de Sylva (1960) report of having examined a photograph of a " spearfish " caught in the Mediterranean near Split, Yugoslavia showing both the bill and pectoral fin short, diagnostic features of *T. angustirostris*. " If unbroken, the bill is about 14 per cent of body length. The pectoral fin is partly erect but appears to be 12 or 13 per cent of body length. Superficially this fish resembles *angustirostris*. The possibility is raised of *T. belone* being a distinct Mediterranean species or senior synonymy of *angustirostris*." Either course will necessitate the proposal of a new name for the Western Atlantic form at present designated as *T. belone*. In the absence of actual material and the possibility of the photograph of the fish from Split turning out to be that of a young blue marlin, they have rightly refrained from coming to any unwarranted conclusions. This only draws attention to yet one more unsettled problem in billfish taxonomy.

STRIPED MARLIN

Tetrapturus audax, Philippi, 1887



Text Fig. 13. *Tetrapturus audax* Philippi, the striped marlin (after Nakamura, 1938).

SYNONYMS :

Tetrapturus audax Philippi, 1887 : 35, pl. 8, figs. 2–3 (Type locality : Iquique, Coast of Chile)

Robins and de Sylva, 1960 : 406

Histiophorus audax Delfin, 1901

Tetrapturus mitsukurii Jordan and Snyder, 1901 : 303 (Type locality : Misaki, Sagami, Japan)

Tetrapturus ectenes Jordan and Evermann, 1926 : 34 (Type locality : About Hawaiian Islands)

Makaira grammatica Jordan and Evermann, 1926 : 55 (Type locality : Hawaii)

Makaira holei Jordan and Evermann, 1926 : 63 (Type locality : Pacific Coast of Mexico, and Lower California, U.S.A.)

Makaira mitsukurii Jordan and Evermann, 1926 : 61

Nakamura, 1938 : 27 ; 1951 : 36

Deraniyagala, 1940 : 69 ; 1951 : 140 ; 1952 : 107

Rosa, 1950 : 132–34

Mendes, 1954 : 147

Morrow, 1954 : 819 ; 1957 : 72–87 ; 1957 : 89

Munro, 1955 : 223

LaMonte, 1958 : 396
Ueyanagi, 1959 : 130–145

Makaira zealandica Jordan and Evermann, 1956 : 65 (Type locality : Bay of Islands near Russell, New Zealand)

Marlina mitsukurii Grey, 1928 : 47

Istiophorus ludibundus Whitley, 1933 : 83 (Type locality : New South Wales, Australia)

Istiophorus audax Fowler, 1944 : 499

Kajikia formosana Hirasaka and Nakamura, 1947 : 13 (Type locality : Formosa)
Nakamura, 1949 : 61
Ueyangai, 1957 : 107–112

Kajikia mitsujukrii Hirasaka and Nakamura, 1947 : 14
Nakamura, 1949 : 60
Nakamura, Yabuta and Ueyanagi, 1953 : 1–8
Ueyanagi, 1953 : 1–5, 1954*a* : 1954*b*

Makaira mitsukurii (in part) Herre, 1953 : 255

Marlina audax Smith, 1956*a* : 30

Makaira audax Smith, 1956*b* : 758
Royce, 1957 : 528–532
Munro, 1958 : 19
Williams, 1959 : 762

While several authors have treated the striped marlin under the genus *Makaira*, for reasons already mentioned, we follow Robins and de Sylva (1960) in relegating it under the genus *Tetrapturus* to which genus also belong the species *T. angustirostris*, *T. belone*, and *T. albida*.

That the specific name *T. audax* Philippi has priority over *T. mitsukurii* Jordan and Evermann, has been well established (Smith, 1956, Royce 1957). In young *T. audax* the middle rays of the dorsal fin are relatively high when compared to the blue and black marlin and it is this character that led to the descriptions of new species, namely *Tetrapturus ectenes* Jordan and Evermann, *Makaira grammatica* Jordan and Evermann and *Kijikia formosana* Hirasaka and Nakamura, all of which are synonyms of *T. audax*.

Jordan and Evermann (1926) described *M. holei* and *M. zelandica* as being closely allied to *M. mitsukurii* (*T. audax*). The descriptions and photographs of the types (from mounted specimens) indicate differences from *T. audax* mainly in body colouration. In other features, such as : the anterior lobe of the dorsal being high and equal to or greater than the depth of the body ; the mandible being more than 50% of the length of spear ; the height of the first anal being distinctly shorter than that of the anterior lobe of the dorsal, etc. it may be seen that specific distinction from *T. audax* is not possible. It is well-known that body colouration in species of marlins differs with age and depending on the duration after capture. Colouration depicted on mounted specimens may not be quite accurate and as such much reliance cannot be placed on this character in the present instance.

We have not seen the original description of *Istiophorus ludibundus* Whitley, but follow Royce (1957) in placing this as a doubtful synonymy of *T. audax*.

Careful analysis of records as mentioned by Robins and de Sylva (1960) and others indicates that the striped marlin is definitely a smaller species as compared to the blue and black marlins, not attaining more than about 350 lbs. Records of weight over this attributed to the striped marlin have been shown to be erroneous and in fact refer to the blue marlin

M. nigricans which also when fresh shows faint vertical light bands on the body causing it to be confused with *T. audax*. Munro's (1958) mention of " 14 feet or 976 lb." for this species should probably refer to *M. nigricans*.

Further Munro (1958) remarks that " An example from N.T. (Northern Territory of Australia) reported to be the short-nosed spearfish, *Tetrapturus angustirostris* is presumably the young of this species (figure 763A)." Munro is right in drawing attention to the malidentification of this fish as *T. angustirostris*, but from the figure given by him (after Whitley) it cannot be said with certainty that it represents the young of *T. audax*. For one reason, the height of the anterior lobe of the dorsal is hardly two-thirds the depth of the body. As would be seen from the work of Ueyanagi (1957) on the young of *Kajikia formosana* (= *T. audax*) the high anterior lobe of the dorsal is very characteristic of also juveniles of *T. audax*. Another difference appears to be the very short pelvic fin which appears to be hardly one-third the length of pectoral in the Western Australian specimen. In adult striped marlin the pelvics about equals the length of the pectoral, while in juveniles it is still longer, but this may not be an important character.

Silas and Rajagopalan (1962) report on two specimens of the striped marlin landed at Tuticorin, Gulf of Mannar, during 1961. The species is known to occur in Ceylon waters (Deraniyagala, 1962) and recent definite records of its occurrence from East and South African Waters are made by Smith (1956*a*) ; and Williams (1959).

Royce (1957) mentions that occasionally the high median dorsal rays are retained in medium sized adult striped marlin off California and off Mexico.

Nakamura, Yabuta and Ueyanagi (1953) have given the relation of spawning season and the sex-ratio in *Kajikia mitsukurii* (= *T. audax*). According to them the ratio of the male rapidly increases and decreases at the beginning and end of the spawning season, respectively. Sexual segregation after spawning is suggested. Ueyanagi (1953) has shown that as in other marlins and the swordfish (*Xiphias gladius*) the males are smaller in *Kajikia mitsukurii* (= *T. audax*) but the difference is not so pronounced.

Morrow (1957) found that in certain morphometric and meristic characters the striped marlin (*M. mitsukurii*) from Peru and Northern New Zealand waters represents separate populations. His study also shows that the pelvic fin in the blue marlin stops growth after reaching a certain length and its length is therefore not related to the length of the adult fish.

Kamimura and Honma (1958) and Honma and Kamimura (1958) have also indicated the independence of populations of striped marlins both of the North and South Pacific for they remark that " the striped marlin of North and South Pacific constitute the extremely separated populations with each other, and furthermore it is suggested that they may belong to different species." The main criteria for the distinctions are that in the equatorial region the hooked rate is very low ; the spawning grounds are located far apart and the spawning seasons in both areas differ by about 6 months [according to Ueyanagi (1959), peak spawning period in the N. Pacific is from May to August in areas approximately between 20° — 30° N. lat. and in South Pacific from October to January in areas around 20° S. lat.] ; and size groups and growth patterns also differ.

Japanese longlining records indicate that in the Indian Ocean the striped marlin is taken over a wide area between 10° N. lat. and 10° S. lat. and South West of the Sunda Archipelago still further southwards. Good fishing is reported from the Andaman Sea ; South West of

Java and Sumatra and south of Ceylon. However the information is scanty when compared to the available data on species of tunas.

Ueyanagi (1959) has recorded larvae of the striped marlin from the Eastern Indian Ocean but spawning seasons are little known although it is suggestive that atleast in the Banda–Flores Seas and adjacent seas of Timor Island, spawning occurs during January-February.

Morrow (1952*b*) ; Hubbs and Wisner (1953), Yabuta (1953) and Royce (1957) have given details of the food of the striped marlin and all mention fish as constituting the most predominant item while cephalpods (squids) and shrimp are of very minor importance.

DISTRIBUTION : Tropical and temperate waters of the Indo-Pacific.

Tetrapturus sp.

We tentatively refer to this a problematic species we have encountered from Indian Waters. Three specimens have been examined from Tuticorin Coast, Gulf of Mannar, and details of anatomical features have been discussed elsewhere (Silas and Rajagopalan, 1962). The external characteristics are :

1. *Size* : Small, largest specimen measuring 1231 mm., weighing 31 lbs. (14 kg.). Body much compressed from side to side as in *Istiophorus gladius.*

2. *Dorsal fins* : Dorsal fin uniformly high without a distinct anterior lobe. Both anterior as well as mid-rays distinctly higher than greatest depth of body. Total count for the dorsal in the specimens is 41 + 7. Both dorsals are dusky except the interspinous membrane between the last three or four spines which is conspicuously whitish. About 3 or 4 dark circular blotches are present on the first dorsal, the blotches resembling those seen in the sailfish *I. gladius.*

Pectorals : With 21 rays each ; markedly short, tip not surpassing vertical below 18th dorsal spine ; and length about 0.75 anterior height of dorsal ; shape slightly falcate ; colour light greyish with upper margin dusky. The fins lie flat against the sides of the body and are not rigid as in *M. indica.*

Pelvics : With I, 1 ray each ; elongate, two times or more length of pectoral and black in colour.

Anal : 13 + 6 ; height of anterior anal about same as length of pectoral. Origin of second anal vertically below that of second dorsal or slightly behind ; distal part of the anterior few rays of the first anal is dusky, but the margin and rest of the fin and second anal are hyaline.

Caudal : is deeply forked with both lobes equal. Colour dusky.

Head : Spear is slender with teeth on either margin and below ; mandible moderately long and about 1.5 to 1.6 in spear length ; eyes large, diameter about 7.5 in headlength from tip of mandible and about 2.75 in post-orbital length of head. Predorsal profile of head very gently sloping.

Vent : is situated at the posterior end of the mid-ventral groove. The distance between the vent and first anal origin is about 1/3 head length (from tip of mandible).

The height of the body is from 7.0 to 7.5 in the length from the tip of the mandible.

Scales : Lanceolate and appear ' deciduous ' as in preserved specimens they are easily shed. The lateral line is well defined and runs straight for some distance from above upper

angle of opercle before curving downwards above the posterior third of the pectoral and then straightening and running along mid-laterally to the caudal peduncle.

The air-bladder is in the form of many chambers arranged in a single layer. Besides these characteristics Silas and Rajagopalan (1962) have drawn attention to some pecularities in the disposition of the visceral organs in this form as compared to other known billfishes from this region.

While we fully recognise that the specimens we have encountered are young ones, the specimens differ from other marlins as follows :

From the black marlin *M. indica* it differs in (1) the flexible pectoral base ; (2) the uniformly high first dorsal ; (3) the short pectoral ; (4) the elongate pelvics ; (5) the slender bill ; (6) the chambers of the air-bladder arranged in a single layer.

From the blue marlin *M. nigricans* it differs in (1) the uniformly high first dorsal ; (2) the markedly short pectorals ; (3) the elongate pelvics ; (4) the laterally compressed body ; (5) the body colour when fresh devoid of faint transverse bands ; (6) the mandible which is more than 50% of the bill length, (7) significantly in the simple unbranched lateral line ; (8) the anterior insertion of the second dorsal being vertically above or slightly ahead of that of the second anal and (9) the anterior insertion of the anal being nearer to the base of the caudal than to posterior end of operculum.

From *T. audax* it differs in (1) the uniformly high first dorsal ; (2) the markedly short pectorals ; (3) the body colour when fresh devoid of vertical stripes ; (4) the relatively elongate pelvics ; (5) the more slender body the depth of which is about seven times or more in fork length from tip of mandible.

From *T. angustirostris* it differs in (1) the bill being distinctly longer than the mandible ; (2) the first dorsal count being much lower (49 versus 53) ; and (3) the anterior insertion of the second dorsal being slightly behind that of the second anal.

It is likely that some of the above noted differences may reflect juvenile characteristics. However, until more material becomes available, we consider it best to denote this as *Tetrapturus* sp.

TWO SPECIES OF DOUBTFUL VALIDITY

1. **Marlina jauffreti** Smith, 1956

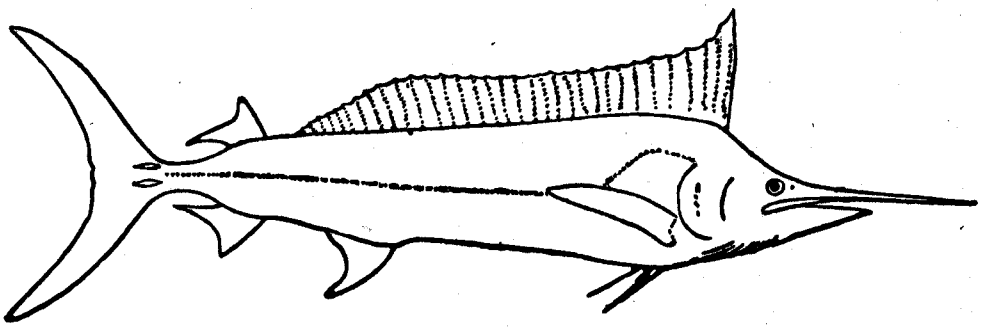
Smith's description of this species is cited below :

" A 168 lb. fish (Fig. H, plate 1), taken at Mauritius in February, 1956, has the general appearance of a Striped Marlin. The photograph is not clear in all essential details, but as far as it is possible to judge, the origin of the anal fin is barely nearer caudal base than head, the second dorsal and anal are relatively remote from caudal base while the lower jaw appears as shorter and the spear stouter than in a typical *audax* ; they are in fact indicative of the " Blue " Marlin. In favour of its identity as *audax* are the stripes, the second anal is clearly in advance of the second dorsal, the pelvics are fairly short, the dorsal fin is almost as deep as the body, and distinctly but not much longer than the distance between the origins of the second dorsal and upper caudal lobe. This fish may have softened in the heat, so that the body below the dorsal is probably bulged out, and the caudal peduncle unduly elongated. The discrepancies from the typical *audax* are hightened by the contrasted white hind border of the dorsal which

the captor notes was distinct. There are also unusual white patches on the body. An examination of the actual specimen would doubtless clear up all doubts, but meanwhile I propose to name this *Marlina jauffreti* n.sp. (after its captor, M. M. Jauffret of Mauritius who states that *audax* is well-known there, and that this fish is different, another specimen having been caught there)."

On this Williams (1959) remarks that "I must point out that *Marlina jauffreti* Smith 1956, from Mauritius, was named purely on the details of a marlin visible in a not very clear photograph and a few notes received by Smith. Although a new species of marlin may be present in Mauritius waters, the establishing of a new species of fish on the basis of a photograph and without access to the fish itself at a later date (it appears to have been destroyed) is likely to introduce confusion to the system of nomenclature and is to be depreciated, especially in such a closely related group as the marlins." We are in full agreement with this view. Further it is felt that although superficial resemblance to *T. audax* is noticeable in some of the characters mentioned by Smith, the following characters, namely, (1) the mandible short, being hardly 50% of the spear-length ; (2) the anterior insertion of the second dorsal and anal are relatively remote from the caudal fork ; and (3) the height of the anterior lobe of the dorsal fin is distinctly shorter than the greatest depth of body, indicate the affinities of *M. jauffreti* to the blue marlin *Makaira nigricans*. It will not be surprising if they turn out to be conspecific.

2. **Tetrapturus tenuirostratus** Deraniyagala, 1951



Text Fig. 14. *Tetrapturus tenuirostratus* Deraniyagala (after Deraniyagala, 1952 : figure erroneously labelled by him as *T. acutirostratus*).

SYNONYMS :

(?) *Histiophorus brevirostris* (*nec* Playfair) Day, 1878

Makaira indicus (in part) Deraniyagala, 1933 : pl. 3, fig. 1 (young)

Tetrapturus brevirostris (Playfair) Deraniyagala, 1949 : pl. 23, fig. b

Tetrapturus tenuirostratus Deraniyagala, 1951 : 139, pl. 1, fig. b.; pl. 2, fig. b. (Type locality : Indian Ocean. Type a mounted specimen in the British Museum of Natural History)

(?) *Tetrapturus brevirostris* (in part) de Beaufort, 1951 : 238

Tetrapturus acutirostratus Deraniyagala, 1952 : pl. 27 (apparently plate figure is wrongly labelled as *acutirostratus* for *tenuirostratus*)

Tetrapturus tenuirostratus Deraniyagala, 1952 : 105

Makaira mitsukurii La Monte, 1955

Tetrapturus brevirostris (in part) Munro, 1955 : 223

This is certainly a doubtful species and would need closer study based on more material. Part of the confusion has been created by Deraniyagala himself by not (1) indicating the size of the type specimen, (2) by without proper clarification reproducing the same figure of a fish at different times under different magnifications (although reproductions are of same size) thus throwing confusion and doubt on the size of the specimen. The figure (*b*) on plate 23 (Deraniyagala, 1949) is undoubtedly the same as fig. 1 on plate 3 (Deraniyagala, 1933) and the reduced figures measure 15.2 cm. (fork to tip of spear while the reduction indicated are 1/15 and 1/8 respectively), (3) incidentally the coloured figure on plate 27 wrongly labelled as *acutorostratus* bears strong resemblance to the two figures mentioned above and the figure which is 23 cm. (fork to tip of spear) is said to be 1/14 natural size.

In view of these discrepancies it is not surprising that it has not been possible to precisely determine the identity of this problematic species.

La Monte (1955) reported the occurrence of the striped marlin *Makaira mitsukurii* (= *T. audax*) on the basis of *T. tenuirostratus* which she considered as the young of the former. The differences we could point out are : the anterior lobe of the dorsal being shorter than the depth of body ; the height of the first anal being slightly more than 0.75 height of anterior lobe of dorsal ; the pelvics being much shorter than the pectoral ; the absence of distinct vertical stripes on the body ; and the median first dorsal rays being more than half height of the anterior lobe of the dorsal. Deraniyagala (1952) gives the size as " Total length 2,640 mm. " and if the aforesaid are characteristic of this size specimen, there can be no doubt that *T. tenuirostratus* is distinct from *T. audax*. However, we have noted an element of doubt as regards the sizes and hence the problem remains unsettled.

Neither do certain statements made by Smith (1956*b*) help in clarifying the matter. He has suggested several alternatives to solve the confusion in marlin taxonomy. One is that the black and blue marlins belong to one species *Istiompax indica* (*I. i. indica* the black marlin and *I. i. ampla* the Atlantic blue marlin) in which case Indo-Pacific blue marlin may be the same as the Atlantic blue marlin or " more likely either *Istiompax indica tenuirostratus* (Deraniyagala), or *I. indica howardi* (Whitley), or if neither of these be accepted, *I. indica glauca* nov., the type of the latter a photograph of a specimen 1226 lbs. in weight, from Eden, N.S. Wales, Australia, shown on plate 70 in Roughly 1951." The last said photograph we see is clearly that of the blue marlin *Makaira nigricans*.

Another alternative given by Smith (1956) is that " The ' Black ' and the ' Blue ' are not proved to be distinct species : *nigricans* Lacepede becomes valid and the indeterminable young becomes *Makaira nigricans* Lacépède, the black *M. nigricans herscheli* (Gray) ; the blue of the Atlantic *M. n. ampla* (Poey), and the blue of the Indo-Pacific, (if it be different), *M. n. tenuirostrata* (Deraniyagala) or *M. n. howardi* (Whitley) or possibly *M. n. glauca* nov., as in B. 2 (should be A. 2) above....."

The proposal of yet another new name *glaucus* does not help in clarifying the position of *T. tenuirostratus* which until restudied based on fresh material may have to be considered a species of doubtful validity.

Genus **Makaira** Lacépède, 1803

Makaira Lacépède, 1803. Hist. Nat. Poiss., 4 : 688 (Type : *Makaira nigricans* Lacépède, Based on notes and a sketch of a specimen washed ashore on the Ila du Ra' sent to Lacépède by MM. Traversay, Fleurian — Bellevue, and Lamathe). The spelling of

the generic name was amended to *Machaera* by Cuvier and to *Macaria* by Nardo (1833).

Istiompax Whitley, 1931. *Rec. Austral. Mus.*, 18 (Type : *I. australis* Whitley).

Marlina Hirasaka and Nakamura, 1947. *Bull. Oceanogr. Inst. Taiwan* 3 : 15 (Type : *Makaira marlina* Jordan and Hill) (*nec Marlina* Grey 1928 — a synonym of *Tetrapturus* Rafinesque, 1810).

Eumakaira Hirasaka and Nakamura, 1947. *Bull. Oceanogr. Inst. Taiwan*, 3 : 16 (Type : *E. nigra* Hirasaka and Nakamura).

Probably *Zanclurus* Swainson, (1939 : *Hist. Nat. Fish.*, 2 : 239 : Type : *Z. indicus*) is also a synonym of *Makaira* as restricted here.

Jordan and Evermann (1926) recognised 16 species under the genus *Makaira* of which four were described as new and several ".....very imperfectly described and await better definition." Although a generic description was not given, the key characters used by them for separating *Makaira* from *Tetrapturus* and *Istiophorus* were : " Dorsal fin low, the lobe high, its anterior spines thickened, and others progressively shortened to the last ; ventrals much shorter than pectorals."

Nakamura (1949) divided the family Istiophoridae into two subfamilies, Tetrapturinae and Marlinae, the former to include the genera *Tetrapturus, Istiophorus* and *Kajikia*, and the latter *Marlina* and *Eumakaira*. The general grouping of the genera appears natural enough as later workers (Robins and de Sylva, 1960) have shown, but the need for the two subfamily divisions has been questioned and at the same time current nomenclature used for some of the genera is different.

Robins and de Sylva (1960) have followed in the main Nakamura (1938, 1949) in recognising two species, the blue marlin *M.* (*M.*) *nigricans* (denoted as *Eumakaira nigra* Nakamura and treated in Japanese literature as the " Black Marlin " and popularly known in Japanese as *Kurokajiki* or *Kurokawa*), and the black marlin *Makaira* (*Istiompax*) *indica* [denoted as *Marlina marlina* (Jordan and Hill) and treated in Japanese literature as the " White marlin " and popularly known in Japanese as *Shirokajiki*] under the genus *Makaira*, which thus corresponds with the subfamily Marlinae. Hence the key characters used by Nakamura (1949) for Marlinae to distinguish it from Tetrapturinae would partly cover the generic diagnosis of *Makaira* on the one hand and *Tetrapturus* and *Istiophorus* on the other as given below :

(1) " Vertebrae are 12 + 12 = 24. The body is slender with the height of the first dorsal exceeding the depth of the body. The anterior portion of the first dorsal has a concave outline. The lateral line is single and clearly discernible. The ventral fins are generally well developed.....Subfamily Tetrapturinae.

(2) Vertebral formula 11 + 13 = 24. Body stout, height of first dorsal less than body depth ; height of the fin decreases sharply posterior to the 4th or 5th ray. Lateral line obscure, may be single or complex. Ventral fins generally short..... Subfamily Marlinae."

The genus *Makaira* as recognised here has as generic diagnosis the characters given by Nakamura for the subfamily Marlinae in addition to the other characters drawn attention to by Robins and de Sylva (1960), namely, (1) compared to other Istiophoridae, species of *Makaira* attain a very large size of about 2,000 lbs. (907 kg.) (while species of *Istiophorus* and *Tetrapturus* do not attain more than about 300 lbs. (136 kg.) ; (2) the bill of *Makaira* (" Makairinae ") shows positive allometry (*versus* negative allometry in " Tetrapturinae ").

As only two species of the genus are known the question of subgeneric subdivisions into *Makaira* s. str., and *Istiompax* appears superfluous.

DISTRIBUTION : Warmer waters of the Indo-Pacific and Atlantic.

BLACK MARLIN

Makaira indica (Cuvier), 1831

(Plate VIII, Fig. D)

SYNONYMS :

Tetrapturus indicus Cuvier, 1831 : 286 (Type locality : Sumatra—based on a drawing by Sir Joseph Banks)

Histiophorus brevirostris Playfair, 1866 : 53 (Type locality : Zanzibar)

Makaira marlina Jordan and Hill, *in* Jordan and Evermann, 1926 : 59 (Type locality : Pacific coast of Mexico from Cape San Lucas southward)

Istiompax australis Whitley, 1931 : 8 (Type locality : Australia)

Tetrapturus mitsukurii Tanaka, 1933 : 163 (*nec* Jordan and Snyder)

Makaira australis Fowler, 1934 : 400, 402

Makaira indicus (in part) Deraniyagala, 1933 : 55

Makaira nigricans tahitiensis Nichols and LaMonte, 1934*a* : 1 (Type locality : Tahiti)
Rosa, 1950 : 144

Makaira nigricans marlina Nichols and LaMonte, 1935*b* : 328
Rosa, 1950 : 143
Morrow, 1954 : 819
Williams, 1959 : 763

Makaira ampla marlina Nichols and LaMonte, 1941 : 8

Makaira ampla tahitiensis Nichols and LaMonte, 1941 : 8

Marlina marlina Hirasaka and Nakamura, 1947 : 15
Nakamura, 1949 : 63
Ueyanagi and Yabe, 1959 : 162 ; 1960 : 167–173
Ueyanagi, 1960 : 85

Makaira herscheli Smith, 1949 : 315, fig. 875 (*nec* Gray, 1835)

Makaira indica Fowler, 1949 : 74
Deraniyagala, 1952 : 107
Munro, 1955 : 223
Silas and Rajagopalan, 1962

Makaira indica (in part) Rosa, 1950 : 140
Mendes, 1954 : 147

Istiompax dombraini Whitley, 1954 : 60 (Type locality : Australia) 1955 : 295

Makaira mazara (in part) LaMonte, 1955 : 336

Makaira mazara tahitiensis (in part) LaMonte, 1955 : 342

Makaira herschelii Smith, 1956 : 27 (*nec* Grey, 1835)

Istiompax marlina Royce, 1957 : 524
Munro, 1958 : 19
Makaira marlina marlina Morrow, 1957 : 89
Makaira marlina tahitiensis Morrow, 1957 : 89
Istiompax brevirostris Morrow, 1958 : 358
Istiompax indicus Morrow, 1959 : 321
Black Marlin : Williams, 1959 : 78
Makaira (*Istiompax*) *indica* Robins and de Sylva, 1960 : 406

The black marlin *Makaira indica* is a very distinct species that can be easily recognised by the Key characters given on p. 6, as well as the combination of characters detailed below : the bill is shorter and stouter than in other marlins or spearfishes and in larger examples the lower jaw from tip to angle of mouth is half length of bill ; the body is markedly deep above the pectoral and humped resulting in the dorsal profile of the head showing a steep ascent to origin of dorsal fin ; in larger specimens the height of the anterior lobe of the dorsal fin hardly equals the distance between its origin and that of pectoral ; origin of the first anal fin is situated almost midway between the head (end of opercle) and the base of the caudal ; the lateral line is simple ; and the air bladder is foam-like with several layers of small chambers, all enclosed within a thick membrane.

Nakamura (1938) has given the meristic counts for this species as : D. III, 10–12, XXIII–XXV, 7 ; A. II, 10–11, 7 ; V–I, 2 ; Vertebrae 24 (11 + 13).

Rivas (1956) mentions that in *Makaira marlina* the dorsal spines number from 33 to 41 but are usually 37 to 40 and anal spines 10 to 14, usually 12 or 13.

Two specimens examined by Silas and Rajagopalan (1962) at Tuticorin had 36 and 37 dorsal spines. The same authors have drawn attention to certain anatomical features of the black marlin in relation to other Indian istiophorids in addition to giving morphometric data for Indian bill fishes to which reference may be made.

The chaotic state in which bill fish nomenclature has been till now will be evident from the numerous combination of names used by earlier workers to denote the black marlin. Part of the confusion has stemmed from the use of popular names in English to denote this species. Japanese workers have used the term ' white marlin ' (in Japanese *Shirokajiki*) on account of the whitish body colour when fresh which incidentally also figured as the prime factor in the description of the ' Silver marlin ' *Makaira nigricans tahitiensis* Nichols and LaMonte, 1935. At present, the term ' White Marlin ' is used to denote *Tetrapturus albidus* Poey from the Atlantic. The terms Pacific black marlin, giant black marlin and black marlin have been used by American workers to denote the present species. At the same time, what is currently known as the blue marlin — *Makaira nigricans* Lacépède from the Atlantic and the Indo-Pacific has been denoted by some workers as the black marlin.

It should be admitted that *M. indica* and *M. nigricans* are more closely allied than they are to other istiophorids. However, Hirasaka and Nakamura (1947) drew attention to some principal differences between the species *Makaira marlina* (= *M. indica*) and the blue marlin and striped marlin *M. ampla* (= *M. nigricans*) and *M. audax* (= *Tetrapturus audax*) respectively. The main characters involved are, the considerably broader shoulder gridle in *marlina* and its articulation with the pectoral fin restricting its movement and making it ' rigid ' ; the fusion

of both the halves of the pelvic girdle ; and the air bladder consisting of several layers of small chambers (*versus* flexible pectoral ; both halves of pelvic girdle separated by broad space and air bladder chambers in single layer).

These differences led them to propose the genus *Marlina* which unfortunately is preoccupied. According to Royce (1957) the differences noted by Hirasaka and Nakamura " Warrant retention of *marlina* in a separate genus ; however, the generic name *Marlina* cannot be applied to this genus. In the first place, its use is prevented by Zane Grey's introduction of the name *Marlina mitsukurii* in 1928. Since he used the name solely in this combination and prior to 1928 when such a proposal was permitted, *mitsukurii* is the haplotype of *Marlina* Grey. In the second place, Whitley (1931 : 18) proposed the genus *Istiompax* for *I. australis*, a new species, recognised as a synonym of *Makaira marlina* Jordan and Hill. Therefore, the generic name *Istiompax* has precedence over *Marlina* Hirasaka and Nakamura (*non* Grey)."

Robins and de Sylva (1960) recognised *Istiompax* Whitley as a subgenus of *Makaira* with a single species *M. (I.) indicus* (black marlin) and one other species for the genus, *M. (Makaira) nigricans* (blue marlin). Some authors including Smith (1956) have considered the above two as conspecific. However Morrow's studies on the pectoral girdle of these fishes (marlins) clearly indicate that for reasons given by Hirasaka and Nakamura (1947) and additional points (See Morrow, 1957) they certainly merit specific distinction. Since only two species are involved, we consider it best to treat these under the genus *Makaira* as *M. indica* and *M. nigricans* instead of :

(1) relegating each species to a different genus (*Istiompax* and *Makaira*) respectively, or

(2) relegating each species to a different subgenus under one genus *Makaira* as *M. (Istiompax) indica* and *M. (M.) nigricans.*

Ueyanagi and Yabe (1959, 1960) were the first to draw attention to larvae possibly referable to *M. indica.* Later, Ueyanagi (1960) gave a more detailed account of the larvae and spawning areas of *Marlina marlina* and also indicated the fishing grounds for the species in the Western Paciffic and Indian Ocean. Of four additional larvae of the black marlin examined by Ueyanagi (1960), one was obtained from the southern waters off Ceylon and another from south of Sunda Islands, indicating likely spawning grounds. The rigid pectoral of the adult appears to be characteristic of also early larvae by which it could be easily separated from larvae of other istiophorids.

No detailed study is available on the food, maturity etc., of the black marlin from the Indian Ocean. Records from various parts of the Pacific indicate that the species may attain over 1500 lbs. (681 Kg.) and available data show that males are smaller, generally not attaining more than 320 lbs. (Royce, 1957). In the Pacific, Royce (1957) mentions of an instance where a 157 lb. (71 Kg.) 154 cm. yellowfin tuna was found in the stomach of a black marlin 402 cm. long. Other instances of tunas forming food are also mentioned.

Information on fishing condition for the black marlin in the Indian Ocean may be had from the ' Average year's fishing condition of tuna long-line fisheries 1958 edition ' edited by Nankai Regional Fisheries Research Laboratory (1959) ; for other areas reference may be made to Nakamura (1949) (Western Pacific, Indian Ocean) ; and Royce (1957) (Central Pacific).

DISTRIBUTION : The known distribution of *M. indica* closely follows the pattern of *M. nigricans* in the Indo-Pacific ranging through most of the temperate and tropical parts of these oceans. In Indian coastal waters specimens have been taken off Bombay and in the Gulf of Mannar.

BLUE MARLIN

Makaira nigricans Lacépède, 1803

(Plate VIII, Fig. B)

SYNONYMS :

Xiphias ensis Lacépède, 1802: 296 (Based on spear only found on west coast of France)?
Makaira nigricans Lacèpède, 1803 : 688–91, pl. 13, fig. 3 (Type locality : La Rochelle, France)
Morrow, 1959 : 1–11
Xiphias makaira Shaw, 1805 : 104 (after Lacépède's *Makaira nigricans*)
? *Histiophorus gracilirostris* Cuvier, 1831 : 308 (Based on spear only from La Rochelle, West Coast of France)
Makaira velifera Cuvier, 1832 : 43 (after Lacèpéde, 1803)
Tetrapturus hersehelii Gray, 1838 : 313 (Type locality : Cape of Good Hope, South Africa)
Tetrapturus amplus Poey, 1860 : 237, 243–44, 1861 : pl. 15, Fig. 2 (Type locality : Coast of Cuba)
Tetrapturus mazara Jordan and Snyder, 1901 : 305 (Type locality : Misaki, Japan)
Istiophorus nigricans Ribeiro Miranda, 1915
Makaira herseheli Thompson, 1918 : 118 Barnard, 1927 : 808
Makaira mazara Jordan and Evermann, 1926 : 53
Morrow, 1959 : 322–23
? *Makaira ensis* Jordan and Evermann, 1926 : 57
? *Makaira gracilirostris* Jordan and Evermann, 1926 : 58.
Makaira nigricans ampla Conrad and LaMonte, 1937 : 207
La Monte, 1937 : 207
Makaira ampla ampla LaMonte and Marcy, 1941 : 2
Morrow, 1957 : 90
Makaira ampla mazara LaMonte and Marcy, 1941 : 2
Morrow, 1957 : 44 ; 1957 : 89
Eumakaira nigra Hirasaka and Nakamura, 1947 : 16 (Type locality : Formosa)
Nakamura, 1949 : 65
Nakamura, Yabuta and Ueyanagi, 1953 : Yabuta, 1954
Ueyanagi, 1957 : 91–102 ; 1957 : 103–106
Ueyanagi and Yabe, 1959 : 151–69
Makaira perezi de Buen, 1950 : 171–75
Makaira nigricans mazara Rosa, 1950 : 141
Makaira mitsukurii (in part) Herre, 1953 : 255
Istiompax howardi Whitley, 1954 : 58
Makaira ampla LaMonte, 1955 : 334
Rivas, 1956 : 59–73
Royce, 1957 : 535–38
de Sylva, 1958 : 412–15
Munro, 1958 : 19
Makaira mazara (in part) LaMonte, 1955 : 336
Makaira herscheli Fourmanoir, 1957 : 220–21
Makaira herschelii Morrow, 1958 : 356
Makaira indica (in part) Scott, 1959 : 117

Xiphias ensis Lacépède and *Histiophorus gracilirostris* Cuvier, are given as doubtful senior and junior synonyms of *Makaira nigricans*. Of these, Jordan and Evermann (1926) remark that " The nominal species *Makaira ensis* known by the spear only, which is very long, and *Makaira gracilirostris* from the same region and with the spear even more slender, cannot be inserted in the Key (Their " Analysis of the species of Makaira ") for lack of other information. The two are probably identical, and *M. ensis* is very likely valid. *M. nigricans* is, very doubtfully, figured with a much stouter spear. The name *ensis* has priority over *nigricans*. Morrow in his several works on the blue marlin does not comment on Lacépède's *X. ensis* but shows that *nigricans* is the name for the blue marlin. Jordan and Evermann (1926) published a photograph of the skull of the type specimen of *M. ensis* in which the length of the spear is about 15 times its width at the base. Of *Makaira gracilirostris* (Cuvier) they remarked that : " This species is based on the spear of a spearfish or sailfish said to have been 25 to 30 feet long, the length of the spear 25 to 26 times its width at base, its sides more rounded than usual ; lower jaw 2/5 length of upper. It is from La Rochella and is probably identical with *Makaira ensis*, though the spear is still longer ; *Makaira nigricans* from the same locality has the spear much shorter. A spear from the Seychelles, said to be similar to *gracilirostris* is mentioned by Cuvier and Valenciennes but the original type specimen came from France, if we read the description correctly. Lütken regards *gracilirostris* as probably a distinct species, but it is not likely that it is really different from *ensis* also recorded from La Rochelle, although its spear may be longer." It is our opinion that these species names based only on the spears should under no circumstance be resurrected.

Morrow (1959) has shown that *T. herschelii* Gray, *T. amplus* Poey, and *M. perezi* de Buen are synonyms of *M. nigricans* Lacépède. To this list may be added *Eumakaira nigra* Hirasaka and Nakamura and as Rivas (1956) has shown *I. howardi* Whitley also. Slight differences in the structure of the pectoral girdle between the blue marlin from the Pacific and the Atlantic Oceans have been observed by Morrow (1957) leading to the recognition of two subspecies, the Atlantic blue marlin *Makaira a. ampla* and the Pacific blue Marlin *M. a. mazara*. However, there are hardly any external differences between the Atlantic and Pacific forms which led Rivas (1956) and Royce (1957) to synonymise the two forms, an action which seems to us to be justifiable as we recognise only a single circumtropical species *M. nigricans* with no subspecies.

Diagnostic characters of *M. nigricans* are :

(1) Large size females of the species attaining between 1,500 and 2,000 pounds while males are smaller weighing 300 lbs. or less.

(2) Pectoral fin flexible and can be adpressed to the side of the body without any difficulty.

(3) Anterior lobe of the first dorsal is less than the greatest depth of the body.

(4) The anterior lobe of the first anal fin is almost equal to the anterior lobe of the first dorsal. Regarding this Royce (1957) remarks that it is the best character for distinguishing between " *ampla* from *audax* " for " In *ampla*, the height of the first anal averaged 86 percent of the height of the first dorsal with a range of 76 to 100 per cent ; in *audax*, the range was from 50 to 76 per cent with an average of 66 per cent."

(5) An additional difference between the blue and striped marlins drawn attention to by Royce (1957) is in the relative height of the middle rays of the first dorsal with growth. " The centre of the first dorsal fin is low and in our specimens

there is a suggestion of an actual decrease in the average length of the 20th ray with the growth of the fish up to 200 cm.; but in specimens of more than 200 cm. fork length the length of the 20th ray is nearly constant. The average length of the ray in *ampla* is approximately 6 cm. with the range in our specimens from 3 to 9 cm.; in *audax*, which has a similar growth pattern, the range is from 8 to 14 cm. with an average of 10 cm."

(6) Unlike the black marlin and the striped marlin, the spear in the blue marlin is relatively longer in relation to the length of the mandible, the latter being less than half the spear length. This according to Royce (1957) is on account of the growth relation of mandible/spear in the striped and black marlins being approximately isometrical whereas in the blue marlin the mandibular growth is definitely negatively allometric.

Additional characters mentioned are that the dorsal profile in the blue marlin does not show the high elevated ' hump ' as seen in the black marlin, but the profile is slightly more arched than in the striped marlin.

Another important, but more easily noticeable character is the peculiar lateral line pattern of the blue marlin of which Rivas (1956) writes that " unlike other species of marlin, *Makaira ampla* (= *M. nigricans*) does not possess a visible, simple lateral line running along the middle of the sides of the body. Instead, the lateral line is inconspicuous, complex and forms a reticulate pattern covering the sides of the body. It is fairly visible only when a patch of skin is removed and held up to the light. Both Atlantic and Pacific specimens were found to be similar in this character." Similar complicated reticulate or hexagonal pattern of lateral line was also noted by Hirasaka and Nakamura (1947) while describing *Eumakaira nigra*, which as already mentioned is a synonym of the blue marlin *M. nigricans*.

Body colouration is not a diagnostic character. In life " the predominant colour of the upper parts is a brilliant, deep metalic blue which fades rapidly after death to a lead-grey colour mixed with brown whenever the fish has been rubbed or scraped. Stripes usually are present on the sides immediately after death but are rarely conspicuous, and generally some are so faint that it is difficult to count them " (Royce, 1957).

Silas and Rajagopalan (1962) record one young blue marlin from Tuticorin Coast, Gulf of Mannar showing the above diagnostic characters. Morphometric and meristic data for the specimen are given by them along with certain anatomical features.

What little is known of the food of the blue marlin (Nakamura, 1942 ; Royce, 1957; Krumholz and de Sylva, 1958) indicates that fish constitutes the predominant item with cephalopods (squids) next in the order and rarely shrimps.

For size attained by the blue marlin reference may be made to Nakamura (1949) ; Nakamura *et al.* (1953) ; Ueyanagi (1953) ; Yabuta (1954) and Royce (1957). Little is known about the spawning habits of the species other than what has been mentioned by Nakamura (1942; 1951). For osteological characters of the blue marlin reference is invited to Nakamura (1938) and Morrow (1957), and for details regarding the anatomy of the alimentary tract and reproductive organs, to LaMonte (1958).

The structure and disposition of the scales in the blue marlin are discussed at length by LaMonte (1958) while Krumholz (1958) has given data on the relative weight of the viscera of the blue marlin of different sizes and also in relation to other Atlantic marlins. De Sylva

(1958) has compared the juvenile blue marlin with adult blue marlin and white marlin from the Atlantic.

Data on Japanese longline fishery shown in the atlas prepared by the Nankai Regional Research Laboratory (Yabuta 1954) indicate good fishing grounds for the blue marlin in the Indian Ocean over a wide area, especially south west of Sumatra and Java ; the Andamans and Nicobar Islands ; 4° N. and S. of the equator and off the N. Western Coast of Australia.

DISTRIBUTION : Throughout the warmer waters of the Indo-Pacific and the Atlantic.

FAMILY XIPHIIDAE

Genus **Xiphias** Linnaeus

Xiphias Linnaeus, 1958. *Syst. Nat.* ed. 10 : 248 (Genotype : *Xiphias gladius* Linnaeus).
Phaethonichthys Nichols, 1923. *Amer. Mus. Novitates*, 19, pl. 1, Oct. 19, 1923 (Genotype : *Phaethonichthys tuberculatus* Nichols) (*nec* Bleeker, 1879).

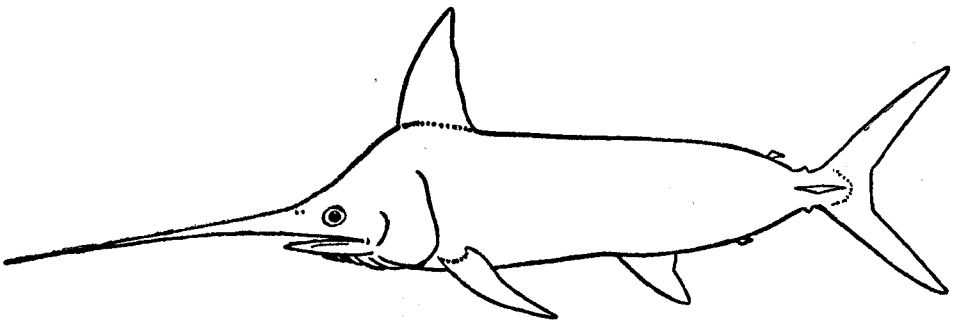
Body elongate, compressed, with long pointed rostrum which is depressed, elliptical in cross-section ; young with lower jaw produced, but not equalling rostrum ; scales absent in adults ; posterior spines of first dorsal lost with age leaving only anterior high falcate lobe ; second dorsal and anal short ; latter divided in adult ; detached finlets absent ; a single median conspicuous caudal keel on each side ; pectorals moderately long, about equalling height of first dorsal lobe ; pelvics absent ; teeth wanting ; branchiostegal membranes not united ventrally ; gill lamellae of each arch united as a single plate by reticulation ; air-bladder present ; pyloric caecae numerous ; intestine zig-zaging a few times ; vertebrae 26 (16 + 10) ; monotypic.

DISTRIBUTION : Tropical and temperate seas. Cosmopolitan.

SWORDFISH

Xiphias gladius Linnaeus, 1758

(Plate IX, A & B; Text Fig. 15)



Text Fig. 15. *Xiphias gladius* Linnaeus, the swordfish (after Deraniyagala, 1952).

SYNONYMS :

Xiphias gladius Linnaeus, 1758 : 248 (Type locality : ' Habitat in Oceano Europae ')
Cuvier, 1831 : 255
Günther, 1860 : 511–12

Gray, 1871 : 338–39
Lutken, 1880 (1883) : 575–79 ; 1880 : 441–447
Goode, 1883 : 289–386
Haley, 1887 : 132-D
Day, 1878 : 198 ; 1889 : 130
Thompson, 1918 : 119
Regan, 1924 : 224
Jordan and Evermann, 1926 : 71
Barnard, 1927 : 805
Deraniyagala, 1933 : 57 ; 1936 : 1937 ; 1951 : 140–41 ; 1952 : 108
Copely, 1935 : 1936 : 19–23 ; 1952 : 169–70
Fowler, 1936 : 648–49
Gudger, 1940 : 218–315
Rich, 1947 : 7–15, 30–98
Smith, 1949 : 314 ; 1956*a* : 1065 ; 1956*b* : 251
Rosa, 950 : 63–167
Nakamura, *et. al.*, 1951 : 264–71
Yabe, 1951 260–63
Arata, 1954 : 183–243
Munro, 1955 : 222 ; 1958 : 19
Taning, 1955 : 438–450
Williams, 1956 : 46
Maeda, 1957
Royce, 1957 : 518–519
Jones, 1958 : 357–61
Yabe *et. al.*, 1959 : 107–150

Xiphias platypterus Shaw and Nodder, 1792 : III, pl. lxxxliii (Brazilian and East Indian Seas, Northern Ocean)
Shaw, 1804 : 101

Xiphias imperator Bloch and Schneider, 1801 : 93, pl. 21 (Mediterranean Sea : Based on young swordfish copied originally from Aldrovandi)

Xiphias rondeletii Leach, 1818 : 58

Ziphius gladius Hector, 1875

Ziphias gladius Cheeseman, 1876 : 219–20

Phaethonichthys tuberculatus Nichols, 1923 : 1 (Type locality : Rapa Island, Austral. group, South Seas. Based on fragmentary portion of young swordfish taken from gullet of red-tailed ocean bird)

Xiphias estara Phillipps, 1932 (Type locality : New Zealand)
Whitley, 1954

Xiphias thermaicus Serbetis, 1951 : 269–73 (Type locality : Gulf of Thermaicus)

We recognise only a single cosmopolitan species which is very distinctive from other billfishes and can be easily recognised by the Key characters given on p. 6.

Day (1878) while citing a few instances of attack by ' swordfish ' on ocean-going vessels remarked that *Xiphias* has " Not as yet been found in the seas of India." *X. gladius* is a truly oceanic species and its occurrence in coastal waters is rare. A few stray records of its occurrence in Ceylon waters are mentioned by Deraniyagala (1937, 1952). Till recently there appears to be no authentic record of the species from Indian waters although malidentifications of

marlins (spearfishes) as swordfish may be found in Indian ichthyological literature. Jones (1958) first reported on *X. gladius* larvae from the Laccadive sea. Since then, during exploratory fishing operations conducted in the Laccadive Sea, two adult swordfish were obtained on 25–1–1960 (in drift net), and 7–4–1960 (in long-line) and the former is figured here (Plate IX).

The rostrum or sword is usually one-third the total length inclusive of rostrum or slightly less than or about 2 times in length from tip of mandible to base of caudal. Munro (1955) mentions the fin-ray counts as " D 40 + 4 ; A. 18 + 4 ; P_1 2 + 14 " apparently this being for early juveniles as in adults the first dorsal count is II, 15 (Deraniyagala, 1952) as the posterior rays are lost with age being coverd by the skin.

The species attains about 5 metres in length and weighs well over 1,200 lbs. For recent works on aspects of the biology of this species reference may also be made to Nakamura (1938, 1955) ; LaMonte and Marcy (1941), Nakamura, *et al.* (1951) ; Yabe (1951) ; Arata (1954) and Tibbo, Day and Doucet (1961). Gregory and Conrad (1937) have made a comparative study of the osteology of the swordfish and the sailfish. Pugnacity of the swordfish is well known and the subject has been dealt with at length by Gudger (1940) and Rich (1947). More recently Smith (1956*a*) has also given instances of the pugnacity of marlins and swordfish.

Organised fishery for swordfish exists only in parts of the Mediterranean and in the North Western Atlantic off the Coast of United States and Canada. Stray catches have been reported from Japanese longline fishery from various parts of the Indo-Pacific.

Recent investigations by Nakamura *et al.*, 1951 and Taning, 1955, tend to indicate that while the known breeding areas of *Xiphias* as evidenced from collection of larvae are to be found in tropical waters where northern and southern summer surface isotherm is 24° C. or more, the adults are largely dispersed in more temperate waters.

General Remarks

We have, in the foregoing account, made an attempt to give briefly along with our own observations the available information on the systematics of the scombroid fishes known to occur in the Indian Ocean region and the taxonomical problems confronting some of the species. A review of the taxonomical literature in India on scombroids would show that there has been hardly any change during the next eight decades since the publication of Day's *Fishes of India* in 1878. The tendency has been obviously due to either ignorance or apathy, to conveniently assign any scombroid to one or the other of the species listed in the above publication till " incursions " by some species into the ichthyological literature of this region within the last one decade especially on account of the work of de Beaufort (1951). It could perhaps be said with some amount of justification that the picture has begun to change within the past two or three years based on the contributions from this institute though this has brought in its wake fresh problems requiring elucidation. All scombroids are pelagic fishes and many of the larger species are oceanic while a few are circumtropical in distribution. Most, if not all the oceanic species in the Indo-Pacific are common to both the oceans. It is now evident that tunas and marlins occurring in the Indian region are not confined to the few listed in the earlier literature and that the apparent discontinuous distribution of many in all probability may be due to want of any proper search for them.

While above is the case with reference to systematics, the position with regard to the biology of scombroids is still worse with the possible exception of the Indian mackerel which in view of its economic importance has received certain amount of attention.

This is probably because fishing in this country is confined to coastal waters where none of the scombroids except the mackerel form a fishery of any magnitude. Tunas, the most potentially important fishes, and marlins and seerfishes occur only in stray numbers or as seasonal catches but never form major fisheries. Only in the island of Minicoy an organised tuna fishery exists mainly for the oceanic skipjack.

The world catch of tuna now stands at about 8,00,000 tons and the demand for it is constantly on the increase. India's share at present is negligible but her central position in the Indian Ocean offers her considerable advantage over other countries for the development of the latent oceanic fisheries of this region. It needs no emphasis that for the scientific development of any fishery and its maintenance at the optimun sustainable level, systematics, is the foundation on which all other aspects of study should be based. Therefore it is high time that more attention is paid to the study of the systematics of the scombroid fishes of this region than hitherto.

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THE PAPER WAS READ BY DR. E. G. SILAS

DISCUSSION

Mr. G. P. WHITLEY : It appears to me that the picture of the seerfish shown with the broadly rounded pectoral fin looks very much like *S. semifasciatus*.

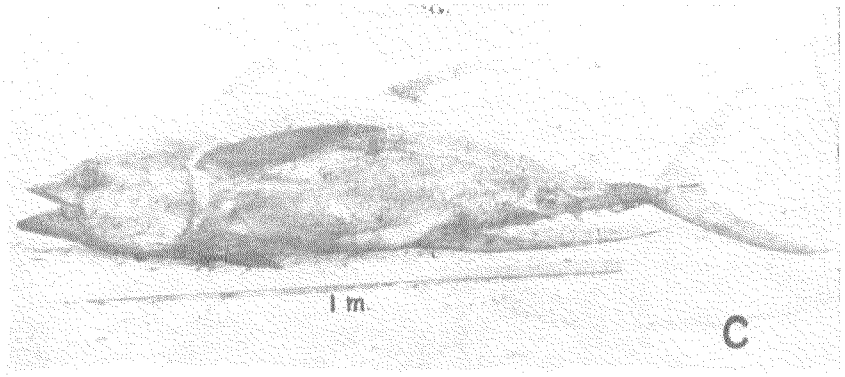
Dr. E. G. SILAS : The one you have referred to is *S. commerson*. *S. semifasciatus* has characteristic distinct vertical bands on each side of the body, in addition to having a higher gill-raker count and the lateral line not decending abruptly below or behind the second dorsal. When species of *scomberomorus* are compared, the affinities between *S. commerson* and *S. semifasciatus* are greater and it may not be surprising if studies based on good series of specimens show that *S. semifasciatus* is only a subspecies of the widely distributed *S. commerson*. The work on the taxonomy of scombroid fishes has had the drawback of not being based on good series of specimens from different locations along the distributional ranges of the different species, mainly on account of the large size of the specimens.

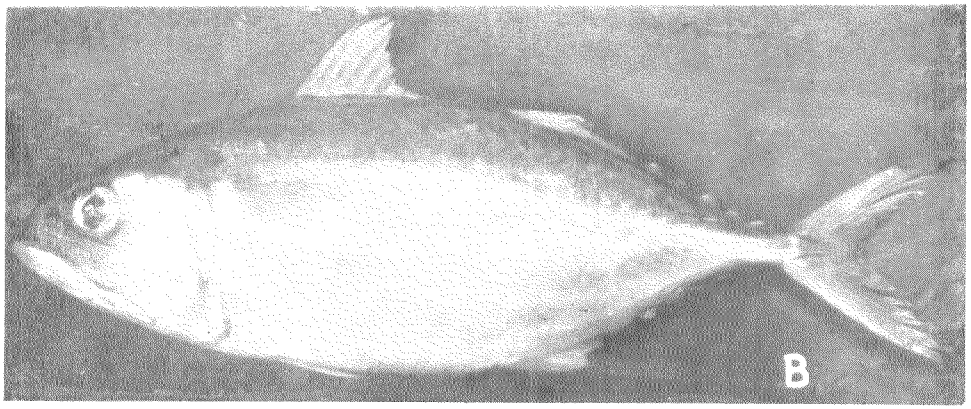
Dr. W. M. CHAPMAN : Yes, I thought one of the things that came out of the Hawaiian Symposium last summer that was useful was the offer of the Japanese scientists to send specimens from their far-flung fisheries around the world to the U.S. National Museum for extensive systematic work. I do not think there is any possible way of working out the systematics of scombroid fishes absolutely until some one person has specimens of all the species he can examine.

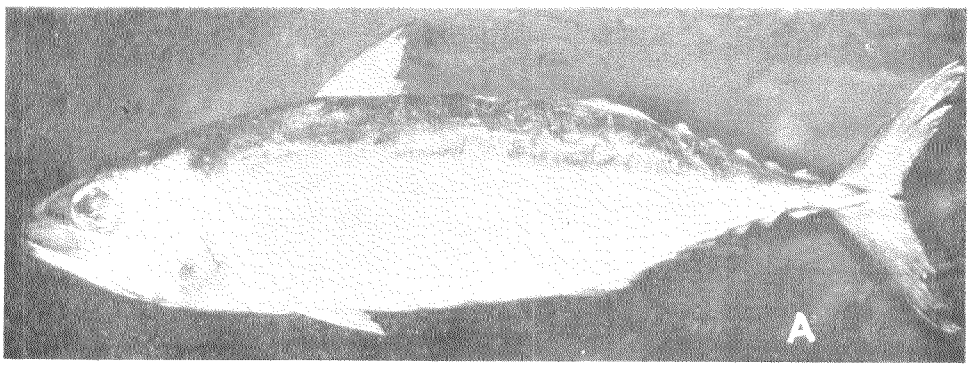
DR. S. JONES : This is one group that should be studied on a global basis and we should have the material from all the oceans. It might be desirable to have not only one centre but more than one centre for the study as well as the deposition of representative reference material so that workers from different regions could have easy access to these as it may not be possible for all to go to one place.

Mr. RODNEY JONKLAAS : Dr. Silas, you mentioned that there is some variation in the dorsal fin of the sailfish *Histiophorus*. Has any study been made with reference to sex and the length of the dorsal fin or the distance between the first and second dorsal fins.

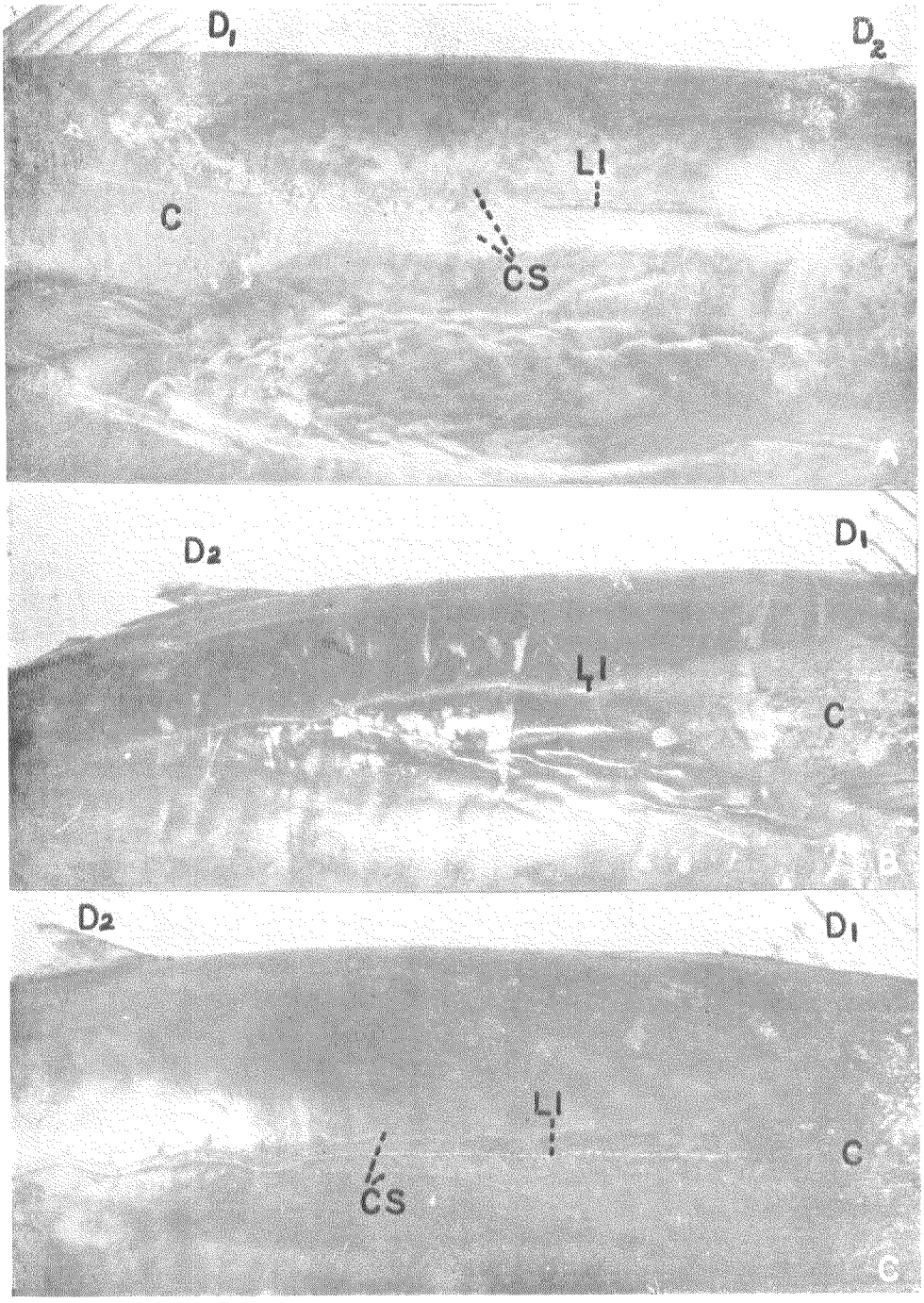
Dr. E. G. SILAS : To my knowledge there is no study of sexual dimorphism in *I. gladius* with special reference to the shape of the dorsal fin. I have not come across any noticeable difference in the shape of the dorsal fin in male and female specimens of *I. gladius* caught off Tuticorin although difference in the maculation of the fins may be seen from specimen to specimen. In young juveniles of *I. gladius* described by Deraniyagala (1952) and Jones (1959) from Ceylon Waters and the Laccadive Sea, the first and second dorsal fins are contiguous. In half grown and adults, a gap between these fins is seen. However, the mid-dorsal groove in this gap conceals a few of the stumpy last rays of the first dorsal fin, from which it would appear that the difference in the distance between the dorsal fins may have something to do with the size or age of the specimen.



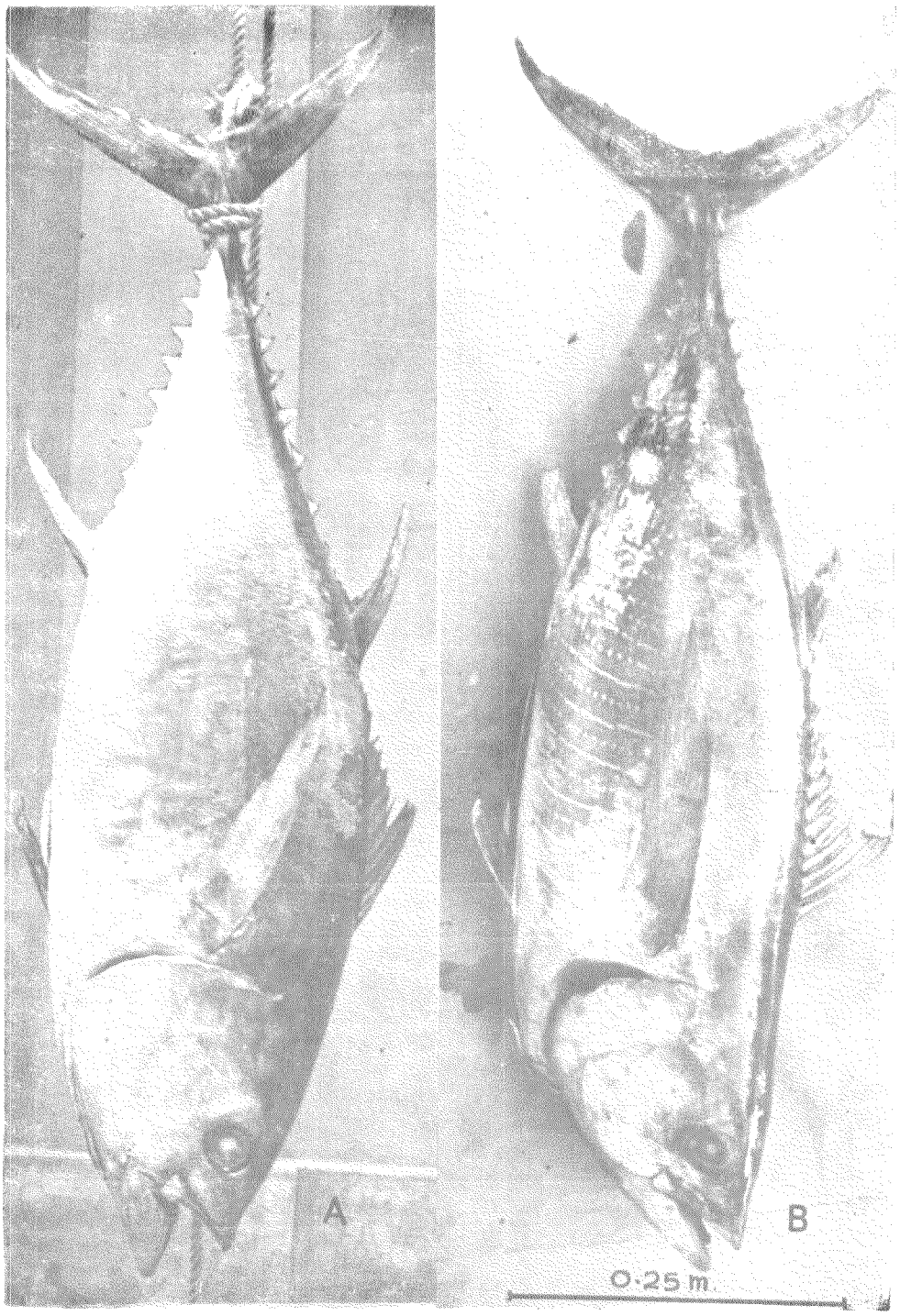




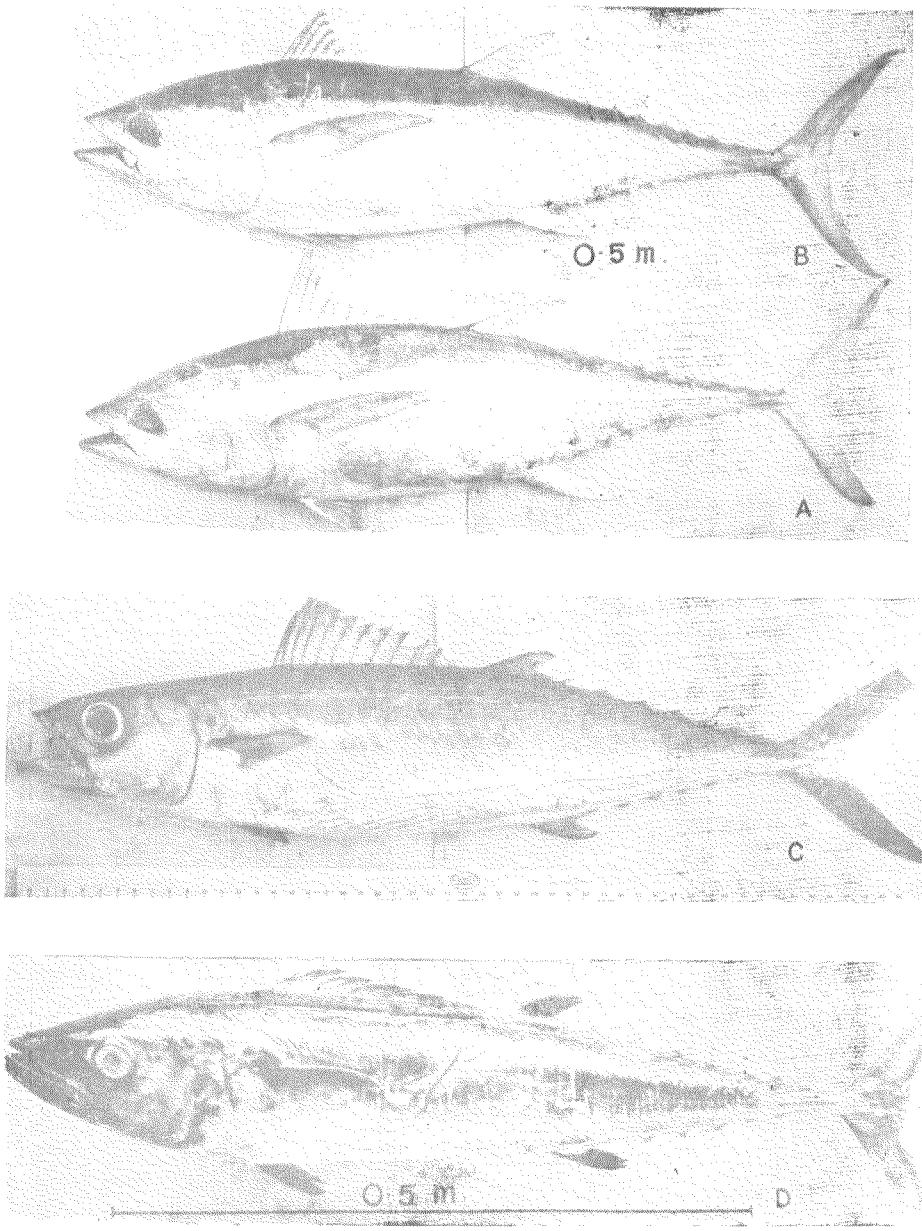
A. *Rastrelliger kanagurta*, 236 mm. from Andamans ; B. *R. brachysoma* (Bleeker) 213 mm. from Andamans ; C. *Thunnus* (*Neothunnus*?) *itosibi* Jordan and Evermann), from Andaman Sea.



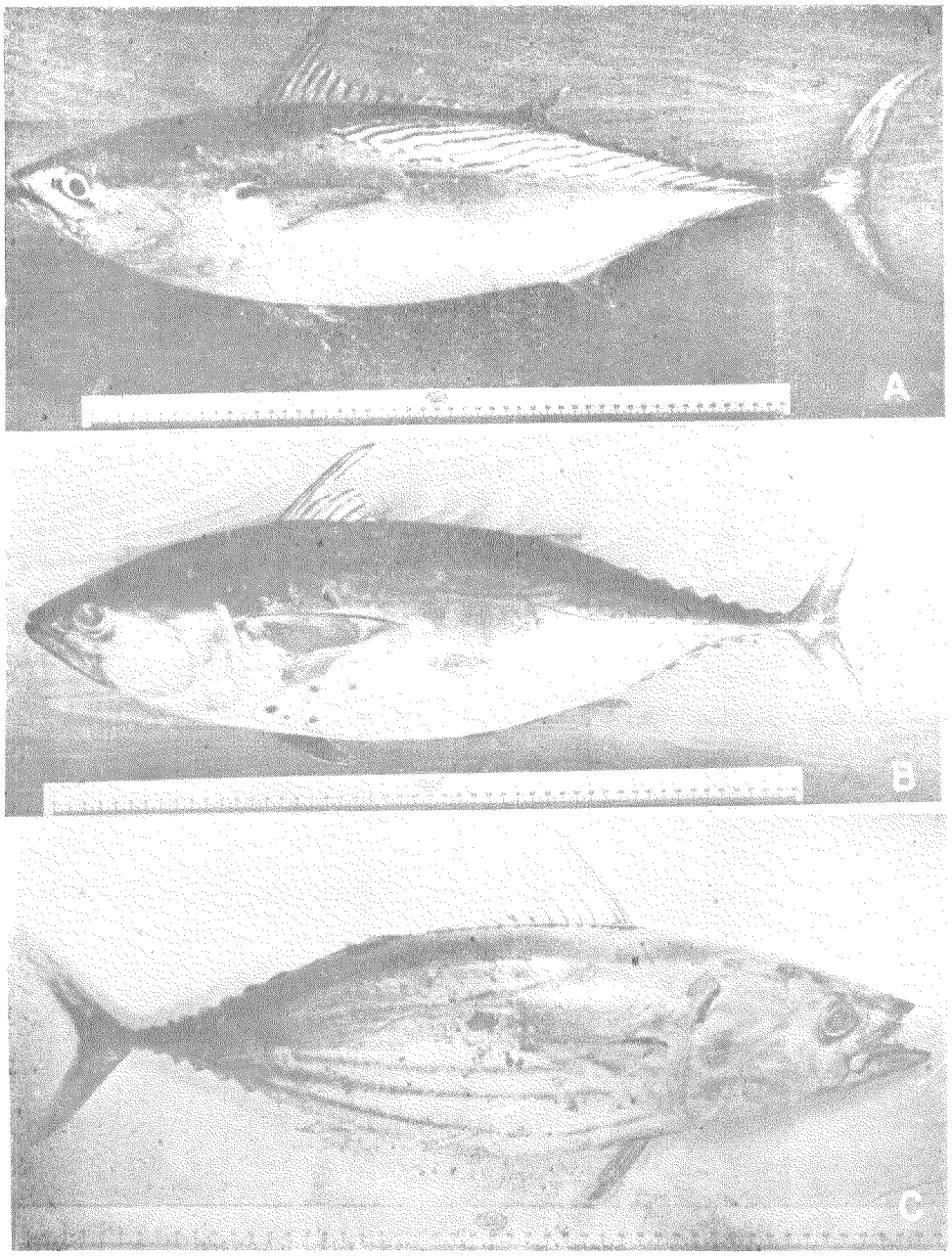
A. Part of side of body of *Auxis thynnoides* (Bleeker) showing the broader and gently tapering corselet ; (B and C). Two types in the abrupdly constricted and norrowly tapering corselet of *Auxis thazard* (Lacepede). (D_1 = first dorsal fin ; D_2 = second dorsal fin , C = corselet ; C.S = corselet scales ; L. I. = lateral line).



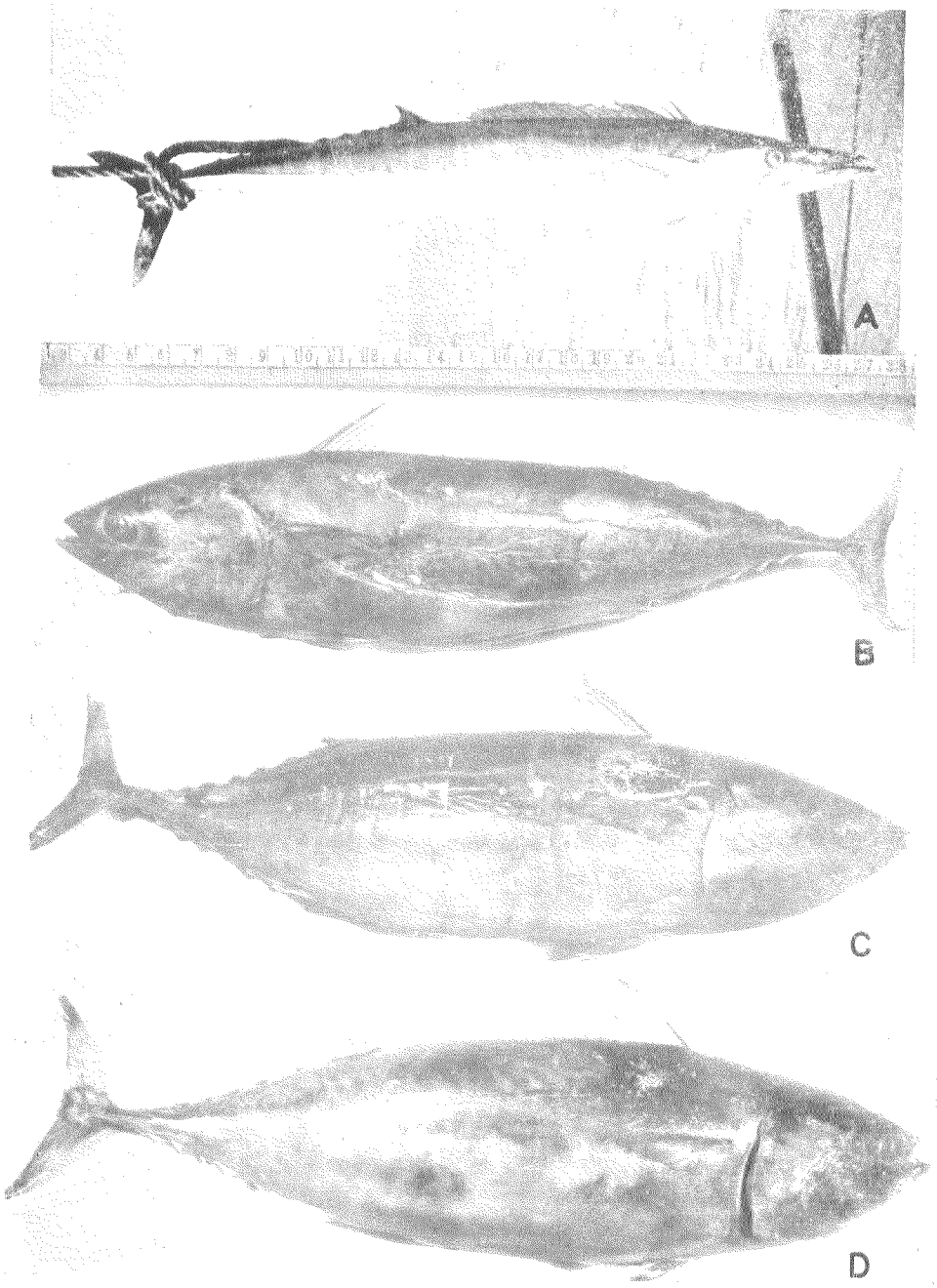
A. *Thunnus* (*Parathunnus*) *obesus mebachi* Kishinouye, 173 cm. long from Laccadive Sea ; B. *Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel), from Laccadive Sea.



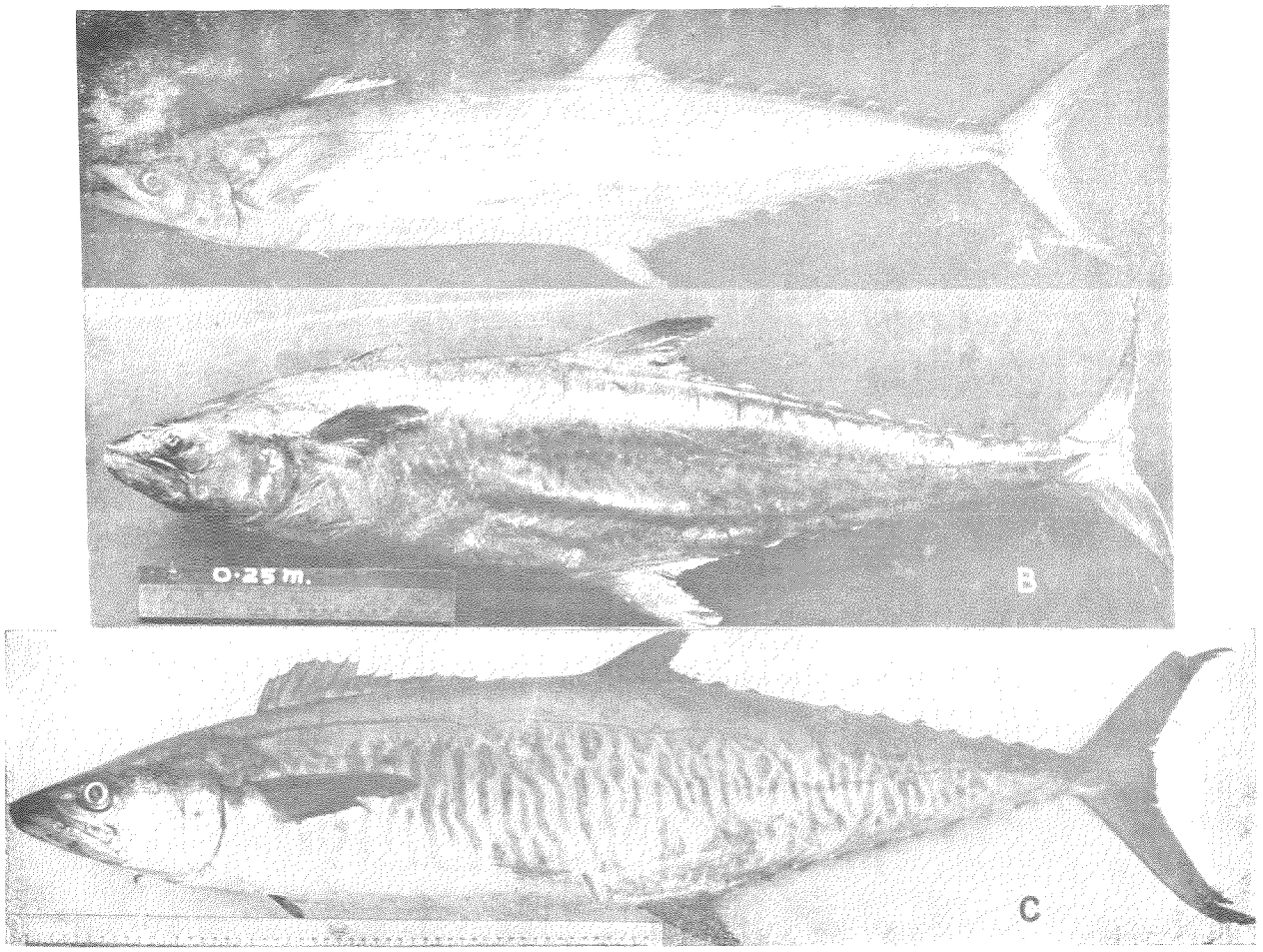
A. *Thunnus* (*Kishinoella*) *tonggol* (Bleeker) 792 mm. long from off Mangalore, south west coast of India ; B. Same species—specimen 783 mm. caught at Mangalore with abnormality in the first dorsal fin (with the last few rays missing) ; C. *Grammatorcynus bicarinatus* (Quoy and Gaimard), 449 mm. long (female) from Port Blair, Andamans ; D. *Gymnosarda unicolor* (Rüppell), 680 mm. long from Port Blair, Andamans.



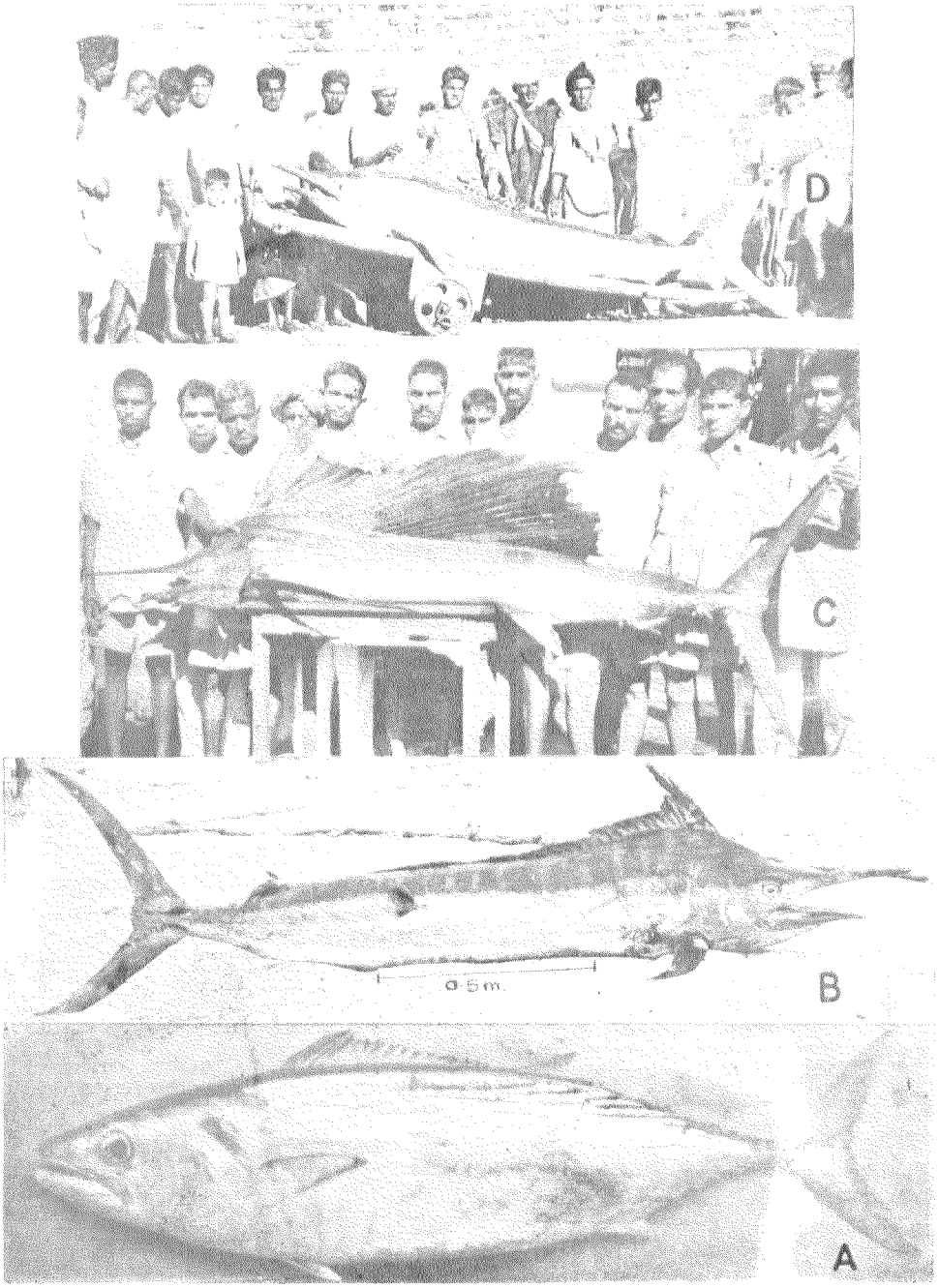
A. *Euthynnus affinis affinis* (Cantor) from Pudumadam, Gulf of Mannar showing complete absence of the usual black spots below the base of the pectoral and outside corselet ; B. *Euthynnus affinis yaito* Kishinouye from Hawaiian waters (specimen kindly sent by Mr. J. C. Marr) ; C. *Katsuwonus pelamis* (Linnaeus) from Minicoy, Laccadive Sea.



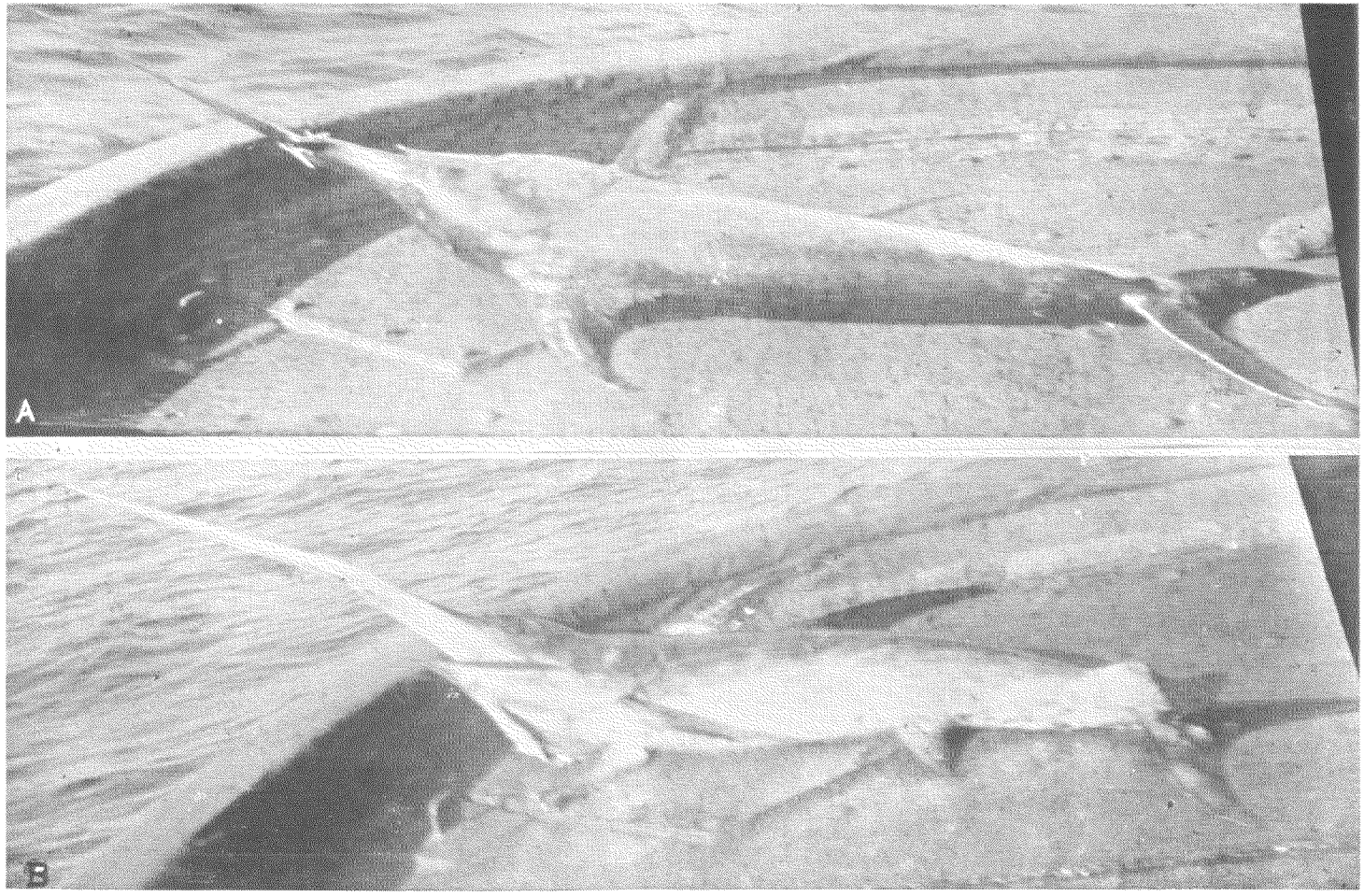
A. *Acanthocybium solandri* (Cuvier) from between Port Blair and Mayabundur, Andamans ; B. *Auxis thynnoides* (Bleeker) from Vizhingam, south west coast of India ; C and D *Auxis thazard* (Lacèpède) from Vizhingam showing differences in the disposition of corselet scales.



A. *Scomberomorus lineolatus* (Cuvier) 740 mm. long from off Rameswaram, Palk Bay; B. *Scomberomorus guttatus guttatus* (Bloch and Schneider) from Veraval, Gujarat coast, Arabian Sea; C. *Scomberomorus commerson* (Lacèpéde) male, 810 mm. long from Andamans.



A. *Sarda orientalis* (Temminck and Schlegel) female, 386 mm. from Vizhingam, South West Coast of India; B. *Makaria nigricans* Lacepede, the blue marlin from off Tuticorin, Gulf of Mannar (after Silas and Rajagopalan, 1962); C, Sailfish *Istiophorus gladius* (Broussonnet) caught off Bombay; D. Black marlin *Makaira indica* (Cuvier) caught off Bombay (C and D—by courtesy, Dr. S. B. Setna).



A and B. Two views of the swordfish *Xiphias gladius* Linnaeus caught in the Laccadive Sea.

THE SCOMBROID FISHES OF EAST AFRICA

BY

F. WILLIAMS,

East African Marine Fisheries Research Organization, Zanzibar

INTRODUCTION

This paper is a review of the existing fisheries for scombroid fishes in the East African Coastal area between Lat. 1°30'S and 10°30'S, the biological knowledge on those fishes to date and the research work being carried out, or in the process of being implemented, by the East African Marine Fisheries Research Organization (EAMFRO), Zanzibar. Since the inception of the EAMFRO in 1951 the emphasis has been mainly on pelagic fishes as it was considered that they gave the best chance of rapid development and exploitation. The original survey of the pelagic fishes (1951–1954) was made by multiple trolling and fully reported on in Williams 1956. Over the whole period the catch-rate was 1.14 pounds/line/hour (65822 line hours at trolling speed), but varied considerably from one area to another. Of the catch, scombroid fishes represented 22 % of the total weight, but consisted mainly of one species, *Scomberomorus commerson*. Surface trolling from EAMFRO research vessels could not, therefore, be considered as giving a satisfactory sample of the population of Scombroids in view of (*i*) the considerable native fisheries by gillnets, handlines and trolling already existing for species of *Scomberomorus*; (*ii*) the large surface shoals of tuna-like Scombroids observed which did not take a trolled lure, except on rare occasions, and which were not exploited by local fisheries; and (*iii*) the increasing number of billfish being taken by game fishermen surface trolling in the Malindi area of Keneya. (These problems are dealt with fully under the appropriate sections).

The mackerels have been excluded from this paper as practically nothing is known about them in the area, and there are no native fisheries for the species which has been identified as *Rastrelliger kanagurta* (Russell).

The scombroid fishes already play a relatively important part in the economy of East Africa; however, there is little doubt that proper exploitation of the stocks of scombroids, especially the surface shoals of tuna, could be of prime importance in the expansion of East African fisheries in the immediate future.

Environmental Conditions in East African Waters:

The coastline of East Africa consists of a series of fringing reefs which may extend from a few yards to several miles off shore. Beyond the reefs the depth normally drops rapidly to over 100 fm. and the extent of continental shelf is negligible, except in the area of the Lamu Banks, Zanzibar Channel and the Mafia-Kilwa Islands. (Fig. 1). There are a few major river systems entering the sea in the area, namely the Ruvuma, Rufiji, Sabaki and Tana; these have considerable effect, in times of flood, on the local bottom topography due to deposition of silt, and the large amounts of fresh water on certain fisheries is not to be underestimated.

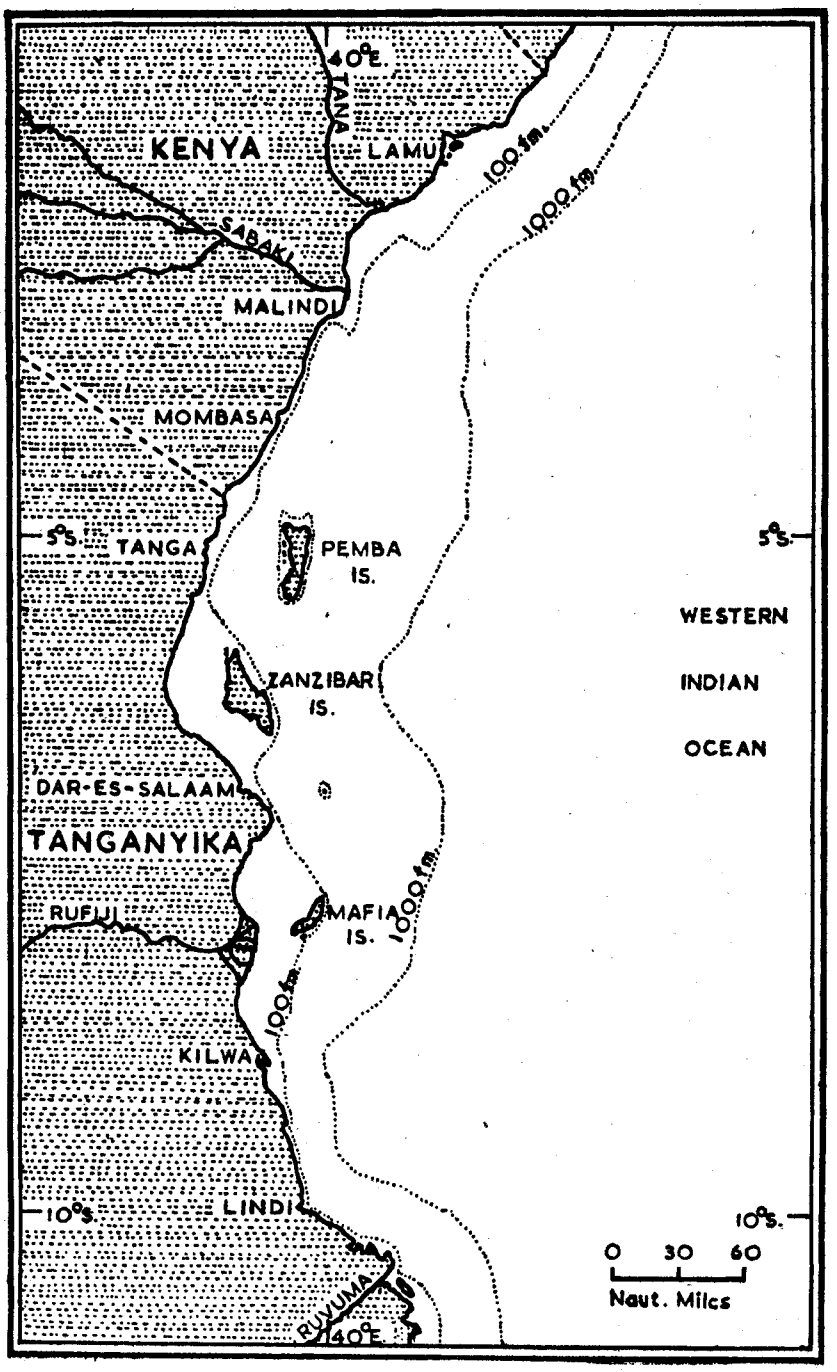


Fig. 1.—The East African Coast.

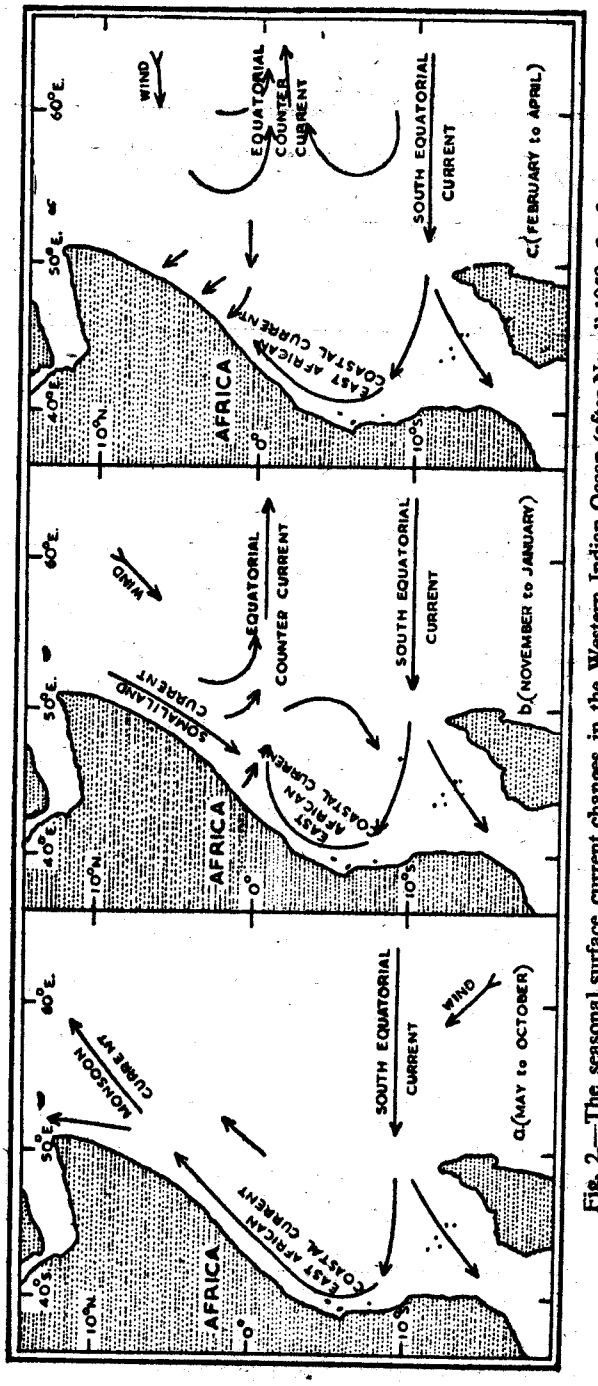


Fig. 2.—The seasonal surface current changes in the Western Indian Ocean (after Newell 1959, fig. 2).

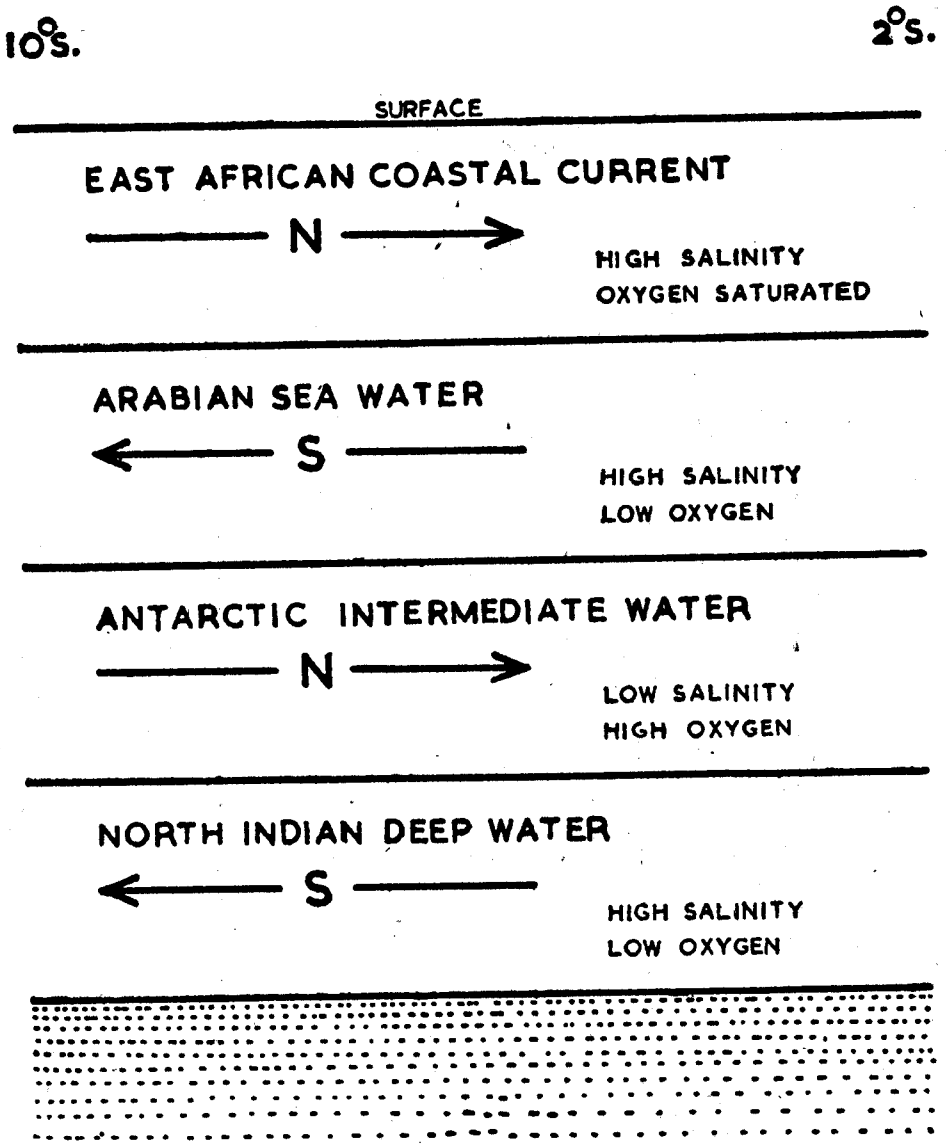


Fig. 3.—Diagrammatic representation of the stratification of the water masses off the East African coast.

The East African coast is affected by the monsoon conditions existing in the northern half of the Indian Ocean. The year is divided into two main periods, that of the northeast (NE) monsoon (hot) from about December to March/April and that of the southeast (SE) monsoon (cool) from about June to October. These periods are connected in April/May and October/November by the "long" and the "short" rains respectively. The monsoons are never constant in behaviour or strength and vary from year to year. The NE monsoon with fairly constant winds (Beaufort Scale 1—5, av. 2) is strongest in December and January and is already weak by the end of February. South of 9°S the effect of the NE monsoon is not felt

so strongly and winds are lighter and more variable. Sea and swell (ENE), are usually slight during this monsoon but there may be violent NW squalls with heavy rain and shorter seas at this time of the year.

The SE monsoon lasts longer than the NE and the winds are stronger and more constant in direction (BS, 2-6, av. 3-4). The SE winds are a continuation of the SE trades of higher latitudes ; close inshore there is usually a deflection because of the land, and winds may become South-westerly. There is a steady sea, and swell (ESE), during the whole of the monsoon.

The basic oceanographic conditions prevalent in East African Waters during the year have been reported on in Newell (1957, 1959) and partially summarised from a biological point of view in Morgans (1959). The north flowing East African Coastal Current (EACC) forms the whole of the surface water mass throughout the year, being the northern branch of the South Equatorial Current after it impinges on the African coasts in the area of Lat. 10–11°S. The physical and chemical properties of the EACC vary considerably from one monsoon to the other.

Fig. 2 a–c (after Newell 1959) shows the distribution of surface currents during the year. In the SE monsoon (Fig. 2a) the prevailing wind helps to increase the speed of the EACC which flows at 2-4 knots, as far as the Arabian Gulf. Minimum water temperature is towards the end of the SE monsoon and is in the order of 24–25° C. During the NE monsoon the speed of the EACC is reduced to 1–2 knots, and in the area of Lamu 2°S, meets a south flowing Somaliland current ; together they are pushed eastwards and form the Equatorial Counter Current. Part of the EACC is deflected southward forming a closed circuit (Fig. 2b), whilst later in the monsoon more variable conditions exist, and the closed circuit breaks up (Fig. 2c) – this phase does not always take place and there may be a direct return to the conditions of the SE monsoon (Fig. 2a). Surface temperature reaches a maximum towards the end of the NE monsoon at about 29–30°C. At the end of the NE monsoon, or start of the SE., there is a salinity minimum (34.7–34.8°/00) and a corresponding salinity maximum (35.2–35.3°/00) at the end of the SE monsoon or start of the NE monsoon.

The EACC is the upper water mass in a well stratified system, shown diagrammatically in Fig. 3, and in which the direction of flow alternates north and south; the depth ranges of the various masses vary according to the time of the year. The biology of most Scombroids is related to the EACC but with subsurface shoals of tuna the underlying Arabian Sea Water (ASW) is also of interest ; the properties of the Antarctic Intermediate Water and Indian Ocean Deep Water are not discussed. There is at all times a very sharp and distinct thermocline between the EACC and ASW. In the SE monsoon a great deal of vertical mixing takes place in the EACC and the mass is relatively isothermal throughout its depth range ; the thermocline is deep at 60–70 fm. and may even reach 100 fm. However, in the NE monsoon the stability of the EACC breaks down and a series of subsidiary thermoclines appear, this layering is not very stable and varies according to the wind force ; the main thermocline between the EACC and ASW is then found at 30–40 fm. Newell (1957) and later work has shown the stratification (Fig. 3) to exist right up to the fringing reef.

Chemical analysis confirms that a seasonal phytoplankton cycle occurs in the surface waters ; the outburst of growth commencing in the NE monsoon–the actual date being dependent on the length and intensity of the previous SE monsoon. Maximum growth takes place in March and minimum fertility of coastal waters is reached in June and

September. However, total phytoplankton growth is small when compared with, say that in the Arabian Gulf.

The oceanographic conditions in East African waters are important in discussing Scombroid fishes, especially the surface current distribution throughout the year and the physical and chemical properties of the two upper water masses, the East African Coastal Current and the Arabian Sea Water.

Definitions of Gonad Maturity States :

Gonads were examined macroscopically *in the field* and a system based on seven stages in females and five in males was used in EAMFRO. Reference to this system was made in Williams and Newell (1957) and Talbot (1960) and is given in Appendix I to this report. This system was used for the Tunas and Seerfishes (Parts I & III of this report), but not for the Billfishes (Part II), as the gonads of those fishes require more careful laboratory examination before discerning the exact state of maturity.

ACKNOWLEDGEMENTS

The author wishes to express his thanks to the following:—The Director and Staff of EAMFRO., Zanzibar, for much help and advice during the preparation of this paper ; Messers. King, Allfree and Lockley, the Fisheries Officers respectively of Zanzibar, Kenya and Tanganyika, for information on local fisheries for Scombroid fishes ; Dr. F. H. Talbot (South African Museum) for help with yellowfin tuna data ; Mrs. Jane Bailey (Malindi, Kenya) for valuable measurements made on billfishes ; Dr. James E. Morrow Jr. (University of Alaska) for field data on billfishes as well as comments on nomenclature ; Col. John K. Howard (Miami, Florida) for advice and comments on billfishes ; The Fisheries Laboratory, Lowestoft, England, for statistical treatment of marlin data ; Mr. A. G. T. Carter (East African Statistical Department, Nairobi, Kenya) for statistical treatment of seerfish data ; Mr. S. Prudhoe (British Museum of Natural History) for identification of parasites.

PART 1. THE TUNAS

Until comparatively recently Tunas attracted very little attention in East African waters, the existing native fisheries for them being negligible.

The initial survey of the pelagic fishes of East Africa (Williams 1956) showed that considerable stocks of tuna in the form of unexploited surface shoals existed in the immediate coastal area. More recently (1958–1960) research longlining by EAMFRO within 50 miles of the coast has shown the existence of subsurface stocks of tuna. These two findings are discussed at some length later in this section.

The species of tuna known to occur in East Africa are as follows :

Yellowfin tuna.....*Thunnus albacares* (Bonnaterre)*
Albacore.....*Thunnus alalunga* (Bonnaterre)*
Skipjack.....*Katsuwonus pelamis* (L.)
Bonito.....*Euthynnus affinis* (Cantor)ϕ
Frigate mackerel.....*Auxis thazard* (Lac.)
Rüppell's bonito.....*Gymnosarda unicolor* (Rüpp.)

*See p. 112.....ϕ See under species p. 123.

Yellowfin tuna, skipjack, bonito and frigate mackerel have been recorded from East Africa for many years ; however, the first confirmed record of Ruppell's bonito was in Williams (1956) and that of the albacore, a single specimen from longlining by EAMFRO in 1959.

There is no sign of the longtail tuna, *T. tonggol* (Blkr.), reported from Somalia and Gulf of Aden (Fraser Brunner 1954) or the bigeye tuna, *T. obesus* (Lowe), recorded from Japanese longline catches 100 to 300 miles off the African coast between 1°S. and 10°S.

A field key to the confirmed East African species of tuna is given below :—

1. (*a*) Body completely scaled, those of corselet and lateral line usually largest.....2
   (*b*) Body naked except for a corselet of scales in area of pectoral and lateral line...3
2. (*a*) Pectoral fin moderate in length, tip reaching as far as origin of 2nd dorsal fin. Surface of liver not striated.....*Thunnus albacares* (Bonn.)
   (*b*) Pectoral fin very long, tip reaching beyond origin of 2nd dorsal fin. Surface of liver densely striated with dark lines.....*Thunnus alalunga* (Bonn.)
3. (*a*) Dorsal fins contiguous or only separated by a very small interspace (equal to eye diameter). Axillary scales between the pelvic fins short, half or less than half length of pelvic fins.....4
   (*b*) Dorsal fins separated by a wide interspace greater than half head length. Axillary scales between the pelvic fins long, about equal to length of pelvic fins.....*Auxis thazard* (Lac.)
4. (*a*) Number of gill rakers on first gill arch 2–3+10=12—13. First dorsal fin low, margin straight or slightly convex.....*Gymnosarda unicolor* (Rupp.)
   (*b*) Number of gill rakers on first gill arch exceeds 20. First dorsal fin high, margin strongly concave.....5
5. (*a*) Gill rakers on first gill arch 7—10+22—23=29—33. Palatines toothed. Black markings on back above lateral line ; black spots at naked area of thorax below pectoral fin.....*Euthynnus affinis* (Cantor)
   (*b*) Gill rakers on first gill arch 15—16+38—40=53—56. Palatines edentulous. No black marking on back ; longitudinal stripes on body below lateral line.....*Katsuwonus pelamis* (L.)

Note on Taxonomy and Nomenclature of Tunas :

At the Dakar Tuna Symposium, December 1960, attended by representatives of most nations fishing in African waters, it was noted that views differed considerably in respect of concepts of genus, subgenus and species in the Tunas. Talbot (South Africa) and Williams (East Africa) were of the opinion that genera such as *Neothunnus, Parathunnus, Kishinoella* and *Germo* should be subjugated to the genus *Thunnus* on the grounds that the differences were specific rather than generic. It was also thought that there was but one species of yellowfin, albacore and bigeye throughout the oceans. These conclusions were extremely subjective and a small committee was formed to consider the matter and to report to the FAO World Tuna meeting in 1962.

However, at the more recent Pacific Tuna Biology Conference held in Hawaii in August 1961, Collette presented a Manuscript on a "Preliminary Review of the Tunas of

the genus *Thunnus*" based on the work being undertaken in collaboration with Dr. Gibbs. This work has not been finalised but it was generally agreed at the conference that (i) "there was no need to split the tunas taxonomically to the point where each species is given a generic name" and (ii) that "the single species concept was strongly advocated for yellowfin, bigeye, albacore and skipjack". As at Dakar it was recognised that the problem was very subjective and that a thorough background paper should be presented to the FAO World Meeting.

The scientific names used in this paper for the yellowfin and albacore are, therefore, those which are considered valid for a world-wide distribution of those fish and are as given in the manuscript of Collette.

The Composition, Distribution and Seasonal Abundance of the Tuna Shoals :

Tuna-like Scombroids were not taken in large numbers by multiple trolling during the original pelagic fish survey and were represented by only 8% of the total number of fish caught by that method. However, numerous shoals of these fishes have been observed at many points in the coastal region throughout the year and in all weather conditions, although they appear to be more numerous in the calmer NE monsoon. These shoals appear to be composed as follows :—Type I, bonito and/or skipjack and/or yellowfin tuna and/or Rüppell's bonito, averaging about 8 to 12 lbs., Type II, small yellowfin tuna, bonito, skipjack and frigate mackerel and, perhaps, the Caranagid *Megalaspis cordyla* up to 5 lbs., and Type III, large yellowfin tuna of 20 to 50 lb. A detailed "log" of shoals was kept throughout 1953 and this was given together with a distribution chart as Table 6 and Fig. 8 in Williams (1956). It must be emphasized that these observations were made from a single boat in the very large survey area and that these shoals were probably much more numerous and widespread than is apparent from the "log". The shoals of yellowfin seemed to make their appearance at the end of the SE monsoon and stay through the NE monsoon. When seen from R. V. RESEARCH these tuna shoals were invariably feeding and did not take a trolled lure, but fishing from smaller boats by game fishermen, does occasionally sample these shoals. Morrow (1954 a ; b) recorded small yellowfin, skipjack, bonito and frigate mackerel from trolling feather jigs mainly inside the 50 fm. line. The bonito averaged 7 lb. and the yellowfin 12 lb. and this is typical of the shoals of Type I. A similar distribution of size, 7—12 lb., has been seen in angling catches of yellowfin, bonito and skipjack made in the Zanzibar area and examined by the author. It seems probable that the shoals are of mixed species.

The tuna shoals have been seen mainly inside the 100 fm. line with the main concentrations in the shallow Zanzibar Channel and North Mafia Bay (see Fig. 1). Very often the positions of the shoals are indicated by the presence of sea-birds, usually terns, which are continually diving and feeding on the small fishes, etc., being chased by the tuna. The speed of the shoals through the water was very high and often exceeded the maximum 8 knots of R. Vs. RESEARCH and MANIHINE, and changes of direction were rapid unpredictable.

Summing up future developments in the pelagic fishery, Williams (1956) stated that future research in East Africa must include catching methods for those tuna shoals not exploited by the existing fishery. Live bait, purse seining and pole and line fishing were suggested. The former is difficult due to the problem in the area of obtaining a constant supply of suitable live bait, whilst purse seining was not possible from either

RESEARCH or MANIHINE because of the unsuitability of those vessels in that they had insufficient space aft. In addition there was a lack of finance for either project; thus since 1954 the problem has received no attention although the possible economic importance has been repeatedly stressed. It now seems likely that in 1962 experimental purse seining for tuna will be undertaken by Greek fishermen with Government backing, and along the lines suggested by EAMFRO which should lead to a proper evaluation of the fishery. At the same time purse seining for Clupeids will be developed and it is possible that supplies of live bait might become available for tests of the pole and line technique.

The use of longlines for subsurface shoals of tuna was also advocated, and this development took place in 1958 with the start of research longlining. So far only yellowfin appear to be present in any numbers, and as expected, the size range was considerably larger than that of the surface shoals (10 to 150 lb.); but the period of abundance at subsurface levels is in the SE monsoon (this is the reverse of the smaller tuna found at the surface). Details on longlining will be given in a later publication.

The potentialities of the tuna fishery in East African waters have been indicated for some eight years, but lack of finance has precluded the experimental and research work necessary to start an industry. This is now being rectified. The possible value to the East African territories of tuna products is great; it has been suggested that the white meat tuna (yellowfin) be processed for export or high class local markets, and that the red meat tunas (bonito, skipjack) be processed for local consumption in the form of fish stick or some similar product. Recommendation VIII of the Dakar Tuna Symposium discussed the latter and advocated the production of something like the Japanese *Katsuwebuschi* for local consumption.

Thunnus albacares (Bonnaterre) 1788.

(Yellowfin tuna. Jodari (Kiswahili)

As stated in the introduction to this section, the one species concept has been applied to the yellowfin and the following are therefore considered the main synonyms of *T. albacares* (Bon.):—

Thynnus argentivittatus Cuvier 1831

Germo albacora Lowe 1839,

Thynnus macropterus Temminck & Schlegel 1844

Neothunnus itosibi Jordan & Evermann 1926.

Description and Colour. The description and colour of the yellowfin given by such authors as Kishinouye (1923), Godsil and Byers (1944), and Fraser-Brunner (1950) are considered adequate; a few notes on East African specimens are given in Williams (1956).

In East African yellowfin the pectoral fin rarely reached as far as the origin of the second dorsal fin. The tri-lobed liver is not striated.

Distribution:

Geographical. The yellowfin is found throughout the East African area from 1°30'S to 10°30'S, and is cosmopolitan in the tropical and subtropical Indian, Pacific and Atlantic Oceans.

Depth : Originally yellowfin were only taken at the surface by trolling (Morrow 1954 : Williams 1956). Yellowfin form a high percentage of all the types of surface shoals of tuna reported from the East African area (See introduction). In recent years (1958–1960) longlining has shown the presence of yellowfin at subsurface levels, at least down to the first main thermocline between the EACC and the ASW.

Size : (Numbers of specimens are given in brackets).

Troll caught.

48 to 87 cm. FL & 2 to 28 lb. (29).....Morrow 1954.

60 to 120 cm. FL and 6½ to 63 lb. (18).....Williams 1956 and unpublished data.

Longline caught.

62,5 to 164 cm. FL. & 10 to 150 lb. (107).....Williams unpublished longline data.

40% of catch from 83 to 124 lb. .....Anon. 1956. Japanese longline results off East Africa.

Fishery :

Method. For surface shoals the only method in use in East Africa is trolling, but the percentage taken from any of these shoals is very small indeed. Only in isolated cases do local fishermen go trolling specifically for tuna, when both fresh fish bait and artificial lures are used. Normally catches of tuna are incidental to other methods of fishing. A few specimens are taken in nets of all kinds or on handlines.

In view of the large number of surface shoals and the apparent high percentage of yellowfin, live bait pole and line and the purse seine were suggested as methods of capture as long ago as 1954. It now seems probable that in 1962 experimental purse seining will be started in the Zanzibar Channel area.

To date subsurface shoals in the immediate coastal waters have only been exploited by longlines on a research basis by EAMFRO. Japanese exploratory longlining took place at a minimum distance of 100 miles from the East African coast in 1955–56.

Catch and Value. The trolled tuna catch of local fishermen is small but the fish normally fetch good prices because of the high grade flesh. EAMFRO research longline catches during the season averaged 1.54 yellowfin per 100 hooks, with individual days as high as 9.2 per 100 hooks. It is possible that higher catch-rates will be achieved when supplies of a good silvery pelagic fish become available to replace the bottom fish (*Lethrinus variegatus*) now being used as bait. The catch-rates are very low when compared with the average of 8.9 per 100 hooks (range 2.6–17.6) achieved by the Japanese longlines 100–200 miles off the coast between 3°S—9°S (Anon. 1956). In addition it was found that the average catch-rate was higher the closer the coast was approached.

Longline caught tuna from EAMFRO, gutted, cleaned and refrigerated were always in great demand in the Zanzibar fish market and never brought less than 0/50 cents per pound whole fish and sometimes reached Sh. 1/00 per pound. Packaged deep frozen fillets and cutlets of yellowfin were prepared by a Zanzibar firm and exported to East and

Central Africa, and the Congo. Upwards of Sh. 3/00 per pound was paid and at that price demand far exceeded supply from research catches. There is a great potentiality for such a high grade product in the markets of East and Central Africa.

Seasonal Abundance :

Observation on surface shoals of yellowfin show that they are present throughout the year in East African waters, but that there is a marked increase in numbers at the end of the SE monsoon and during the NE monsoon.

Longline catches to date show that in the depth range normally fished by EAMFRO gear, the vast majority of yellowfin are taken during the SE monsoon. Only four specimens out of a total of 107 were taken during the NE monsoon and, as noted in the next section, yellowfin are replaced at that time by billfish. It is interesting to note that Japanese longline catches (Anon. 1956) were made 100 to 200 miles east of the African coast in the period between 12th November 1955 and 6th February 1956 (NE monsoon).

Ecological Note :

The greater abundance of surface shoals of yellowfin from October to March is probably closely tied up with the fertility cycle found in East African surface waters (See p. 109).

In the case of subsurface shoals now caught by longline in areas up to 25 miles off the coast, the catches occur when the EACC is at its coldest and is isothermal over its complete range from the surface to the EACC/ASW thermocline at 50–70 fm. It seems probable that most tuna are caught at, or just above, this thermocline. The question of environmental factors and tuna longline catches will be discussed more fully in the paper on longlining.

Biological Data :

In the past morphometrics and meristic data have been used to split the yellowfin into different species (*albacora, macropterus, itosibi*), or at least into distinct races from different geographical areas (if following the one species concept). Morphometric data comparisons were made by Schaefer and Walford (1950), Schaefer (1952), Godsil and Greenhood (1952), Royce (1953), Ginsberg (1953) and in Royce's MS to the Pacific Tuna Biology Conference 1961 : however, more recent work by Broadhead (1959) has shown that such differences can also occur between fishes from the same area over a period of time. Nevertheless morphometric data have been recorded (since 1958) on East African specimens by the author and on South African specimens by Talbot (S. Afri. Mus.) and standardised on the "Definitions of body dimensions used in describing tunas" by Marr and Schaefer (1949). This standard method was subsequently considered at the Dakar Tuna Symposium and agreed to as Recommendation XIII.

Work is now proceeding under Talbot on a comparison of yellowfin in East Africa and South Africa, as well as those from Angola (after Schaefer and Walford 1950). Comparisons will also be made with other Indian Ocean yellowfin (Tsuruta and Tsunoda 1960, Royce MS 1961). The more precise methods of assessments of adult populations by biochemical and serological methods, especially the latter, are to be implemented as soon as possible, utilising help offered by the U. S. Fish and Wildlife Biological Laboratory in Hawaii.

Meristic Data. Morrow (1954) gave meristic data on 29 specimens by surface trolling. Table I gives the counts of dorsal spines, dorsal and anal finlets of subsurface longline caught yellowfin (1958–60), as well as those of Morrow. Counts of rays of second dorsal and anal fins were not made by EAMFRO; the count of finlets is that of completely detached finlets not connected to the second dorsal and anal fins. (Totals do not necessarily agree as the characters were occasionally omitted in some specimens).

TABLE I

Frequency distribution in fin counts of East African yellowfin

	Number of dorsal spines			Number of dorsal finlets				Number of anal finlets			
	12	13	14	7	8	9	10	7	8	9	10
Frequency :—											
Morrow (1954) ...	...	5	19	...	2	23	1	1	12	12	1
Williams (unpublished longline data) ...	1	34	56	3	84	12	...	2	90	5	...

Gill raker counts. Gill raker counts for longline caught yellowfin from East Africa are as follows :—

Upper limb :

Number of rakers	6	7	8	9	10	11
Frequency	1	0	11	37	30	5

Lower limb :

Number of rakers	17	18	19	20	21	22
Frequency	1	1	12	32	37	2

Total :*

Number of rakers	26	27	28	29	30	31	32
Frequency	1	3	12	25	45	15	3

*more figures are available for total counts as several counts were made without allocation to the upper or lower limb of the raker which occurs at the centre of the arch in some specimens.

Length Frequency and Age and Growth. A preliminary examination of length frequency distribution shows two modes in the 1958–59 season and three in the 1959–60 season, and that the modes were different in each season.

East African yellowfin	Mode I	Mode II	Mode III
1958–59	650 mm.	1150 mm.	...
1959–60	725 mm.	950 mm.	1280 mm.

This was pointed out by Talbot in his MS to the Dakar Tuna Symposium in which he compared length groups of East African yellowfin with those of South African fish (from S. Cape Province), details of which are given below :—

South African yellowfin	Mode I	Mode II	Mode III
1957–58 ...	550 mm.	950 mm.	1400 mm.
March 1959 ...	800 mm.	1150 mm.	1500 mm.
March 1960 ...	600 mm.	1150 mm.	1500 mm.

The assumption that the length groups will probably represent year groups cannot be confirmed at present.

No attempts have been made to age yellowfin by methods other than length frequency, but this will be attempted in future operations.

Length/Weight Relationship. For the 29 small specimens taken by trolling, Morrow (1954) calculated the length/weight relationship to be :—

$W = 0.960 \times 10^{-6} L^{3.16}$ using the usual length/weight regression $W = a L^b$ ($\log W = \log a + b \log L$).

The regression equation has not yet been calculated for the 107 specimens caught by longlining in East Africa. Talbot MS 1960 suggested that East African yellowfin were lighter in weight for a given length than yellowfin from the tropical Pacific.

Sex and Maturity. Morrow's trolled catches showed 18 males and 10 females, a sex ratio of males to females 1 : 0.55; EAMFRO longline catches showed males to females 1 : 1.06; and Japanese central Indian Ocean catches showed males to females 1 : 0.75 (Kataoka 1957).

Morrow reported that all specimens examined (48 cm. FL. and greater) were sexually mature and that several specimens had spawned recently. Williams (1956) found immature fishes up to 70 cm. FL. from trolled catches, whilst a check on longline catches shows 7 immature specimens (6 male and 1 female) ; and it would appear that maturity is reached at about 70 cm. FL. in both males and females. Wade (1950) stated that yellowfin in the Pacific mature at about 54 cm. length in males and 64 cm. in females.

During the season (SE monsoon) longline catches of fish show all stages of maturity to be present in both males and females. Occurrence of spawning and spent fish is as follows :—

	October/November, 1958	July, 1959	November, 1959	Totals
Males :				
Ripe running IV ...	...	...	...	...
Spent V ...	...	3	...	3
Females :				
Ripe running VI ...	1	...	1	2
Spent VII ...	9	6	7	22

East Africa is obviously a spawning ground for yellowfin and bearing in mind that yellowfin are only taken in quantity during the SE monsoon, it seems possible that they make a migration into the area for the purpose of spawning.

Large shoals of a very small tuna (less than one pound) were seen at the surface astern of the vessel during longline operations on several days in February 1960. It was not certain what species they were, but by using a very small lure on a "fly" rod one specimen was taken which proved to be a yellowfin of approximately 1 lb. weight. Unfortunately no other data was obtained before the fish was lost due to unforeseen circumstances.

Food. All the longline caught yellowfin had stomach contents averaging about 100 c.c. per stomach. All but three of the stomachs were examined quantitatively as well as qualitatively; the final analysis of the data has not been completed, but a preliminary check of percentage volume shows the results given in Table II. The figures for Pacific yellowfin based on Reintjes and King (1953) and King and Ikehara (1956) are also given in Table II, together with those given in Talbot MS 1960 for the same species in South Africa (Cape). It is intended that the completed paper on the food of the yellowfin will be presented in such a manner as to enable easy comparison with the work of the American workers quoted above.

TABLE II

Food of yellowfin tuna by percentage volume

Food	East Africa	South Africa	Pacific Ocean	
	Williams	Talbot MS. 1960	Reintjes & King 1953	King & Ikehara 1956
Fish ...	42	56.1	46.7	62
Cephalopods ...	37	39.1	26.2	29
Other Molluscs ...	1	...	1.7	7
Stomatopods ...	8.5	...	4.6	...
Decapods ...	2	4.78	17.9	1*
Others Crustacea ...	1	0.04	2.3	...
Other Groups ...	1	...	1	...
Unidentified animal matter ...	10.5	...	...	...

*Total crustacea.

Parasites. The large trematode *Hirudinella marina* Garcin has been recorded from the stomachs of many yellowfin, but no complete records were kept of frequency occurrence. This species is very similar to the giant trematode, *H. ventricosa* Pallas, taken from the Wahoo. *H. marina* is recorded from yellowfin in all geographical areas (Nigrelli and Stunkard 1947; Iverson and Hoven 1958).

The Cestode, *Bothriocephalus manubriformis* (Linton) has been recorded from one yellowfin.

Nematodes have not been identified as yet.

Thunnus alalunga (Bonnaterre) 1788.

Albacore.

As stated earlier, the one species concept has been accepted in albacore and consequently the following are classed as main synonyms :—

Germo alalunga (Bonnaterre)

Germo germo (Jordan and Seale)

Thunnus germo Kishinouye.

The albacore is a new record for East African waters, a single specimen having been taken by longline on 24th July 1959 approximately five miles east of Ras Mkumbi at the northern tip of Mafia Island, Tanganyika.

The fish was clearly identified as an albacore and detailed measurements were made as for yellowfin. Total length was 1160 mm., fork length 1065 mm. and weight 56 lb. ; female, ripe running to part spent (VI–VII). Fin counts were D XIV : 14 + 8, A 14 + 8, and gill raker counts 9 + 19 = 28 on the first right arch.

The interesting feature is that the albacore was taken on a hook adjacent to a break in the longline. Hooks were set to fish at a theoretical depth of 70 fm. on that day, the EACC/ASW thermocline being at 58 fm. The water was 26.7°C at the surface, 24.4°C at 58 fm., whilst below the thermocline temperature decreased rapidly to 19.7°C. at 78 fm. Due to the break in the line the hook catching the albacore had probably been fishing a considerable distance below the theoretical depth of 70 fm.

Albacore are broadly distributed in the Oceans from the Equator to 45°Lat. in waters of 10°–28°C. However, the main albacore fisheries (pole and line) are in fairly high latitudes of the northern hemisphere, 30° to 40°N, relatively close to the surface in waters of the optimum temperature range of 18°–21°C. In low latitudes (equatorial) albacore are normally only taken in numbers at greater depths – in waters presumably approaching the optimum temperature.

Japanese longline vessels fishing off the East African coast between 5°N and 16°S in 1954–55, only found albacore in the area of 9–16°S and 42–45°E.

Auxis thazard (Lacédède) 1802.

Frigate mackerel. Sehewa (*Swahili*) also refers to *Euthynnus* and *Katsuwonus* spp.

It is now generally accepted that there are two species of *Auxis* each with world-wide distribution. In recent papers Matsumoto (1959 ; 1960) has shown the valid species to be *A. thazard* (Lac.) and *A. thynnoides* Blkr. *A. tapeinosoma* Blkr. is synonymous with *A. thazard* and is now known not to represent the correct name for the second species.

To date only *A. thazard* has been identified from East Africa. Morrow (1954) records, without details, *A. thazard* caught trolling with feather jigs during the NE monsoon mainly inside the 50 fm. line between Mombasa and Zanzibar.

The only specimens of *A. thazard* taken by EAMFRO have been from the stomachs of sailfish, black and striped marlin taken by longline in December 1958, January, February and November 1959 and February and March 1960. Many specimens were examined but due to the various stages of digestion and damage only limited data are available. In those

specimens with the corselet still visible, it was the short form typical of *A. thazard.* In the other specimens with the corselet obliterated it was possible that the long corselet may have been present, in view of the known mixing of shoals of *Auxis* spp., but other features tended to the opinion that they were indeed *A. thazard.*

No dorsal fin counts were possible, but the finlets numbered 7 to 9 ; the dorsal fins were widely spaced. Gill rakers were long, slender, close set and numbered 9–10 + 30–31 = 39–41. Total number of vertebrae was 38–39. Teeth in the jaws were slender but none were present on the vomer and palatines. Pectorals were shorter than the postorbital ; and the inter-pelvic process of Fraser Brunner (1950) absent. Specimens ranged from 30 to 40 cm. total length at 1 to 2 lb. weight.

At the time that frigate mackerel were observed in the stomachs of billfishes caught by longline at subsurface levels (above the thermocline at 35 fm.) in the offshore areas, shoals were seen at the surface. Small specimens of the frigate mackerel were found in the stomachs of the dolphin fish (*Coryphaena hippurus*) previously seen feeding on these shoals, which numbered from 100 to 1,000 individuals.

The occurrence of frigate mackerel in both inshore and offshore waters in East Africa appears to be restricted to the months of the NE monsoon when the temperature of the surface water mass (EACC) is maximal.

A. thazard is not taken by local fishermen. As stated in the introduction to this section, the frigate mackerel possibly represents, at least during the NE monsoon, a part of the unexploited " surface tuna shoals."

" A synopsis of existing knowledge on the fishes of the Genus *Auxis* Cuvier, 1829 in the Indian Ocean" was presented by the author to the Dakar Tuna Symposium, December 1960. This is being revised, as far as *A. thazard* is concerned, for the FAO World Tuna Meeting 1962, and the author would appreciate information on the species in the Indian Ocean which may not have been published.

Gymnosarda unicolor (Ruppell) 1835.

Jodari (Kiswahili). Ruppell's bonito (Indian Ocean);

Dog–tooth tuna (Pacific Ocean).

Little information of any kind is available on this species of tuna, which now seems to be widely distributed in the Indian Ocean. The species was originally illustrated and described from the Red Sea by Rüppell (1828), who named it *Thynnus* (*Pelamis*) *unicolor.* Gunther (1860) gave the name *Pelamys nuda* to this species of Rüppell; whilst Kishinouye (1923), describing an obviously similar fish, retains the specific name *nuda*, calling the species *Gymnosarda nuda* (Gunther). This name has been retained for this tuna in the Western Pacific (Warfel 1950; Dung & Royce 1953); whilst for the Indian Ocean form Rüppell's name *Gymnosarda unicolor* has been retained (Fraser–Brunner 1950; Wheeler and Ommanney 1953; Williams 1956; and Smith 1956c). Although actual specimens from the Indian and West Pacific Oceans have not been compared by the author, there seems little doubt that the fish are the same and should be considered under the original specific name of Ruppell.

Description :

No detailed description has been made on the six specimens taken in East African waters, but the species is most easily recognised by the following:—

Large slender pointed teeth in a single row in each jaw. The body is robust, and naked except for a corselet of scales, mainly beneath the skin, in the area of the pectoral fin and on either side of the dorsal fins. The first dorsal fin is low and the margin is straight.

Colour. Greenish bronze dorsally, silver ventrally, rest of body uniform blue. In post-mortem state a mid-lateral yellow green streak on the body. First dorsal fin bluish green, second dorsal under anal fins bronze with whitish tips. Post-mortem coloration of body and head a uniform silver grey.

Comparison with other records : Meristic and gill raker data are given in Table III.

TABLE III

Data on *G. unicolor*

	Williams East Africa	Ommanney Seychelles -Mauritius	Rüppell Red Sea	Warfel Philippines	Kishinouye Japan
D_1 ...	XIII-XIV	X-XIII	XIV	XIV	XIV
D_2	13+ 6— 7	12—14+6—8	13+6	13+7	13+7
A ...	11—12+ 6	12—13+6—7	13+6	12+6	12+6
Gill rakers ...	1+ 1+10—11= 12—13	12—13	...	1+1+10—12	...

No morphometric data are available on East African specimens. In Ommanney and Wheeler (1956) a few body proportions on the nine specimens caught in the Seychelles and Mauritius area are compared with details given in Kishinouye (1923) for Japanese specimens; selected measurements on 123 specimens from the Western Pacific Ocean are given in Dung and Royce (1953).

In East African waters *Gymnosarda unicolor* is known only from the east coast of Mafia Island, Tanganyika. Six specimens have been taken by surface trolling very close to the fringing reef, and several others were lost due to breakage of gear.

Three specimens were taken on 8th January 1953, two on 3rd December 1955, and one on 17th January 1956 ; specimens were also lost on those days. It seems that records are restricted to the NE monsoon, as between 1953 and 1956 trolling was carried out off the east coast of Mafia in all months of the year. Game fishermen out of Mafia have also recorded the species from the east coast between December and February. Kishinouye (1923) gives the temperature range for Rüppell's bonito as 20°–28°C.

The EAMFRO specimens, in order of capture, were as follows :—

TL. cm.	WT. lb.	Sex	Gonad Maturity
142	78	M	Mature running V
125	45	M	Mature running V
121	41	M	Mature running V
137	70	F	Mature nearly ripe IV
126.5	48	M	Mature ripe IV
145	80	F	Not recorded

M=Male F=Female

Specimens taken by game fishermen off Mafia ranged from 40 lb. to just under 100 lb. ; those caught by Wheeler and Ommanney in the Seychelles-Mauritius area were from 78–115 cm. at 12–38 lb. Kishinouye (1923) reported this species as growing to about 240 cm. with a weight of 80 kgm. (176 lb.) but commonly being 100–150 cm. at 20–30 kgm. (44–66 lb.) ; Warfel (1950) gives maximum size caught in the Philippines as 48 lb. with an average of 16 lb., and Dung and Royce (1953) give Western Marshalls and Eastern Carolines data on fish 52–108 cm. TL. at 4½ to 41 lb.

From the six specimens caught it seems likely that the species spawns off the Mafia coast in the NE monsoon.

The stomachs of the fish were examined, three were empty and three contained unidentifiable fish remains.

It is thought possible that some of the Type I and III surface tuna shoals may, in fact, be composed, or partially composed of *Gymnosarda unicolor* (Rüpp.).

Flesh of this species is good but inferior to yellowfin and albacore in taste and quality.

More data are required on this species in the Indian Ocean.

Euthynnus affinis (Cantor) 1850.

Bonito ; little tuna. Sehewa (Kiswahili) : also refers to *Katsuwonus* and *Auxis* spp.

Although Fraser-Brunner (1949) revised the species of the genus *Euthynnus*, clarification is still needed in relation to the nomenclature of the various "species" (Matsumoto 1959). This author outlined the difficulties with regard to the Indian Ocean form *E. affinis* (Cantor) and to the West Pacific form *E. yaito* (Kishinouye). Both Kishinouye (1923) and Matsumoto (1959) believed the two forms to be co-specific but no decisions could be reached due to lack of data on adult *affinis* and on the holotype of that species. The Dakar Tuna Symposium, December 1960, recommended (III) that research should be initiated on *Euthynnus*, so as to determine the correct name for the Indian Ocean form (and also to clarify existing world species.). This work is now being undertaken by Dr. F. H. Talbot (S. Afri. Mus.) and the author, and the results will be presented as soon as possible.

The first data on *E. affinis* in East African waters, based on eleven specimens caught by surface trolling, were given in Morrow (1954a) ; further information on twenty-nine specimens taken by the same method was presented in Williams (1956). Since 1956

only a further eight specimens have been caught by EAMFRO vessels and data have been added to that in the previous report by Williams.

Fin counts are as follows:—

D XIV–XV:11–12+8. A 12–14+6–7 (Morrow).
D XV–XVI:11–13+8. A 13–14+6–7 (Williams)

Morrow (1954) found that there was no significant difference between mean fin counts of males and females except in the total anal count when the difference was at the 5% level. Gill raker counts, first arch (left) were 7–10+22–23=29–33 (Williams).

The general description of the species is similar to that given by authors such as Fraser-Brunner (1949; 1950) and de Beaufort and Chapman (1951). Fine villiform teeth are present on the vomer and palatines of all East African specimens. The black thoracic spots, one to six in number, are all below the base of the pectoral fin, whilst in occasional specimens the spots may be absent altogether.

Size range of specimens was:—

52 to 71 cm. fork length and 4 to 11½ lb. (Morrow)
40·5 to 78 cm. fork length and 2 to 16 lb. (Williams)

Morrow calculated the length/weight relationship in the normal manner $W=a\ L^b$ ($\log W=\log a+b \log L$), where L=fork length in cm. and W=weight in lb. The regression equation was $W=1{\cdot}63 \times 10^{-6}\ L^{3{\cdot}16}$ which is relatively close to the theoretical cube relationship.

Sex of specimens was:—

Males 6, Females 5 (Morrow)
Males 22, Females 15 (Williams)

Only three of the 37 EAMFRO specimens were immature—one male of 40·5 cm. fork length, one female of 54 cm. and one unsexed of 52·5 cm. Gonad maturity is shown in Table IV.

TABLE IV

Gonad maturity in *E. affinis*

Stage		Jan./Feb.	Mar./Apr.	May/Jun.	Jul./Aug.	Sep./Oct.	Nov./Dec.
Males :							
I	...	0	2	0	0	0	0
II	...	1	0	1	1	1	2
III	...	2	1	0	3	0	6
IV	...	0	2	1	0	0	0
V	...	0	0	0	0	0	0
Females :							
I	...	0	0	1	0	0	0
II	...	0	0	0	0	0	0
III	...	0	1	0	0	0	0
IV	...	0	2	0	0	1	0
V	...	1	2	0	3	0	0
VI	...	0	0	1	0	0	0
VII	...	0	1	0	1	0	0

Bonito are present in the area throughout the year, but seem to be slightly more abundant at the end of the SE monsoon and during the NE monsoon; certainly this is borne out by the numbers passing through the Zanzibar Fish Market.

Of the 34 stomachs examined qualitatively, 10 (29·4%) were empty; of those with contents (24) the percentage occurrence of food groups was as follows:—Fish 71%, Squid 21%, Crustacea 21%, Zooplankton 8%. The vast majority of the fish remains were *Atherina* sp. and Clupeids in large numbers—25 to 100 per stomach.

Bonito form a large proportion of the Type I and II surface shoals of tuna seen in East African waters. The bonito (*E. affinis*) could be an additional and important part of the catch of pelagic fishes in this area in the future.

Katsuwonus pelamis (L.) 1758.

Skipjack. Sehewa (Kiswahili): also refers to *Euthynnus sp. and Auxis spp.*

Little information can be added to that given in Williams (1956) on five specimens as no further skipjack have been taken by surface trolling. This is partly due to the nature of the work now undertaken by EAMFRO research vessels, when trolling is only carried out on passage. Two skipjack have been taken by longlining at subsurface levels, one having been severed just behind the head, presumably by a shark. Data on the seven specimens of skipjack are given in Table V.

TABLE V

Data on 7 specimens of *K. pelamis*

Date	TL. cm.	WT. lb.	Sex	Gonad maturity	Stomachs
12-3-52	62	8	M	Mature unripe II	2 squid.
18-6-52	56	7	M	Ripe III	squid, fish & plankton.
21-2-53	65	7	M	Ripe III	1 mackerel.
21-2-53	60	5	F	Ripening III	plankton remains.
24-3-53	58	6	F	Ripe V	Nil.
*24-7-59	60	8	F	Spent VII	5 clupeids.
* 4-3-60	remains only	10	M	Ripe IV.	Nil.

M=Male F=Female

*Taken by longlining.

Fin counts of the 5 trolled specimens were:

D XIV–XV: 13–15+7–8. A 14–15+7, and gill raker counts 15–16+38–40=53–56.

Skipjack are distributed throughout the East African area between 1° 30'S and 10° 30'S mainly inside the 100 fm. line. The species is not caught in large numbers by local fishermen as it does not readily take a trolled lure. Skipjack probably form a fairly high percentage of the Type I and II surface shoals of tuna at present not exploited in the area.

Knowledge on *Katsuwonus pelamis* is negligible in East Africa.

PART II. THE BILLFISHES

Billfishes, like the tunas, attracted little attention in East African waters until recently, and knowledge of them was fragmentary. However, during the 1950's game fishermen, working out of Malindi, Kenya, fished considerable stocks of billfish (especially sailfish) found in that area. Subsequently research longlining by EAMFRO has shown the presence of large numbers of the striped marlin throughout the East African area. Native fisheries for billfishes are negligible and, with a few notable exceptions, catches are largely accidental.

The species of billfishes known to occur in East African waters and authenticated by the author are as follows:—

The striped marlin.....*Tetrapterus audax* Philippi

The black marlin.....*Makaira indica* (Cuvier)

The Indian Ocean sailfish...*Istiophorus gladius* (Bloch)

The broadbill swordfish.....*Xiphias gladius* (L.)

Sports fishermen, including several of high international standing, fishing in Kenya waters have reported the capture of the blue marlin—*Makaira nigricans* (Lac.). Unfortunately the author has not been present when these were landed except on one occasion when the specimen, on examination, was found to be a large striped marlin. The difficulty in identifying specimens of striped and blue marlin in the 200 lb. range is well known and discussed later in this report. Thus the appearance of the blue marlin in East Africa awaits scientific confirmation, although Morrow (1959) recording the discovery of the blue marlin in the Indian Ocean, found specimens in the Maldive Is., Ceylon, Mauritius and Mozambique areas.

There is no report of the Indo-Pacific short bill spearfish, *Tetrapterus angustirostris* Tanaka from East African waters, or indeed from the Western Indian Ocean (Smith 1956a). The most westerly record in the Indian Ocean, according to Robins and de Sylva (1960), appears to be that of Yabe *et al.* at Lat. 25° 13'S, Long. 99° 83'E.

A preliminary key to the billfishes of East Africa is given below:—

1. (*a*) Pelvic fins absent; one pair of keels on the caudal peduncle; bill broad flattened and long .....*Xiphias gladius* (L.) (Xiphiidae)

   (*b*) Pelvic fins present ; two pairs of keels on caudal peduncle; bill cylindrical in cross-section and rod-like.....Istiophoridae 2.

2. (*a*) First dorsal fin extremely high with the central rays the longest—sail-like.....
   .....*Istiophorus gladius* (Bloch)

   (*b*) First dorsal ray low to moderate, with anterior rays the longest.....3

3. (*a*) Pectoral fin rigid—cannot be folded back against the body. Anterior lobe of first dorsal fin low, height less than body depth. Stripes may be found on the body, but do not persist after death.....*Makaira indica* (Cuvier)

   (*b*) Pectoral fin not rigid and folds back against body. Anterior lobe of first dorsal fin moderate, height greater than depth of body in all but largest specimens, when it is equal to depth. Stripes on sides of body conspicuous even after death.....*Tetrapterus audax* (Phillipi)

Investigations into the billfishes are in an early stage and preliminary reports are in the process of preparation and will be published shortly. It is not intended to discuss in detail in this paper the varied nomenclatorial problems which have existed, and still exist, in the billfishes throughout the world. Rather it is the intention to give the broad outline of the results of billfish work to date.

Xiphias gladius (L.) 1758.

Broadbill swordfish

The swordfish is extremely rare in East African waters and only three specimens have been taken by EAMFRO since its inception in 1951. The details are as follows :—

(1) TL. 138 cm. Wt. 9½ lb. Female immature. Stomach contained small fish and squid. Surface trolling at 0012 hr. 1–11–51, 35 miles SE of Mombasa, Kenya. Dark night.

(2) TL. 215 cm. Wt. 64 lb. Male immature/mature unripe. Stomach contained remains of 15 squid. Surface trolling at 0300 hr., 30–11–54. 5 miles NE of Ras Mkumbi, Mafia Island, Tanganyika. Dark night.

(3) TL. 147. cm. Wt. 18 lb. Female immature. Stomach empty. Subsurface longlining by day, 21–2–59, about 15 miles SE of Kilifi, Kenya.

A small juvenile of TL. 40 cm. was also taken from the stomach of a longline caught Lancet fish (*Alepisaurus* sp.) on 22–7–59, at approximately Lat. 8°30'S Long. 39°40'E.

In addition a 114 lb. specimen was recorded from Malindi, Kenya (Copely 1955) and a 125 lb. specimen from Zanzibar market on 11–12–54 (EAMFRO records). On 16–8–60, a 224 cm. swordfish was taken close inshore at Malindi by striking it on the head with a surfboard-weight unknown.

Smith (1956a) states that the swordfish is rare in South African waters and no confirmed records are known from north of Mozambique ; whilst Deraniyagala (1953) reports specimens from Ceylon. Japanese longlining records 5 specimens taken between 5°N and 3°S and one between 3°S and 9°S, 100 to 300 miles off the African coast during the period November 1954 to February 1955 (Anon. 1956). No sizes were given.

To my knowledge no swordfish have been taken by game fishermen in East African waters ; any catches made by local fishermen are purely accidental.

Nakamura *et al.* (1951) believe that the tropics are the spawning grounds of swordfish, as only juveniles and small adults are taken by longlining, whilst the majority of adults are taken in more temperate zones. This is also the suggestion from POFI data (Royce 1957).

In the Pacific and Atlantic Oceans swordfish reach at least 1000 lb. and form distinct and important fisheries in certain regions. Maximum size in the Indian Ocean is not known. It is recommended that records be kept of all swordfish caught or observed in the Indian Ocean area.

Istiophorus gladius (Bloch) 1793.

Indian Ocean Sailfish. Mbassi ; Nsulinsuli (Kiswahili).

The Indian Ocean Sailfish is commonly referred to under the scientific name *I. gladius* (Broussonet). However, Broussonet's authority cannot stand, as although the specimen is

in the British Museum (Nat. Hist.), Broussonet did not give the fish a scientific name. The use of *I. gladius* (Bloch), the next available name, is tentative pending the solution of many highly complex taxonomic problems in the sailfish as a whole, and the publishing of the new "Rules of Nomenclature". One of the main problems is the lack of sufficient taxonomic work to determine the relationships of the sailfishes from the various oceans. International co-operation is necessary and it is probable that future work on the sailfish of the Atlantic, Pacific and Indian Oceans will show that they are co-specific.

The nomenclatorial position will be discussed in more detail in a later publication. In addition, a report on a survey of the sailfish catch by game fishermen out of Malindi for the period July, 1958–June, 1961, is in the course of preparation.

Important Characteristics :

The sailfish is easily distinguished from all other billfishes by the extremely high first dorsal fin or "sail". In addition, it has a slimmer body form, being more laterally compressed than other billfishes, and has long pelvic fins.

The life or immediate post-mortem colouration of the East African sailfish is as follows :—

The upper body, brilliant cobalt blue, the lower areas shining silver (the boundary line is quite sharp and as a rule parallels the dorsal profile). The body normally has 20–24 crossbars, each bar made up of numerous pale cobalt blue spots. Head is dusky cobalt blue above and silvery below. The first dorsal fin or "sail" is brilliant cobalt blue with some purplish reflections. The posterior two-thirds or three-quarters of the fin has numerous black spots on the membranes between the spines, from the base to the edge of the fin. The first anal is usually bright cobalt ; the second dorsal, second anal, caudal and pectoral fins are dark blue black ; the pelvics are black. Deraniyagala (1952) plate 26 gives a reasonable representation of the colour pattern of the first dorsal fin of the Indian Ocean sailfish.

Distribution :

Surface trolling and longlining show that the sailfish is distributed throughout the East African coastal region (up to 30 miles offshore) from 1°30'S. to 10°30'S. but with concentrations in certain areas at times of abundance. The maximum numbers are found in the Malindi area of Kenya, and smaller numbers off the southern tip of Zanzibar island and in Moa Bay, Tanganyika. However this may prove to be an artefact of the fishing effort put into certain areas such as Malindi. Japanese longlining results from 100 to 300 miles east of the African coast showed "average" catches of sailfish. More exact records of distribution in the Indian Ocean are required.

Size :

The range of size of 17 longline caught sailfish was total length of 232 to 303 cm. with weight 60 to 105 lb. Japanese longline caught fish averaged 83 lb. Data on about 1,000 Malindi troll caught sailfish show a size range of TL. 142 to 305 cm. and weight of 8 to 111 lb. with the majority of fish from TL. 230 to 280 cm. and 50 to 80 lb. The Kenya record sailfish is 135 lb. (1957) but it is reported that the species reaches a greater size in Mozambique waters. Weights of 200 lb. have been quoted for other parts of the Indian Ocean but need confirmation. Record size for the Pacific sailfish is 132 lb. and for the Atlantic 124 lb.

Fishery :

The sailfish is by far the commonest of the billfishes in East African waters, forms important local fisheries in certain areas and is the basis of the very large game fishing "industry" at Malindi, Kenya.

As soon as the appearance of sailfish is noted at Kizimkazi on the southern tip of Zanzibar Islands, fishermen go out after the species with fishing dhows, mashuas and ngalawas using handlines in deep water. Many fish are lost but one or two a day may be averaged over a few weeks and, because of the size, form an important addition to the normal subsistence fishing.

In the Moa Bay area of Tanganyika (4°48'S.39°15'E.) a similar small scale native fishery exists for the species (where it enters comparatively shallow water) and the fish are taken by handlines, trolling and even in nets (set for other species).

Surface trolling by big game fishermen within 40 miles of Malindi has produced a recorded number of 1,116 sailfish in three seasons. The value of such a sport to the tourist attractions of Kenya is becoming increasingly important and approximately £200,000 capital is invested, more than three quarters in the fleet of craft operating from that resort. Catch/effort data have been recorded for this 3-year period so that a proper biological evaluation can be made of the species.

Research sub-surface longlining throughout the East African region from RV. MANIHINE in 1958–1960 has not resulted in such large numbers of sailfish as were taken trolling at Malindi (the opposite is true in the case of the striped marlin) ; only 17 sailfish out of a total of 130 billfish from 54 longline stations. The overall longline catch rate is 0.14/100 hooks but, as with the striped marlin, the catch is seasonable and reaches a peak of 0.3/100 hooks.

To local fishermen in Zanzibar and Tanganyika catches of sailfish average about 30 cts. per lb. whole fish and a similar price is paid for research catches. Malindi anglers receive about 20 cts. per lb. which helps to offset some of their expenses. The redder flesh of the sailfish is not as well liked in Zanzibar as the more palatable white flesh of young striped marlin.

Seasonable Abundance.

Over 80% of catches of sailfish by game fishermen at Malindi are made in the months of December to February inclusive and virtually no fish are taken in the months of April to September. This is similar to what local fisheries and longlining records show—that billfish are restricted to the months of the north-east monsoon.

Ecological Notes :

The majority of catches are made in the north-east monsoon when the EACC reaches its maximum temperature and its minimum salinity. The game fishing catches at Malindi are made at the surface between the 25 fm. and the 150 fm. lines in an area where there is, for East Africa, a "considerable" stretch of gently sloping shelf of sand and mud (Malindi and Formosa Bays). Similarly the Moa Bay fishery is inside the 100 fm. line and that at Kizimkazi is not far from the southern edge of the shallow Zanzibar Channel.

Longline catches are made between the surface and just below the EACC/ASW thermocline, which is at its shallowest during the north-east monsoon.

Biological Data :

To enable certain essential information on sailfish to be collected from the catch at Malindi a short form (Appendix II) was designed by EAMFRO. EAMFRO now possess a very large number of measurements of total length, fork length, head length, depth of body, maximum height of "sail", length of pectoral and pelvic fins. Thus, although insufficient morphometric data are available for racial studies, the data are valuable in determining the relative growth relationships of various parts of the body. More extensive measurements, like those made on the striped marlin (see under that species), have been carried out on the 17 sailfish taken longlining. The lack of published morphometric data on the Indian Ocean sailfish make comparisons with the East African area impossible at the present time ; published data, even for the Pacific sailfish, are scarce ; details on 8 specimens of *I. orientalis* from Formosa are given in Nakamura (1955) and on 6 specimens of the same species from the central Pacific in Royce (1957).

Length Distribution. A preliminary examination of the length frequency of the data on three seasons at Malindi show what appears to be a single and similar length group, with a fairly wide mode at 76″ to 100″ (203 to 254 cm.) fork length present in the catch each year. (It must be remembered that the catch is mainly over a 3-month period). Comparisons will be made at a later date with data for the Atlantic sailfish given in deSylva (1957).

Weight frequency distribution could not be used because of the great variation in weight at a given length—*Length/Weight Relationship.* Some 906 length/weight data await regression analysis of the form $W = a\ L^b$ ($\log W = \log a + b \log L$). The data will be presented for the three years separately as well as for the overall period.

Age, Sex and Maturity. No examination has been made of vertebrae or other bony structures of sailfish for possible age determination. The apparent lack of more than one mode in the length frequency distribution of East African specimens prevents the use of the length frequency method of ageing. Until such time as more juvenile specimens are obtained, it is hoped that comparison with the work on the Atlantic sailfish (deSylva 1957) will help in an approximation of the age of the Indian Ocean species ; however, the Malindi specimens can be expected to be at least two years old.

Of the 17 specimens of sailfish taken longlining 13 were males and 4 females, a sex ratio of 3.25:1 males to females. Unfortunately the sexing of the very many specimens at Malindi has proved unreliable due to the difficulty encountered by the observers there in recognising differences between the gonads, especially in the young stages. Specimens caught during the International Billfish Contest in February 1961, were examined by the author, males predominated and one spent female was observed.

All the longline caught specimens were mature and at all stages of maturity, including one spent male (January 1959).

Food. The stomachs of the EAMFRO caught sailfish were examined qualitatively as a matter of routine, but only 7 were examined quantitatively.

Examination showed that 4 stomachs were empty or contained only bait ; of the 13 specimens with contents, the percentage occurrence of fish was 92 and of squid 61. The sailfish appears to be broadly carnivorous on fish and squid.

Tagging. With the co-operation of game fishermen at Malindi a tagging programme is to be instituted in the 1960–1961 season. The tag to be used is the FLOY Type FT–1, coloured bright yellow and marked "Return EAMFRO. Box 668 ZANZIBAR", and bearing a serial number. The object of this programme is to gain information on the rate of growth and the movement of the species, especially during the off-season. It would be appreciated if all representatives at the Symposium could draw the attention of their fisheries divisions to the programme. A reward of Rs. 20 (£1) will be paid for each tag returned. Where possible, total or fork length and weight should be given in addition to date and place of capture.

Makaira indica (Cuvier) 1831.

Black Marlin. Nduaro (Kiswahili).

The most characteristic feature of the black marlin is the rigid pectoral fin, which cannot be folded flat against the side of the body, and this distinguishes it from the rest of the billfishes found in East African waters. The morphology of the pectoral girdle in Marlins is discussed in Morrow (1957b).

The use of the specific name *indica* Cuvier is based on Morrow (1959b), which also gives detailed synonymy and references to the black marlin (see also Morrow 1958), and this is confirmed by Robins and deSylva (1960). From these papers it will be seen that *Istiompax marlina* (Jordan and Hill) as used by Royce (1957) is a synonym of *M. indica.*

Williams (1959b), recording two black marlin taken longlining in East African waters, pointed out that the first record of black marlin in the area (Morrow 1954b) was now validated, a mistake having been made in the published weight of the specimen (see Smith 1956a). An outline of the distribution of the black marlin in the Indo-Pacific is given in Morrow (1959a).

In Williams (1959b) it was stated that "There are at no time any signs of the vertical stripes.....of the striped marlin". This was later found to be incorrect and East African black marlin have been seen to possess bluish-dusky stripes on the body when in the water or immediately after landing; but the stripes do not persist for more than a few minutes after death.

Only five specimens of black marlin have been taken longlining by EAMFRO all in the area south of Lat. 6°30'S. and close to the coast. Two were caught in January 1959, two in July 1959, and one in February 1960. These specimens were between 241 and 272 cm. total length and 112 and 165 lb. weight; all were measured in detail. All were mature females with unripe or ripening gonads; three had empty stomachs and two contained fish remains.

The catch of black marlin by game fishermen out of Malindi is about 15 to 25 per year (22 confirmed in the season July 1960 to June 1961) and details of length and weight have been recorded for EAMFRO. The average weight of specimens is about 120 to 140 lb.; specimens exceeding 200 lb. are rare and the Kenya record stands at 265 lb. (1960).

In the Pacific Ocean the black marlin reaches a record weight of 1,560 lb. and fish over 1,000 lb. are not uncommon in some areas. Indian Ocean specimens do not appear to reach such a large size, although one specimen from Mozambique caught on 28–10–60,

weighed just over 1,000 lb. (Game Fish Union of Africa, 1960). In 1952 the author personally saw a very large black marlin strike at lures trolled from RV. RESEARCH close inshore in the area of the Kenya-Somalia border (Lat. 1° 30'S.). After 'tailwalking' it broke away with several lines ; it was estimated at 10-12 ft. and 500 to 600 lb.

Although not as rare as the swordfish the black marlin is not as abundant as the striped marlin. As with the swordfish, records should be kept of all black marlin caught in the Indian Ocean.

Tetrapterus audax (Phillipi) 1887.

Striped Marlin. Nduaro (Kiswahili).

The use of the specific name *audax* Philippi was first advocated by Smith (1956b) in recording the first striped marlin from the Western Indian Ocean and this was agreed by Williams (1959). Prior to 1956 *mitsukurii* (Jordan and Schneider 1901) had been used by most Japanese and American workers ; *audax* has been used by later American workers such as Royce (1957) in his review of Pacific spearfishes and Robins and deSylva (1960) in their review of *Tetrapterus* spp.

The change from *Makaira* to *Tetrapterus* is of recent origin (Robins and deSylva 1960) and results from a detailed examination of the relationships of the Atlantic long bill spearfish *Tetrapterus belone*. This examination shows that the white and the striped marlins, *M. audax* and *M. albidus* have closer affinities and characteristics with the sailfishes and spearfishes, *Istiophorus* spp. and *Tetrapterus* spp., than with the black and the blue marlins, *M. indica* and *M. nigricans*. It is considered that the striped marlin of the Indo-Pacific should be referred to as *Tetrapterus audax* (Phillipi).

A detailed synonymy and references to the striped marlin, are given in Royce (1957) for work up to that date.

Description and colour :

A short description, with colour notes, of the East African specimens of *T. audax* was given in Williams (1959a), and this will be amplified in a later publication. The distinguishing characteristics are given in the key to the spearfishes (p. 126). In all the East African specimens examined, the height of the first dorsal fin lobe exceeded the maximum depth of the body, except in a few large specimens (over 200 lb.) where height was equal to depth. As stated earlier it is at this size that the striped marlin is often confused with small specimens of the blue marlin.

" East African striped marlin are brilliantly coloured, cobalt blue above and white below on the belly ; the number of pale lavender coloured stripes varies considerably. On death, the fish becomes a uniform slate grey above and pale below ; the pale stripes persist after death for some time, but after refrigeration for a few days the stripes may be lost altogether" (Williams 1959a). The stripes consists of a large number of very small spots of colour.

Distribution :

Striped marlin have now been recorded from the whole of the East African coastal area between Lat. 1°30'S and 10°30'S within 25 miles of the coast. Greatest numbers seem to be taken in the area between the northern tip of Pemba Island and Malindi, Kenya,

(4°40'S. to 3°10'S.) and between the north Kilwa islands and Ras Mkumbi, Mafia (8°40'S. to 7°30'S.) within 10 miles of the 100 fathom line. In other areas specimens seem to be present only in small numbers.

Very little is known of the distribution of the striped marlin in the Indian Ocean. Japanese longlining vessels made "average catches" (1·3/100 hooks) of striped marlin between November 1954 and February 1955 when operating between Lat. 5°N. and 9°S. 100 to 300 miles east of the African coast.

Size :

The sizes of the striped marlin given here for East Africa are based entirely on research vessel catches. The size range is 198 cm. to 296 cm. fork length at 47 and 205 lb. weight respectively. Very few striped marlin over 200 lb. have ever been landed on this coast. The majority of specimens caught are between 210 cm. to 280 cm. at 60 to 160 lb. weight.

Fishery :

No native fishery exists specifically for striped marlin and catches are negligible. Those that are made are usually from hand-lining in "very" deep water (over 100 fm.) for sailfish or *Pristipomoides* spp. (Lutjanidae). This is occasionally carried out in the North Pemba Channel and off the southern tip of Zanzibar Island. However, the majority of specimens are lost because of their size and similarly this happens when trolling. Small specimens are sometimes trapped in five to seven inches gill nets set for other pelagic species such as *Scomberomorus* spp. or for shark.

Game fishermen surface trolling in the vicinity of Malindi land perhaps 10 to 15 striped marlin in the year, a very small number compared with the sailfish catch. Only one striped marlin has been taken by surface trolling from EAMFRO research vessels.

Research sub-surface longlining from the RV. MANIHINE in 1958–1960 showed that the number of striped marlin in East African waters is considerably greater than it would appear from existing records. Altogether some 107 striped marlin out of a total of 130 billfish were taken from 54 longline stations. The striped marlin catch-rate is thus 0.87/100 hooks for the whole period September 1958–February 1960,—a reasonably high figure by any standards. However, the catch is highly seasonable and catch-rates in the season averaged 1.97/100 hooks with the maximum rate 9.2/100 hooks. With the average weight at about 100 lb. per fish the catch is a valuable one.

The catch of a striped marlin is valuable to the local fisherman because of the high average size and weight. In Zanzibar the species fetches 30 to 50 cents per lb. whole fish, whilst in other areas such as Malindi 20 to 30 cents per lb. is more common. Cleaned, gutted and refrigerated fish from research vessel longlining were much sought after, and never brought less than 30 to 50 cents per lb. whole fish.

Royce (1957) refers to the variation in the colour of the flesh of the striped marlin ; from an examination of East African specimens this seems to be related to size. Young specimens are white-fleshed with a gradual change-over to pink in the larger specimens of over 120 lb. ; and certainly the flesh varies similarly in quality and palatability. Deep frozen packs of young striped marlin flesh are of high quality and almost as good as tuna. The possible value of longline catch of striped marlin to East Africa will be discussed in the publication on longlining in the area.

Seasonal Abundance :

Catches of striped marlin are only made in any numbers during the period of the NE monsoon, *i.e.*, November/December to March/April. This applies to the longlining catches of which 93% were made in the period December to February. Japanese longlining operations of the East African coast took place in February.

Catches made at the surface by other methods are restricted to the same period of the year.

Ecological Notes :

The majority of catches are made at the time when the EACC is reaching its maximum temperature and minimum salinity. The catches taken longlining are made between the surface and just below the EACC/ASW thermocline which is at its shallowest during the NE monsoon ; the temperature at the thermocline being 22°–23°C. When this temperature is found near the surface, as in the NE monsoon, marlin are scarce.

It is interesting to note that in the Pacific striped marlin prefer the more temperate waters of Lat. 20°–30°N. or S., whilst catches are lowest in equatorial regions.

Biological Data :

Racial Studies. The striped marlin occurs throughout the warmer parts of the Indo-Pacific Oceans but has known areas of abundance, usually close to the shore, such as that now found in East African waters. Morrow (1957a) discusses the distribution of the species and presents statistical analysis of morphometric and meristic data which show that striped marlin from Peru and northern New Zealand represent separate populations. It was considered likely that data on striped marlin in East Africa might show a similar separate population of the species in the Western Indian Ocean. With this aim in mind some 19 measurements have been made on each of 98 specimens taken by EAMFRO. To make comparisons possible with the work of Morrow (1957a) the standard length—the independent variable—is as defined in that publication. All other measurements—the dependent variables—are as follows :—greatest depth of the body ; length of base of second dorsal fin ; length of pelvic fin ; snout to origin of first dorsal fin ; snout to origin of second dorsal fin ; snout to origin of first anal fin ; snout to posterior edge of operculum ; snout to posterior edge of maxillary ; length of dorsal lobe of caudal fin ; length of ventral lobe of caudal fin ; length of longest spine in first dorsal fin ; length of longest spine in first anal fin ; length of first ray in second dorsal fin ; length of pectoral fin ; tip of snout to pectoral origin ; tip of snout to pelvic origin ; tip of snout to anterior margin of eye ; longitudinal diameter of eye. In addition meristic counts were made where possible. Data not given in Morrow (1957a) have been derived from the field reports of the expeditions mentioned in that publication and on loan to the author.

Statistical analyses of the East African data are now being undertaken jointly by EAMFRO, and the Fisheries Laboratory, Lowestoft, England, but will not be completed for some time. It is suggested that if other centres of abundance of striped marlin are discovered in the Indian Ocean, data of a similar nature are collected for delineation of the Indian Ocean populations.

Length Distribution. Two modes appear in the length frequency distribution for the year (which is based mainly on the short season December to February). The modes are at

210—219 cm. and 260—269 cm. at approximately 60—80 lb. and 130—150 lb. respectively. Further details will be given at a later date.

Length/Weight Relationship. This has been calculated in the normal manner—$W=a L^b$ ($\log W=\log a+b \log L$) where W=weight in pounds and L=fork length (tip of snout to tip of centre rays of the tail).

The regression lines for males and females separately show no significant difference. The regression line for the combined data (98 specimens) is as follows:—

$$\log W=5{\cdot}370650+2{\cdot}84448 \log L \text{ or}$$
$$W=10^{-4} \times 0{\cdot}23480\ L^{2.84448}$$

Comparison of the values of 'a' and 'b' for East African and Pacific areas (Royce 1957) are shown in Table VI.

TABLE VI

Values of 'a' and 'b' from the regression equation $\log W = \log a + b \log L$ for striped marlin of the Indo-Pacific

Area	Source	No. of specimens	'a'	'b'
New Zealand and Australia	Gregory and Conrad 1939	27	— 6.515	3.62405
New Zealand	Morrow 1952	48	— 5.024	3.01090
Central Pacific	Royce 1957	13	— 6.648	3.69078
Hawaii	Hawaii Dept. Fish and Game (after Royce 1957)	30	— 6.110	3.44578
East Africa	Williams	98	— 4.62935	2.84448

Age, Sex and Maturity. Altogether 105 specimens of striped marlin have been sexed; 48 were males and 57 females giving a sex ratio of males to females 1:1.18 for the period under review, September 1958 to February 1960. No further details have been prepared to date.

Food. The stomachs of 104 striped marlin were examined but only 24 were examined quantitatively as well as qualitatively.

A preliminary analysis shows that about 25% of the marlin had empty stomachs or contained only bait; of those with stomach contents the approximate percentage occurrence of fish remains was 80 and of squid remains 38. Small Thunnidae, mainly frigate mackerel, appeared to be the commonest form of fish eaten by the striped marlin.

Parasites.

Internal. There was a very heavy infestation of most stomachs with *Contracaecum incurvum* (Nematoda; Ascaridae).

External. Idenifications not finalised as yet.

PART III. THE SEERFISHES

Strictly speaking the term "Seerfishes" should refer only to the fishes of the Genus *Scomberomorus* Lac. 1802. However, for this paper it was decided that the Wahoo, *Acanthocybium solandri* (C. V.) 1831, should be included, as this species is very closely related to the Seerfishes and as such deserves to be discussed in any paper concerning scombroid fishes. Only two species of *Scomberomorus* are known to occur in East African waters (Williams 1956; 1960) and these are *Scomberomorus commerson* (Lac.) (1802) and *S. lineolatus* (C. V.) 1831.

The common name of Wahoo is used for *Acanthocybium solandri* in most regions of the world, but the commonly used Spanish Mackerel for *Scomberomorus* spp. is replaced by Kingfish in the East African area. Here again, however, the use of the common names causes confusion, as in South Africa the Kingfish refers to fishes of the Family Carangidae. If the scientific names are not to be used in this area, the specifically distinct vernacular names (see under Species) are more satisfactory.

The seerfishes are economically important in East Africa and one species forms a distinct fishery in certain areas at one season of the year. Although important, the detailed biological aspect of Seerfishes has not been investigated by EAMFRO because of other commitments. Some of the biological data given here have been reproduced from Williams 1956, but the majority are the result of purely routine observations made by EAMFRO staff during cruises of research vessels (or on the "ground") over the last nine years. The number of specimens is still very small and only limited information on the biology of the fishes is forthcoming. However, this data could be used as a base line for any work on this important group of pelagic fishes which may be required in the future. So often in the past such limited data have not been presented but filed away and forgotten.

Both the genera *Scomberomorus* and *Acanthocybium* are differentiated from all other Scombroid fishes by the more or less laterally compressed elongate body with a single lateral line and minute scales not differentiated into a corselet in the pectoral region.

The following key separates the Seerfishes encountered in East African waters :—

1. (*a*) Gill rakers present. First dorsal fin with 15–17 spines. Lamellae of gills not reticulated. Vertebrae 44–51..... 2

   (*b*) Gill rakers absent. First dorsal fin with 25–28 spines. Lamellae of gills reticulated. Vertebrae 54–64..... .....*Acanthocybium solandri* (C.V.)

2. (*a*) Gill rakers rudimentary and feeble, 0–1+3–4 = 3–5. Lateral line bent down abruptly under second dorsal fin or finlets. Silvery blue body with numerous narrow vertical wavy dark bands.....*Scomberomorus commerson* (Lac.)

   (*b*) Gill rakers well developed, 2+1+8–11 = 11–14. Lateral line undulating gently under second dorsal fin or finlets. Silvery blue body, on sides a series of 6–8 interrupted horizontal black lines much narrower than the interspaces.....*Scomberomorus lineolatus* (C.V.)

Scomberomorus commerson (Lac.) 1800.

Kingfish. Nguru (Kiswahili)

Munro (1943) in his detailed revision of the Australian Scomberomorids gives an extensive synonymy of *S. commerson* up to that date and this synonymy is not repeated here. Since 1943 taxonomic references to the species in the Indian Ocean or East African area have been made by the following authors :—Fraser-Brunner (1950) ; de Beaufort and Chapman (1951) ; Wheeler and Ommanney (1953) ; Williams (1956) and Smith (1960).

Description :

Although several hundred adult specimens of this species have been caught between 53.5 and 138 cm. fork length, the diagnosis that follows is based on comparatively few specimens, mainly from the extremities of this size range. The main reason for this is that the species was clearly identifiable from the very start of work in East Africa and no attempt was made to collect morphometric and meristic data. Only 5 juvenile specimens (FL. 152–164 mm.) have been taken in East Africa and because of the lack of information on juveniles, especially in the Western Indian Ocean, these are described in detail.

Adults. D XVI–XVIII : III–IV 13–15+9. (rarely 8 or 10).
A III–IV 13–15+9. (rarely 8 or 10).
Pect. i–ii 22–23.
Pelv. I 5.

Vertebrae : 20 precaudal + 24 caudal = 44 total (excluding hypural). Others, 42–43 total.

Gill rakers on first gill arch : 0–1+1+2–4 = 3–6, only very rarely more than this. Gill rakers rudimentary and feeble and only in a few very large fish does the length of raker approach half the length of gill filaments, usually much less than this and frequently almost knob like. The rakers are slightly incurved, the inner edge with many small bony setae, the outer edge smooth. Small bony setae are also present along the gill arch, especially between the rakers.

Depth 5.54 to 6.12 ; head 4.70 to 5.65 ; snout to origin of first dorsal fin 4.35 to 4.60 ; snout to origin of second dorsal fin 2.00 to 2.09 ; snout to origin of anal fin 1.84 to 2.00 ; snout to pectoral origin 4.70 to 4.93 ; snout to pelvic origin 4.21 to 4.39 ; all in fork length. Eye 6.22 to 7.81 ; snout 2.50 to 2.54 ; interorbital 3.23 to 3.73 ; postorbital 2.06 to 2.19 ; maxillaries 1.76 to 1.82 ; pectoral 1.41 to 1.67; pelvic 3.63 to 4.19 ; longest dorsal spine 3.86 to 4.19 ; longest dorsal ray 2.29 to 2.48; longest anal ray 2.20 to 2.38 ; all in length of head. Eye in snout 2.44 to 3.09 ; in postorbital 2.83 to 3.63.

Body is of the typical scomberomorid shape, elongate and compressed. Head pointed ; the dorsal surface from snout tip to origin of first dorsal fin is sharply inclined (to axis of body) but straight with only a very slight depression at the interorbital. Bony interorbital space flat. A rounded ridge on head from snout to pectoral base through the upper edge of the eye ; the ridge is most marked from nostrils to the area of the eye—in the largest specimens not so prominent except in this area. Posterior nostril slit-like, immediately in front of eye ; anterior nostril small and round, diameter half length

of posterior nostril and about diameter of pupil of eye in front and slightly above it. Eye slightly oval, longitudinal diameter greatest. Adipose eyelids well developed from a thick rim around eye; the posterior adipose eyelid reaches a considerable distance on to the postorbital area of the head. Premaxilla wide; maxilla and supplementary bone form a fairly wide expansion posteriorly, more so in larger fishes. Maxilla reaches vertical under posterior edge of eye or slightly beyond.

Jaws equal in length (or lower slightly longer in larger fish) and appear rather "beak-like", especially in large specimens, when the front edge of the lower jaw is vertical. In large fish a small fleshy protruberance at the lower jaw tip.

Teeth. A single row of sharp narrowly triangular shaped teeth in each jaw. Size and number of teeth vary considerably due to damage and partial replacement, but usually largest teeth are about two-thirds along the jaw from the tip. Minute serrations are present on both edges of the teeth of some specimens but not in all, apparently. When the jaws are closed the teeth of the upper jaw overlap outside the edge of the lower jaw; no teeth at symphysis. Minute villiform teeth in a small oval or diamond shape patch on vomer, in a long narrow band on the palatines, in a central patch on the tongue and also on basihyal and first basi-branchial; pterygoids and parasphenoids are rough in most specimens. Preoperculum rounded in smaller specimens to slightly emarginate in larger ones. Operculum rounded with sometimes a slight indentation in the edge just below level of pectoral base.

Body and head mainly without scales. A few scales on upper opercular areas and on the nape below the dorsal line. Small lanceolate scales proximally on the outside of the pectoral fin, on the pectoral base and just above the axil, on the dorsal and anal fins and finlets, and on base of the caudal fin and central caudal rays; also on the sides of the caudal peduncle in a very narrow triangular shaped area including the median peduncular keel, the apex of the triangle being under the third or fourth last dorsal finlet. Lateral line of small tubules and "modified scales" in an undulating curve from above the pectoral to under the first to third dorsal finlets where there is a sharp and most marked downward bend which reaches below the anterior-posterior axis of the body, then gently rising to the level of the axis and thence straight to the caudal peduncle.

Third to fifth dorsal spines normally longest but second to sixth often nearly equal in length; rest of spines decreasing in size posteriorly, last spine usually very small and partially embedded. Second dorsal and anal fins with moderate to high falcate lobes, with anteriorly a number of closely set spines, the rest of the fins composed of branched rays. The last ray of the fins may be finlet-like and partially detached; a number of detached finlets posterior to the fins. Pectoral short, subfalcate; basally in the axil a minute membrane connects the fin to the body. Pelvics short and fit into a shallow groove; a small membrane connects the rear edge of the pelvic fins to the body (the interpelvic process of Fraser-Brunner 1950 is readily discernible). Caudal deeply forked, the lobes about equal in length. Central keel on caudal peduncle is membranous and fairly well developed, the paired keels only weakly so. No swim bladder present.

Colour. (*Immediate*) *Post-mortem.* Head blue black above level of eye, including snout, silvery white below.

Body, upper one-third irridescent blue black, lower two-thirds silvery white with bluish reflections. The junction of colour is more pronounced in older specimens. A large

number of wavy rather irregularly vertical bands on the body, slightly narrower than the interspaces. The bands are more numerous and tend to be more broken up and interconnected in larger fish. Pectoral, outside dusky to black, and inside black except lower edges which are pale; axil black above. Pelvics outside pale to dusky, inside rays white, with membranes black.

First dorsal fin pale below, blackish above, especially anteriorly where the edge of the membrane is black. Second dorsal fin dusky, leading edge black, tips of rays pale; finlets pale to dusky, leading edges in some dusky-black. Anal fin dusky, leading edge pale, rest dusky. Scales on pectoral, and second dorsal and anal fins and finlets give traces of whitish silver reflections. Caudal peduncle, including median keel, intense blue-black above, pale below.

Juveniles. Five specimens, FL. 152, 153, 158 (2) and 164 mm. Collected from Zanzibar fish market (3) in January 1956 and (2) on 23-1-57; presumably from beach seine catches.

Description is omitted where identical with adults.

D XVI—XVII; III 15+8—9

A III—IV 15—16+8—9

Pect. ii 22—24 (2 specimens only)

Pelv. I 5

Gillrakers on 1st gill arch (left) 0—1+1+3—4 = 4—6.

Rakers are rudimentary, very small and stub like; one raker is present in all specimens at the angle of the arch. The top of each raker is directed towards the inside of the gill arch, and is covered with very small sharp pointed bony setae (microscopic examination necessary) which are likewise directed inwards. Between each raker, and on the rest of the gill arch, are transverse bands of similar bony setae, the largest on the inside edge of the gill arch. The setae on the upper limb are less differentiated into bands in two specimens.

Vertebral counts excluding hypural:—

(i) 2 specimens 19 precaudal+24 caudal = 43 total.

(ii) 2 specimens 20 precaudal+23 caudal = 43 total.

(iii) 1 specimen Total 43.

The four specimens under (i) and (ii) were examined by means of X-rays, and the count determined from the resulting radiograph.

Depth 4·5 to 4·93; head 3·92 to 4·30; snout to origin of first dorsal fin 3·73 to 4·15; snout to origin of second dorsal fin 1·88 to 1·94; snout to origin of second anal fin 1·75 to 1·90; snout to pectoral origin 3·68 to 4; snout to pelvic origin 3·47 to 3·77; all in fork length. Eye 4·05 to 4·58; snout 2·43 to 2·85; interorbital 3·54 to 4; postorbital 2·16 to 2·43; maxillaries 1·58 to 1·73; pectoral 2·10 to 2·35; pelvics 3·9 to 4·44; longest dorsal spine 2·81 to 3·31; longest dorsal ray 2·81 to 3·63; longest anal ray 2·81 to 3·47; all in length of head. Eye in snout 1·55 to 1·76; in postorbital 1·77 to 2·43.

These specimens of 152—164 mm. look like immature adults in general shape etc., although the body is much more compressed than in the older fish. Depth of the body is

fairly regular from the area of pectoral to the second dorsal fin. Maxilla and supplementary bone only a little expanded posteriorly. Lower jaw slightly the longer.

Teeth. Narrower than in adults. Villiform teeth on vomer and palatines minute (rough); tongue, parasphenoids and pterygoids edentulous. Edge of preoperculum emarginate, lower corner acutely rounded; operculum smoothly rounded. Body and head virtually without external scales except for a few on the caudal fin base. However, subcutaneous scales are present as shown in Deraniyagala (1952) fig. 43; that is, small elongate diamond shaped scales in the postorbital areas mainly under the extension of the adipose eyelids and subovoid scales in 3—4 rows from the upper opercular edge to a point just below the upper edge of the pectoral fin.

Examination of internal organs shows the liver to be trilobed, the middle lobe the smallest and approximately half the length of the other two. Spleen long and thin and lies next to the mass of pyloric caecae; gall bladder about half length of spleen.

Careful examination of one specimen showed no sign of a swim bladder.

Colour. Post-mortem. Head dusky blue black above, paler below; a little darker above maxillaries. Pupil of eye black, rest pale. Body, upper one-third bluish dusky, below pale silvery; small blue black irregularly rectangular blotches on sides of body (upper one-third). First dorsal fin intensely black anteriorly and posteriorly, leaving a pale area in the centre of the fin, edge of the fin membrane is still black however. Second dorsal fin pale to a little dusky in places; finlets pale whitish. Second anal fin and finlets pale to whitish. Caudal dusky except for scaled areas at base of fin which are paler. Pectoral, outside pale, inside dusky; axil dark. Pelvics pale.

Preserved in formalin (as in post-mortem unless stated). Head dusky blue-brown above, paler below. Snout, operculum and area above maxillaries dusky, nape very dark. Body dusky blue-brown above, paler below. Signs of small blue black blotches on upper areas of body. Second dorsal and anal fins and finlets generaly whitish. Caudal pale to dusky.

General Taxonomic Discussion :

Fin Formulae. The range of fin formulae of *S. commerson* in East African waters (FL. 15·2 to 101 cm.) is:—

D XVI — XVII : III — IV 13 — 15+8 — 10
A III — IV 13 — 16+8 — 10.
Pect. i — ii 22 — 24.

Whilst the usual formula is:—

D XVI : III 13 — 15+9.
A III 13 — 15+9.
Pect. ii 22 — 23.

The variation in fin counts of *S. commerson* over the distributional range of the species is given in Munro (1943) Table III, for literature up to that date. Those data, together with that of Munro for the Australian area, de Beaufort and Chapman (1951) for

the East Indies, and Smith (1960) for Southern Africa, show the maximum known variation of fin formulae to be :—

D XV—XVII : 14—17+9—12

A 14—17+8—12.

Pect. 20—24.

Thus it is seen that the East African specimens fall well within the overall range of variation, although the pectoral fin count seems to be more constantly higher. It seems possible too, that in the past variations in the counts of the soft dorsal and anal fins were due (*i*) to the non-dissection of the anterior part of the fin which consists of spines, especially the first which is very small and inconspicuous and (*ii*) to the last ray of the fin being finlet-like and to varying degrees partially or almost completely detached and to the fact that it may or may not (as in this paper) be counted as a finlet.

Vertebrae. The number of vertebrae has only been checked in four adults and the five juveniles. The total counts of 42–44 and 43 respectively are lower than the 45 (20+25) quoted by Munro for Australian waters and Japan (after Kishinouye). Owing to the lack of numbers examined, however, little can be deduced from this variation.

Gill rakers. These are very similar in the juveniles and adults, and the numbers, size and shape accord closely with the description of the species from other parts of the distributional range.

Body Proportions. Those given in this paper can be compared directly with those of Munro for Australian specimens as the measurements in both cases were made in the same manner and the *fork length* is the primary unit. Table VII shows the range of variation of certain body proportions which are available from East African and Australian (after Munro, Table IV) adult specimens. Although the size range of the East African fishes is less than the Australian ones, the similarity of the data is close.

TABLE VII

Comparison of certain body proportions on *S. commerson* from East African and Australian Waters

Proportion	East Africa 535–1010 mm. FL.	Australia 368–1252 mm. FL.
Snout in head ...	2.50 — 2.54	2.19 — 2.53
Diameter of eye in head ...	6.22 — 7.81	6.00 — 11.84
Interorbital in head ...	3.28 — 3.73	2.59 — 4.64
Maxilla in head ...	1.75 — 1.87	1.66 — 2.14
Pectoral in head ...	1.41 — 1.67	1.46 — 1.80
Head in fork length ...	4.70 — 5.05	4.38 — 5.21
Snout to D^1 in FL. ...	4.35 — 4.60	4.06 — 5.09
Snout to D^2 in FL. ...	2.00 — 2.09	1.78 — 2.15
Snout to pelvics in FL. ...	4.21 — 4.39	3.79 — 4.45
Depth + height of D^2 + height of A^2 in FL. ...	2.72 — 2.97	2.03 — 2.92

No body proportions for juveniles from other areas are available to the author for comparison.

It is unfortunate that previous to the work of Munro, morphometric data on *S. commerson* from other parts of the Indo-West Pacific has been based on few specimens, often over a restricted size range and with varying methods of measurement and definitions of length. As Munro pointed out, large series must be examined to determine if racial differences indeed exist between stocks in the different areas of the Indo-West Pacific where the species is found.

Internal Anatomy. In only one juvenile specimen were the internal organs examined and these agreed closely with the young specimen shown in Munro (1943) Fig. 2 (4).

East African specimens, both juvenile and adult show no signs of a swim bladder and thus are similar to the Australian members of the species. However, Kishinouye (1923) and Deraniyagala (1952) state that in Japanese and Indian specimens respectively a swim bladder is present. Fraser Brunner (1950) in the introduction to his revision of the Scombridae states that the swim bladder is retained in all species of *Scomberomorus* but later subdivides the genus into two subgenera on the presence or absence of the swim bladder. That author lists seven species without the swim bladder, in the subgenus *Scomberomorus* and two, including *S. commerson*, with a swim bladder, in the subgenus *Cybium*. In Munro's subgenera, however, *Scomberomorus* is defined as possessing a swim bladder and in *Cybium* it is variable. This confusion exists in many of the earlier works on the genus, and the intention of this diversion has been to draw attention to the need for more exact information regarding the presence or absence of the swim bladder in *S. commerson* in the areas intermediate between East Africa, India, Australia and Japan. This character might be used as a subspecific or racial character, and also in determining migrations of the fish.

Colour. This is fundamentally similar in East African fish to that reported from elsewhere ; in the juveniles the black first dorsal fin with a central pale area is a little different from those normally described and is extremely like that of the related *S. queenslandicus* Munro 1943 (see plate 8, Fig. 1. of that author).

Conclusion. On the basis of the existing meristic and morphometric data there is little differentiation into geographical races, but the presence of the swim bladder might prove to be a significant feature.

Distribution :

S. commerson is recorded along the entire East African coast from Latitude 1°30'S to 10°30'S. including the Zanzibar Protectorate, and is almost exclusively taken within the 100-fathom line contour (see under *Fisheries*).

Size :

The normal run of specimens are from 50 cm. (2—3 lb.), to 100 cm. (15—20 lb.) with occasional fish up to 140 cm. (40—50 lb.). However, in the area of the North Kenya coast between 1°30'S and 3°30'S, large Kingfish of 160—170 cm. (70—80 lb.) are sometimes taken, but such fish have not been encountered further south. There are no data on juveniles less than 40 cm. except for the five taken from the Zanzibar Fish Market and believed to be from a beach seine haul.

Fishery :

Method :

(1) *Trolling.* Trolling with two or three lines is carried out by most fishing boats throughout the year whilst on passage to and from fishing grounds. At

the period of maximum abundance, there is often concerted trolling by mashuas (30′ square sterned) and ngalawas (outrigger canoes), using 3 or 4 lines specifically for *S. commerson* and the line is "jigged" by hand. On passage, trolling is with a home-made or manufactured lure, with a whole sardine or mackerel, or with a piece of fish stomach or squid. In the season, a fresh sardine 'lure' is used almost exclusively.

(2) *Gill Nets.* These are used at the surface, mid-water, or on the bottom depending on the depth of the fish as established by the fishermen or by custom. The nets are normally anchored, but on occasions may be allowed to drift with the boat. The nets used by the fishermen from the Zanzibar Protectorate and adjacent areas of Tanganyika, are normally 6″ stretched mesh. Previously made of cotton, these are rapidly being replaced by 210/36 ply blue nylon, the length being 50 fathoms by 5 fathoms deep, and a boat commonly uses 3 nets in a fleet. Not used at full moon.

(3) *Handlines.*

(*a*) An ordinary cotton handline baited with sardine or similar fish is allowed to sink and drift with the current to the required depth. "Jigging" may be carried out.

(*b*) An Arabian line method for attracting and catching fish in mid-water is also used. The hook is baited with sardine in the normal manner, but a short distance above the hook is a flat stone attached to the line, on which is placed a paste made of chopped saridine-like fishes. The line is lowered into the water and, when at the correct depth, the line is jerked causing the fine paste to fall from the stone in a "shower" in the area of the hook. This attracts the fish which then takes the baited hook. This method is mainly used during the peak season for this species.

Heavy monofilament nylon is gradually replacing cotton line.

Catch and Value. S. commerson is one of the most prized of food fishes along the East African coast and in all areas fetches very high prices by local standards. Unfortunately, there are few reliable statistics in this part of the world for total fish landings, let alone for species. However in Zanzibar Island, it is estimated that of the approximate annual landing of 9,000 long tons, some 10% or 15% (*i.e.* 900—1350 tons) is composed of *S. commerson.* Prices vary but an average value of 0/75 cents (9d.) per lb. makes the annual catch worth £74,000—£110,000.

An effort is always made by native fishermen to market this species as fresh whole fish, the keeping quality of the flesh being very high indeed. In Zanzibar, and the larger centres such as Malindi (Kenya), the catches are iced or frozen for distribution; but in the distant areas (and some of the highest concentrations are there) the catch is split longitudinally, salted and sun-dried. This dried kingfish is in great demand and considerable quantities of this product are still imported from the Arabian coasts by dhow each year.

Seasonal Abundance :

Shoals of *S. commerson* are present in East African coastal waters throughout the year, but seem to be more abundant at the end of the SE monsoon (September/October)

and during the months of the NE monsoon (November to March). However, in the Zanzibar and Mafia areas, the species is taken primarily in September, October and November. The apparent greater abundance in the NE monsoon may, in fact, be an artefact due to the very much better fishing weather outside the fringing reefs during that monsoon.

Ecological Note :

From the available evidence it would appear that for most of the year *S. commerson* is in relatively small shoals—this seems to be borne out by catches made whilst trolling, but in the peak season dense and localised shoals occur. The species is normally distributed throughout the water mass, often near the fringing reefs, but in the season is often concentrated close to shallow water banks or river estuaries. At the time of the peak catch in the Zanzibar Channel and Mafia, temperature of the surface water mass is minimal or just on the rise, and salinity intermediate and rising, whilst at the height of NE monsoon, water temperature is high and salinity minimal. (See Introduction.)

S. commerson has been seen rarely during underwater work, and on each occasion only single specimens were sighted. Little information is known anywhere about the ecology of the species.

Biological Data :

The first biological data on East African *S. commerson* was fragmentary and was given in Williams (1956). Although no detailed biological work has been carried out on the species, routine observations have been undertaken on all catches made during the routine cruises of EAMFRO research vessels. The data given here are based, therefore, on all observations made since 1951, including those referred to in Williams (1956) and are intended to act as a baseline for any detailed biological investigations on this important food fish which may be required in the future in East Africa.

The majority (98%) of 171 EAMFRO specimens were taken by multiple surface trolling (see Williams 1956), the remainder by gill or set nets, or handlines. Monthly catches of *S. commerson* have been combined for the period December 1951 to December 1960, and are given below :—

Month	*Catch*	
Jan.	10	NE monsoon
Feb.	13	
Mar.	24	
Apr.	13	" Long rains "
May	6	
June	11	SE monsoon
July	13	
Aug.	15	
Sep.	5	
Oct.	12	" Short rains "
Nov.	29	
Dec.	24	NE monsoon

Higher numbers appear to be caught trolling during the months of the NE monsoon, atleast from commercial style vessels (See Seasonal Abundance).

It is regretted that in this section on Biological Data, the " length of the fish " is *not* the fork length referred to in the taxonomic section but the standard length (from snout to tip of central caudal rays). FL. = SL. + 4–5%.

The following data are based on 168 measured and sexed specimens of *S. commerson.*

Length & Weight Distributions, Means & Variances. The normality of the distributions has been tested by carrying out a chi² test on a normal distribution fitted to the grouped data ; the results are as in Table VIII.

TABLE VIII

Normality of Distributions

Sex	Significance of Departure from fitted normal deviations			
	Natural		Logarithmic	
	Length	Weight	Length	Weight
Male ...	NS	7%	NS	NS
Female ...	8%	0.1%	NS	5%
Combined ...	Not fitted		NS	1%

From this it appears that the natural data are not normally distributed whereas the logarithmic data are so distributed. These conclusions need the qualifications that evidence for the non-normality of the natural data is not very strong (non-existent in male lengths) and that the logarithmic weight of females appears to depart from normal (5% probability).

Means and variances tests on the logarithmic data show the results give in Table IX.

TABLE IX

Means and Variances Tests on Logarithmic Data

Difference between sexes	Significance level	
	Length	Weight
Mean (t) ...	NS	NS
Variances (F) ...	1%	5%

Thus there would appear to be no significant differences between the average length and weight of the male and of the female, but on the other hand a distribution free test on the lengths indicates that the difference between sex means is significant at about the 7½% level. There still seems, therefore, to be some doubt as to whether there is a real difference between sexes, but on the whole it appears there is probably not.

On the other hand, there is a very significant difference between variances of the lengths of the different sexes and a strong indication there is a similar difference between weights.

Length Frequency. Figure 4 shows the distribution of length frequencies in 5 cm. groups for the total catch of *S. commerson* over the 9 year period. Because of the small numbers of fish taken in any one month of the years in question, it has been necessary to

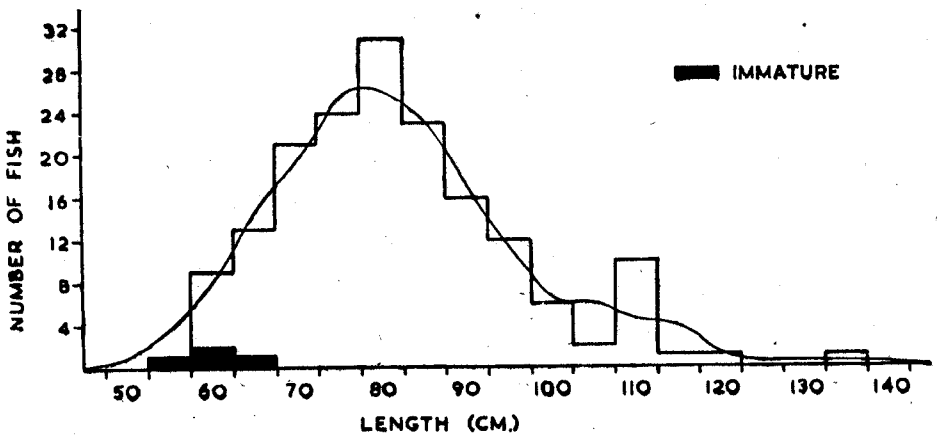


Fig. 4.—Distribution of length frequencies (5 cm. groups) for the total catch of *S. commerson*, 1—12—51 to 31—12—60. (Smoothed curve from a three figure moving average).

combine all the data. Thus determination of growth by mode progression and variations in the population from year to year is impossible. However, Figure 4 does show that the population sampled by commercial style trolling is almost entirely mature. The shape of the smoothed histogram (3 figures moving average) possibly suggests that the East African (adult) stock of *S. commerson* remains a naturally occurring one in which there is normal recruitment and natural mortality. The modal length of the population from Fig. 4 is 80—84 cm. and it is interesting to note that it is similar in the separate sexes, bearing in mind what has been said in the preceding paragraph on means and variances.

Weight Frequency. This has not been considered because of the considerable variations in weight at a given length over 80 cm. (10 lb).

Length/Weight Relationships. Length/Weight relationship has been calculated for the species in the normal manner:—

$W = a L^b$ ($\log W = \log a + b \log L$.) where W=weight in pounds and L=length in cm.

Regression curve is fitted by the method of least squares using a logarithmic transformation.

The calculated regression lines for males, females and combined data are as follows:—

Males	...	$\log W = 3{\cdot}125 (\log L) - 4{\cdot}959$ (SE of slope 0·136).
Females	...	$\log W = 2{\cdot}978 (\log L) - 4{\cdot}686$ (SE of slope 0·077).
Combined	...	$\log W = 3{\cdot}0454 (\log L) - 4{\cdot}8286$ (SE of slope 0·0625).

There is no significant difference between regression lines for males and females and thus there is no evidence of a significant difference in weight of the two sexes at a given length. In Fig. 5 length is plotted against weight for the observed data and the growth curve is drawn from the results of the regression equation for the combined data (95% confidence

limits are also shown). The same equation can be used for the estimation of weight at a given length as follows:—

$$W = 1{\cdot}484 \times 10^{-5} L^{3.0454}$$

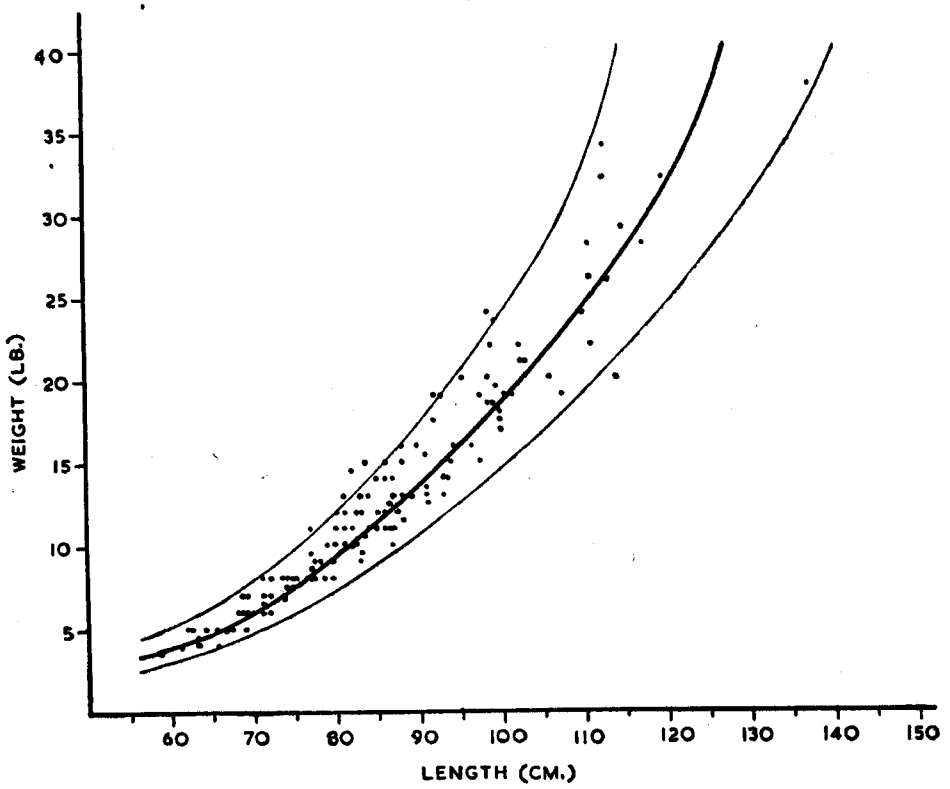


Fig 5.—Length/Weight relationship in *S. commerson.* Regression curve fitted by the equation: log weight = 3.0454 (log length)—4.8286 ; the outer lines indicate the expected range of variation (95% confidence limits).

Some estimated weights at given lengths (within the limits of the observed data) together with the 95% confidence limits are given below in Table X.

TABLE X

Estimated weight of *S. commerson* at a given length

Length in cm.	Estimated weight in lb.	95% confidence limits of estimated weight
56.2	3.17	2.42 — 4.15
63.1	4.5	3.46 — 5.84
70.8	6.39	4.95 — 8.24
79.4	9.06	7.08 — 11.62
89.1	12.88	10.05 — 16.51
100.0	18.29	14.16 — 23.62
112.2	25.97	19.96 — 33.80
125.9	36.88	28.15 — 48.29

Approximate confidence limits are ±25% of W.

It is interesting to note that the regression coefficient 'b' is 3·0454, very close to the theoretical cube relationship ($W=L^3$). Such a value for 'b' is more usually found in stout bodied fishes such as tuna. No values are available to the author for 'a' and 'b' for *S. commerson* in other parts of the world.

Age, Sex and Maturity. Accurate age determination using scales is not possible due to the reduced type of scale found in *S. commerson*, and examinations of otoliths or other bony structures for growth rings have not been carried out. As noted previously, the small number of fish taken per month prevented use of length frequency "ageing" methods.

Figure 4 suggests that maturity is reached between 55 — 70 cm. (4 — 6 lb.) and this is confirmed by observation of gonads in Zanzibar Market specimens (55 — 64 cm.). Only five juvenile specimens (14·5 — 15·5 cm.) have been seen by the author, and no postlarval specimens collected.

Of the 169 specimens of *S. commerson* sexed, the number of males was 58 and females 111; a sex ratio of 1:1·91 males to females. A chi^2 test shows that this is a significant departure from the expected 1:1 sex ratio, assuming a random sampling of the population. Sampling was considered to be random because of the method of fishing employed (multiple trolling), and the fact that no signs of shoaling by sexes have been observed in this species. In Table XI the catches by sexes are given for three-monthly periods of the year together with the probability of so few males (considering the sampling random and the sex ratio 1:1). A chi^2 test on the quarterly data shows no significant inconsistency between the proportions for the different quarters.

TABLE XI

Sex Ratios in *S. commerson* by three-monthly periods

	Dec.–Feb.	Mar.–May	Jun.–Aug.	Sep.–Nov.
Males ...	11	12	14	21
Females ...	30	30	25	26
Probability of so few males ...	0.14%	0.25%	4%	23%

Thus the general indication given that the overall sex r tio for a year is significantly different from the expected 1:1 is borne out by analysis of quarterly data except in September-November. The reason for the sex ratio being much closer to 1:1 in this period is obscure and does not appear to be connected with the breeding season (see below).

Table XII records the monthly gonad maturity states for *S. commerson* for the combined years.

TABLE XII

Monthly gonad maturity states in *S. commerson*

Stage		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Males	I	...	...	...	...	...	...	...	...	...	...	...	...
	II	...	3	3	1	1	3	2	...	...	2	3	2
	III	...	...	7	...	...	1	1	2	1	4	11	4
	IV	...	...	...	1	...	...	...	5	...	...	...	2
	V	...	...	...	...	...	...	...	...	...	...	...	...
Females	I	...	...	1	...	1	...	...	1	...	...	...	...
	II	4	5	3	6	1	3	1	...	...	2	2	...
	III	3	...	3	...	1	...	4	2	1	2	4	6
	IV	1	2	...	...	1	...	3	3	...	1	5	2
	V	1	1	3	...	...	...	1	2	3	...	1	2
	VI	1	...	1	...	...	...	...	...	...	...	2	1
	VII	...	1	3	5	1	4	1	...	...	1	2	...

Spawning would appear to take place over a long period from October to July however, the presence of ripe males in August and ripe females in August and September suggests that this species of fish may in fact breed at any time throughout the year, but with peaks at certain periods. This phenomenon is well known in tropical fishes and appears to be the case with certain demersal fishes in East Africa (Talbot 1960 and Morgans—personal communication). No ova size measurements or weights of gonads were made.

Food. Stomachs of fish caught on routine cruises by EAMFRO vessels were normally only examined qualitatively. No fewer than 112 of out of 171 stomachs examined were empty (65·5%) and this high figure is almost certainly due to the fact that regurgitation often takes place in the water when fish are caught by trolling. Table XIII shows the food items, number of stomachs in which they occurred and the percentage frequency of occurrence in stomachs with food.

TABLE XIII

Frequency occurrence of food items in stomachs of *S. commerson*

Food Items	No. of stomach in which occurred	Percentage frequency of occurrence
Fishes ...	52	88.1
Crustacea-Penaeidae ...	8	13.5
Weed	1	1.7

Fishes have a high frequency of occurrence and must rank as the most important item of food for *S. commerson.* (It is not believed that this high figure is an exaggeration as stomachs were examined very soon after capture and before further digestion of soft items couldt ake place).

Fish remains were, however, usually in a poor state of preservation (perhaps this is due to the regurgitation of more recent items of diet), but enough remained to identify fishes from the following Families:—

Caesiodidae, Carangidae, Chromidae, Clupeidae, Exocoetidae, Labridae and Mullidae.

These fishes, with the exception of Exocoetidae, are found normally in waters close to coral reefs or shallow water banks and this agrees with the distribution of *S. commerson* given earlier in this paper.

Parasites. No external parasites were observed; internal parasites were rare, unidentified nematodes being recorded from the stomachs of *S. commerson* on only three occasions.

Scomberomorus lineolatus (C. V.) 1831.

Kingfish. Kanadi (Kiswahili); Bowrega (Bajune, N. Kenya).

A detailed paper has been published recently (Williams 1960) on *S. lineolatus* in East Africa and the status of the species in the Indian Ocean. It is not intended, therefore, to repeat the taxonomic descriptions and notes in this present paper.

Distribution :

S. lineolatus is recorded along the entire East African coastline from Lat. 1°30'S to about 10°S, including the Zanzibar Protectorate. The species is taken entirely within the 100 fathom line and usually in very much shallower water of less than 25 fm. The main areas of concentration are in the waters of the Zanzibar Channel between Tanga in the north and Dar-es-Salaam in the south and in the Malindi and Formosa Bay areas of Kenya (See Fig.1). The species also appears in fair numbers in North Mafia Bay; elsewhere it is apparently not so abundant and is rarely taken in Pemba Island or on the east coast of Zanzibar Island.

Size :

The normal size of specimens is 60–90 cm. FL. (5–10 lb.) with occasional specimens up to 90 cm. (12–13 lb.). Juveniles have not been seen in the area.

Fishery :

Methods.

(1) *Trolling*. At certain times during the season *S. lineolatus* is seen in very large numbers actively feeding at the surface during daylight, and is usually indicated by the presence of diving birds such as terns. The areas where this occurs seem to vary little from year to year and the local fishermen wait for the bird indicators before going out trolling. Outrigger canoes (ngalawas) are used mainly for this trolling; but when the fish are most abundant all types of fishing boats, canoes and dinghies are operated. One to three lines are used, the hooks carrying a fresh sardine bait, which is often "jigged". With sailing boats it is not always possible for the shoals, which move extremely fast, to be tracked efficiently; the increasing use of outboard motors does make this easier and does not seem to scare off the fish.

Artificial lures are also used, especially white bone jigs, but they do not appear to be as effective as fresh, whole fish bait.

(2) *Nets.*

(*a*) *Gill nets*, are essentially similar to those used for *S. commerson* (see page 143) and under the same conditions. Fish are removed every 3–4 hours. They are not used at the full moon.

(*b*) The " Mensab " net is an old established method of Arabian origin used on the west coast of Zanzibar Island, often on a communal basis. Figure 6 shows the layout of the " Mensab " which is a trap net laid along the expected " paths " of movement of *S. lineolatus* which are known by experience.

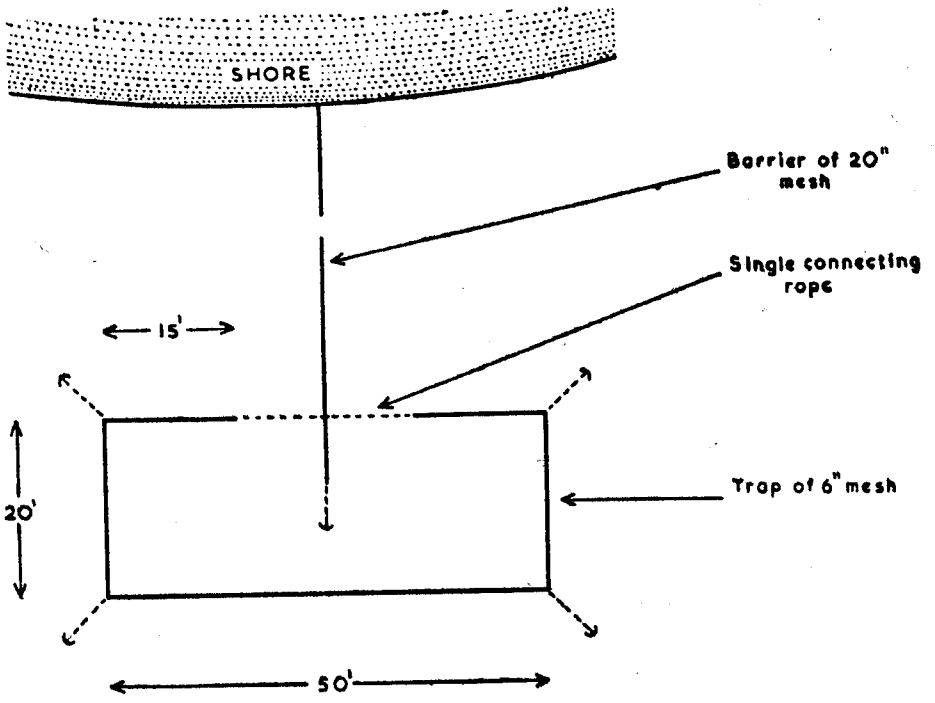


Fig. 6.—" Mensab " net used for *S. lineolatus*.

The net is normally made of 210/36 cotton twine. The " barrier " from the shore to the trap proper is of varying lengths and consists of 20" mesh for most of the distance, but becomes smaller towards the seaward end. The walls of 'trap' are of 6" stretched mesh and are 30 ft. (5 fm.) deep. The net is laid out so that the 'trap' is in 30–60 ft. (5–10 fm.) of water. The fish are deflected from their tracks by the "barrier" and are eventually gilled in the 'trap'. As with the gill nets, the fish are removed from the "Mensab" every 3 or 4 hours by overfishing. The "Mensab" is removed from the sea during the period of the full moon. The number of such nets is declining annually and being replaced by the use of nylon gill nets; some 20–30 "Mensab" nets are in use at the present time.

(3) *Handlines* . The methods described under 3 (*a*) and (*b*) for *S. commerson* are also used for *S. lineolatus.*

In the Malindi area of Kenya catches of *S. lineolatus* are mainly made by trolling and handlines, whilst in the Zanzibar Channel area all methods are used but the gill net predominates.

Catch and Value . In those areas of the coast where concentrations of *S. lineolatus* occur, the fishery is very heavy. In Zanzibar Island it is considered that one-third (33%) of the approximate total annual landings of 9,000 tons is this species. In adjacent areas of the Zanzibar Channel it is equally important; in the Malindi area of Kenya the catch is high but no data are available.

The value to the fishermen of Zanzibar is on an average not more than 0/50 cents (6d.) per pound (whole fish) making the annual catch worth about £84,000.

The reasons for the lower value of the larger *S. lineolatus* fishery, compared with that of *S. commerson* are (*i*) the very poor keeping quality of the flesh, and (*ii*) the fact that the fishery for the species is over a small season with consequent " glutting " of the market. In island areas such as Zanzibar, distribution in time of glut is not too difficult, although prices do drop, but in mainland areas such as Malindi seasonal gluts are a problem. This is especially so in a species such as *S. lineolatus* which does not keep well on ice or produce a good sun-dried salt product ; and hence the price paid to the fishermen, falls off rapidly to a point when it is uneconomic to continue fishing.

The reason for the removal of fish from nets every 3 or 4 hours is the rapid deterioration in the quality of the flesh after death.

Seasonal Abundance. S. lineolatus has a very marked seasonal abundance in the East African area. Although odd specimens are taken throughout the year, very large concentrations are found in the Zanzibar Channel area from March-April to August-September ; the Malindi season closely approximates to this. There seems to be some evidence that the occurrence with time of *S. lineolatus* along the coast does move in a northward direction, but this is not confirmed.

During the season the species is a staple food fish (See Catch and Value).

Ecological Note :

The species shoals in very large numbers (several thousand) and movements seem to follow the same pattern each year. The shoals are normally in shallow water over sand or mud, often close to river estuaries. The season begins in the Zanzibar area in the period of the long rains and is at a peak during the SE monsoon, when the surface water temperature is low and the salinity intermediate and rising. It is interesting to note that Munro (1943) comments that most *Scomberomorus* spp. prefer waters of low density and medium salinity and this apparently accounts for their coastal distribution. The possible northward time lapse in the outbreak of the Kanadi season could perhaps be linked with the changes in the physical and chemical properties of the EACC., which take place from south to north during the change over of the monsoons.

It seems likely that the apparent migration or concentration into the shallow inshore areas is a feeding one, as large shoals of Clupeids and Engraulids are known to be present in the Zanzibar Channel at that time of year. And indeed, the fish always appear to be

gorged with these species. The reason for this abundance of clupeids and engraulids is obscure, especially in view of the known minimal fertility of the EACC between June and September.

What happens to *S. lineolatus* in the off season is not known ; it could be that migrations take place into other areas or deeper water, or that the shoals disperse.

Biological Data :

No organised biological investigations have been carried out on this important food fish and few specimens have been taken during routine cruises by EAMFRO research vessels.

Average size of the specimens taken by the fishery (60–80 cm.) is remarkably constant each year, and is almost certainly a single age group.

From observations of large numbers of fish passing through the Zanzibar Fish Market, the gonads of females are in a ripening condition becoming nearly ripe and ripe towards the end of the season ; males are ripe, not running. Of the small numbers taken by research vessels spent females appeared from September to November.

The stomachs of many specimens caught angling during the season were examined and usually showed full stomachs. *Anchoviella* sp. predominating, and with clupeids such as *Amblygaster* sp., *Sardinella fimbriata* and *S. perforata in* smaller numbers.

It seems that the concentration of *S. lineolatus* into dense shoals which occurs during the season April to October appears to be a feeding migration of possibly a single age group, and that this takes place immediately prior to spawning. The spawning areas and the distribution of the fish during the rest of the year and of other age groups are not known.

Acanthocybium solandri (C. V.) 1831.

Wahoo. Nguru ngaziga (Kiswahili.)

No detailed taxonomic (morphometric, meristic etc.) work has been undertaken on wahoo taken in East African waters and hence comparisons with specimens from other parts of its circumtropical distribution have not been possible.

Distribution :

A. solandri is found throughout the East African area between Latitude 1°30′S and 10°30′S including the Zanzibar Protectorate. Catches have been made over all depths of water but were commonest inside the 100 fathom line.

Size :

The normal run of specimens was from 90—160 cm. (10—65 lb.) but larger specimens upto 80—90 lb. do occur in East African waters. There are no data on juvenile specimens.

Fishery :

There is no fishery specifically for the wahoo and it is taken as incidental catches during general surface trolling for pelagic fishes (see under *S. commerson*).

Although only small numbers are caught the species is valuable because of the high quality of the flesh and the large average size. The average price paid to fishermen in Zanzibar Island is about 0/75 ct. (9d.) per pound whole fish.

Seasonal Abundance. From the little data available, wahoo appear to be more abundant during the period of the SE. Monsoon.

Ecological Note :

Wahoo do not form large shoals, and from the records of multiple trolling operations, it would appear that they are usually present in small groups, 2—6 fish, often caught or striking at the lines simultaneously. This is similar to the findings of Iverson and Yoshida (1957) in the Central Pacific. Catches were usually made close to the fringing reefs especially where the bottom fell away rapidly to great depths. Over open water specimens were commonly caught singly. Underwater observations on the wahoo have been rare, only solitary specimens having been sighted, invariably travelling at very high speed. Only one specimen has been taken by longline to date and it seemed that the fish was taken near the surface during hauling operations.

Biological data :

Biological data on this circumtropical species of fish is slight ; Iverson and Yoshida (1957) having published notes on specimens in the Line Islands of the Central Pacific.

The following notes on East African specimens are based on 53 fish taken by surface trolling and 1 by longline during the period December 1951 to December 1960.

Length and Weight Distributions, Means and Variances. There are insufficient data to be able to test the normality of the distributions, but tests for means and variances on the logarithmic data give the results in Table XIV.

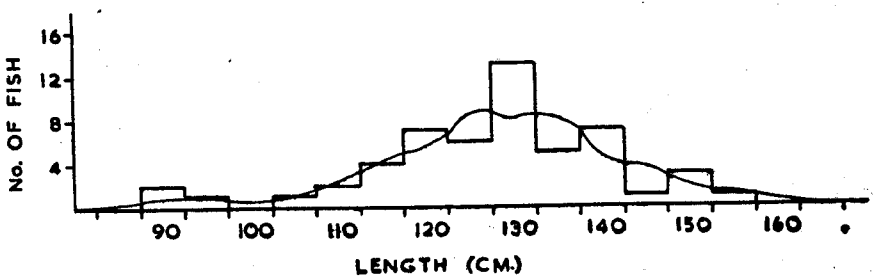
TABLE XIV

Means and Variances of Logarithmic Data

Differences between Sexes		Significance level	
		Length	Weight
Means (t)	...	NS	NS
Variances (F)	...	5%	0.7%

Thus, as in *S. commerson*, the average length and weight of each sex are not significantly different. However, there is a difference between the variances of sexes for length and weight although not as significant as in *S. commerson*.

Length Frequency. The size frequency distributions for 5 cm. length groups of *A. solandri* with sexes combined, are given in Fig. 7. Total numbers involved are so small



Fig, 7.—Distribution of length frequencies (5 cm. groups) for the total catch of A. *solandri*, 1—12—51 to 31—12—60. (Smoothed curve from a three figure moving average).

that little information can be gained from the histogram ; the smoothed curve shows a wide mode at 125—139 cm. It is interesting to note in Iverson and Yoshida (1957) that the size range of troll caught wahoo in the Central Pacific was 98—174 cm., compared with 92—159 cm. in East African waters. Also that those authors found differences in length distribution with sex, the prominent modes being—male 134 cm. and female 128 cm. ; this gives a combined mode of 128—134 cm., compared with 125—139 cm. for East African fish. Iverson and Yoshida pointed out that their results (differential growth rate between sexes and different sex ratios) suggested a non-random distribution of the species and that this made it impossible to study growth by mode progression methods.

The average length of East African specimens is 128·5 cm. and average weight 36½ lb. There is a considerable variation in weight at a given length over 100 cm.

In the Central Pacific small specimens of wahoo (less than 90 cm.) were taken only by longline from open ocean areas.

Length/Weight Relationship. Length/Weight relationships have been detected between the sexes. Use has been made, therefore, of the combined data and the regression equation is as follows :—

Log W=3·232 (log L)—5·270 (SE. of slope 0·147) where W=weight in lb. and L=length in cm.

This compares with the only other data, that of Iverson and Yoshida for the Central Pacific, where the regression equation was :—

log W=3·50583 (log L) =9·4199.

The smaller value of "b" at 3·232 in East African fish compared with 3·50583 for the Central Pacific, is possibly due to the large number of fish examined in the latter area, especially in the upper parts of the size range. In a long slender fish such as the wahoo a high exponent compared with the theoretical cube may be expected.

Fig. 8 shows length plotted against weight for the observed data and the growth curve is fitted from the regression equation for the combined data (95% confidence limits are also shown). Similarly an estimation of weight at a given length can be obtained by using the formula :—

$$\widehat{W}=5{\cdot}370\times10^{-6}.L_i^{3\,2\,3\,2}$$

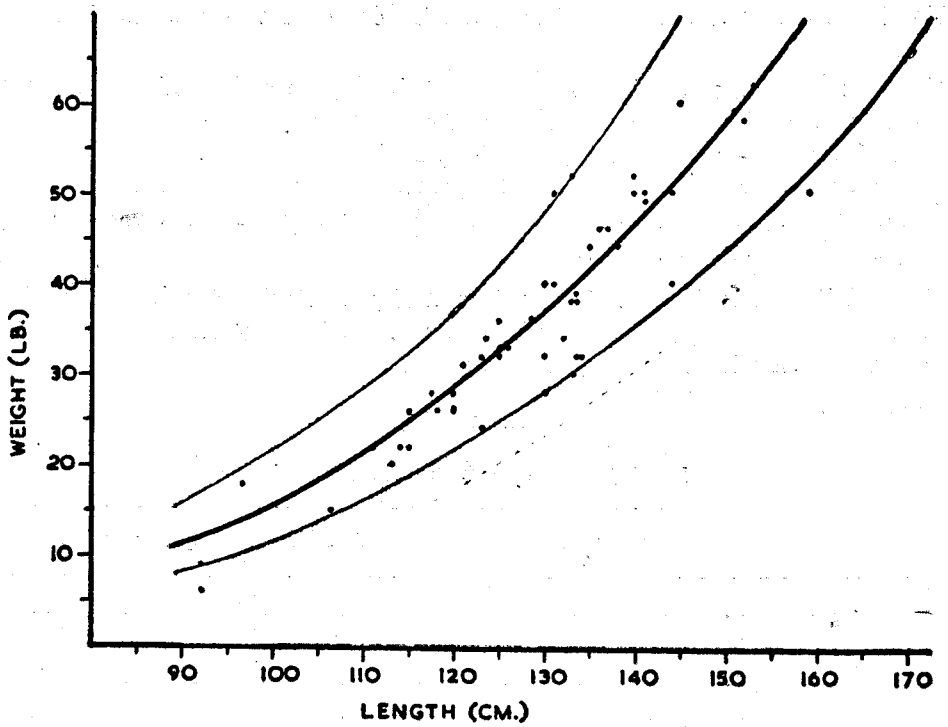


Fig. 8.—Length/Weight relationship in A. *solandri*, Regression curve fitted by the equation: log weight=3.232 (log length—5.270 ; the outer lines indicate the expected range of variation (95% confidence limits).

Some estimated weights at given lengths, together with the 95% confidence limits are given in Table XV.

TABLE XV

Estimated weights at given lengths in *A. solandri*

Length in cm.	Estimated weight in lb.	95% confidence limits on estimated weight in lb.
89.1	10.8	7.6 — 15.3
100.0	15.6	11.3 — 21.6
112.2	22.7	17.1 — 30.1
125.9	32.9	25.8 — 42.0
141.1	47.7	36.2 — 62.9
158.5	69.2	50.5 — 95.00

The approximate confidence limits are $\pm$ 25% of $\widehat{W}$ which is similar *to S. commerson.*

Age, Sex and Maturity. As in *S. commerson* accurate age determination by use of scales is not possible and examination of otoliths or other bony structures such as vertebrae has not been carried out.

No immature specimens have been caught or even observed in East African waters.

Fifty-two specimens of wahoo have been sexed, 31 were males and 21 females; a sex ratio 1: 0·67 males to females. Assuming that the sampling is random, the departure from the expected 1:1 sex ratio is not significant, the probability of so many males being about 7½%. However, in view of Iverson and Yoshida's findings in the Central Pacific, it is possible that sampling in East African waters is also not random and sex ratios might vary from one part of the coast to another.

Table XVI records the monthly gonad maturity states for *A. solandri* for the years under review, but it is not possible to deduce a great deal from the scattered data. No ova size measurements or gonad weights were taken.

TABLE XVI

Monthly gonad maturity stages in *A. solandri*

Stage		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Males	I	...	...	...	...	...	...	...	...	...	...	...	...
	II	...	...	...	...	1	1	3	...	6	4	6	1
	III	...	...	3	1	1	...	...	...	1	...	1	2
	IV	...	...	...	...	...	...	...	...	...	...	...	...
	V	...	...	...	...	...	...	...	...	...	...	...	...
Females	I	...	...	...	...	...	...	...	...	...	...	...	...
	II	...	...	...	2	...	...	2	...	1	1	1	2
	III	...	...	...	1	...	...	1	...	...	...	2	1
	IV	...	...	...	...	...	...	...	...	...	...	1	1
	V	...	...	...	...	...	...	...	...	...	...	...	...
	VI	...	...	...	...	...	...	...	...	...	...	...	...
	VII	...	...	1	...	1	...	1	...	...	1	...	...

Food. Stomachs of 52 specimens were examined qualitatively and 14 (27%) were found to be empty. Table XVII shows the food items, number of stomachs in which they occurred and percentage frequency of occurrence in stomachs with food.

TABLE XVII

Frequency occurrence of food items in stomachs of *A. solandri*

Food Item	No. of stomachs in which occurred	Percentage frequency of occurrence
Fishes ...	36	94.6
Squid ...	10	26.3
Crustacea ...	1	2.6

Fishes have a high frequency of occurrence and must rank as the most important item in the diet of wahoo; squid are of lesser importance. This is similar to other workers' results in the Pacific Ocean and probably persists throughout the year.

Fish remains were mainly of large pelagic species such as *Euthynnus* sp. other Thunnidae, *Elagatis bipinnulatus*, *Caranx* spp. with a number of smaller species of the families Engraulidae, Clupeidae, Exocoetidae and Diodontidae.

Parasites. The only parasite on which a careful check was kept was the giant trematode, *Hirudinella ventricosa* (Pallas) from the stomach. This trematode was present in 28 out of 53 specimens examined (53%); the number per stomach are as follows:—

No. of *H. ventricosa* present in stomach	Frequency of occurrence in hosts
0	25
1	13
2	11
3	3
4	1

Iversen and Yoshida (1957) found a 98·2% infection by *H. ventricosa* in Central Pacific wahoo; the number per stomach varying from 0 to 17, but with the average number 2 per stomach, except in the largest fish over 160 cm. length when 4 were commonly found. Little is known regarding the effect of the parasite on the host, but it is presumed that an equilibrium must be set up.

Summary

The very low catch of Scombroid fishes, taken by surface trolling from research vessels of the East African Marine Fisheries Research Organization, Zanzibar, during the original pelagic fish survey of East Africa, is not a true indication of the existing stocks of Scombroid fishes in the area.

The environmental conditions in East African waters are outlined with especial reference to basic oceanographic data.

Definitions are given of gonad maturity stages as used for tuna and seerfish.

The mackerels are not discussed due to the non-existence of native fisheries and a general lack of data. Thus the Scombroids are discussed under three sections—(i) the Tunas, (ii) the Billfishes and (iii) the Seerfishes. "Keys" are given to aid in the identification of the East African fishes of these three groups which are classified as follows:—

TUNAS. Yellowfin (*Thunnus albacares*); albacore (*T. alalunga*); frigate mackerel (*Auxis thazard*); Rüppell's bonito (*Gymnosarda unicolor*); bonito (*Euthynnus affinis*); skipjack (*Katsuwonus pelamis*).

BILLFISHES. Swordfish (*Xiphias gladius*); sailfish (*Istiophorus gladius*); black marlin (*Makaira indica*); striped marlin (*Tetrapterus audax*).

SEERFISHES. Kingfish (*Scomberomorus commerson* and *S. lineolatus*); wahoo (*Acanthocybium solandri*).

Available information on these fishes, which ranges from the fragmentary to the detailed, is given under the following headings:—Taxonomy ; Distribution; Size ; Fishery (method, catch and value); Seasonal Abundance; Ecological Note; Biological Data (includes size frequency distributions, length/weight relationships, age, sex and maturity, food and parasites).

The Scombroid fishes already play an important part in the economy of East Africa. Nevertheless, the potential value of the unexploited stocks of Scombroids, especially the surface shoals of tuna, is again emphasized.

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TALBOT, F. H. AND M. J. PENRITH. Provisional report of the Genus *Thunnus* off the East Coast of Africa.

———— AND M. J. PENRITH. *Thunnus* (*Neothunnus*) *albacares* Bonnaterre, the yellowfin tunny, and *Thunnus* (*Parathunnus*) *obesus* (Lowe), the bigeye tunny, on the South and East Coasts of Africa.

WILLIAMS, F. A synopsis of existing knowledge on the fishes of the Genus *Auxis* Cuvier, 1829 in the Indian Ocean.

N.B.—The above manuscripts were presented as papers Tunny (60)—10, 11 and 3 respectively to the CCTA/CSA African Tuna Symposium, Dakar, December, 1960.

COLLETTE, B. A preliminary review of the tunas of the Genus *Thunnus*.

ROYCE, W. F. A morphometric study of yellowfin tuna *Thunnus albacares* (Bonnaterre).

N.B.—The above manuscripts were presented as papers VI–1 and III–6 respectively to the informal Pacific Tuna Biology Conference, Honolulu, August, 1961.

APPENDIX I

EAMFRO Definition of Gonad Maturity Stages

(as used in Parts I and III of this report)

Males	I	*Immature.*—Testes very small, thread like, no sperm extruded on cutting and squeezing.
	II	*Mature Unripe.*—Testes small, sperm extruded on cutting and squeezing.
	III	*Mature Ripe.*—Testes enlarged and full of sperm.
	IV	*Mature Ripe Running.*—As above, but sperm extruded with or without pressure to flanks.
	V	*Mature Spent.*—Testes crinkled and shrunken, little sperm, much blood.
Females	I	*Immature.*—Ovaries very small, thread like, eggs microscopic.
	II	*Mature Unripe or Virgin Maturing.*—Ovaries small to moderate, eggs microscopic, usually translucent.
	III	*Mature Ripening.*—Ovaries moderate, eggs visible to naked eye, opaque.
	IV	*Mature Nearly Ripe.*—Ovaries enlarged, eggs clearly visible, opaque.
	V	*Mature Ripe.*—Ovaries enlarged and distended, tunica breaks easily, some eggs transparent.
	VI	*Mature Ripe Running.*—As above, most eggs transparent and extruded on slight pressure to flanks.
	VII	*Mature Spent.*—Ovaries flaccid, shrunken, some residual eggs, much blood.

APPENDIX II

FORM FOR DATA ON MARLIN, SAILFISH & SWORDFISH

Please complete this form and return to

F. WILLIAMS

East African Marine Fisheries Research Organization

P. O. Box 668 ZANZIBAR

Type of fish .....

Time and date of capture .....

Method used .....

Where caught .....

Total length .....

Length from tip of spear to centre of tail fork .....
.....

Weight in lb. .....

Sex .....

Tip of spear to posterior end of head .....

Greatest depth of body in straight line (usually at shoulder) .....

Maximum height of first dorsal fin (fin erect) .....

Width of spear at tip of lower jaw .....

(Marlin only)—
Is Pectoral fin rigid or can it be depressed? .....

Colour Notes .....

Name and address of Angler and/or Club .....
.....
.....

THE PAPER WAS READ BY DR. E. G. SILAS

DISCUSSION

DR. W. M. CHAPMAN : I think the two figures showing the environmental conditions in East African waters are most illustrative of the problems we have in respect of the Indian Ocean — the enormous effect of the monsoon system here on the upwelling and vertical circulation rather sharply changes the distribution of the tunas atleast in their commercial sense. Here in East coast of Africa the shift in available tuna population is very short with the change in the monsoon. I think Mr. Williams mentioned the shift in the type of population you have at the juncture of the East African coastal current and Somali current about the equator and the monsoon shifts to give a completely different assortment of species and the fisheries there. I will hope that out of this great Indian Ocean Expedition that is being sponsored for the next three or four years a good deal of information will come out about the ocean current circulation in the Indian Ocean, to lead us to more understanding, how the tunas are distributed.

DR. E. G. SILAS : The information of *Acanthocybium* given by Mr. Williams is most interesting as very little is known about this species from the Indian Ocean while some aspects of its biology has been studied recently by Iversen and Yoshida 1957, (*Pacific Sci.* 11 : 370-379) from Central Pacific. Perhaps Dr. Chapman may have something more to add as he had met Mr. Williams recently and had discussions with him regarding this paper.

DR. W. M. CHAPMAN : Well, I really couldn't add anything more except to commend this paper to you for reading as an excellent review of the situation of the East African coast. Mr. Williams has done an excellent piece of work in correlating not only the systematics but also the oceanography with the occurrence of the different kinds of fish.

SCOMBROID FISHES OF SOUTH AFRICA

(*With Plates* 1–10)

BY

J. L. B. SMITH

Rhodes University, Grahamstown, South Africa

(1) BILLFISHES

These giants of the sea long accepted as the premier big game angling fishes, have in recent years been the focus of attention by scientists all over the world. While the major divisions are clear cut, and most workers generally recognise two families, at both generic and specific level there have been many puzzling problems for the taxonomist and in some cases there still are.

KEY TO FAMILIES

A. No pelvics. One keel on caudal. Bill flattened, blade-like. No scales in adult.....Xiphiidae

B. Pelvics present. Two keels each side of caudal. Bill rod-like. Adults scaly.....Istiophoridae

FAMILY XIPHIIDAE

Body elongate, compressed, adult with a long bony tapering sword-like depressed rostrum. Teeth obsolete in adult. Adult with 2 dorsal fins, the first elevated in front, no distinct spines. Second dorsal and anal small. No anal spines. No pelvics. Pectorals falcate, inserted low down on side. Caudal large, lunate. One keel each side of slender peduncle. No scales in adult. Gill membranes free. Gills 4, each united as a plate-like structure, no gillrakers. Airbladder present. Numerous pyloric caeca. Only the type genus, *Xiphias* Linn, 1758, with the characters of the family. A single wide-ranging species found in all but the coldest seas, attaining a considerable size, an unmistakable fish. Great changes occur with, growth, described below.

Xiphias gladius Linn, 1758 (*Plates* 1 *and* 3)

Xiphias gladius Linn, 1758, 248. Numerous references including descriptions with illustrations covering most warm seas. Reference to South African and neighbouring seas are: Cuvier and Valenciennes 1831, 255, Pls 225, 226, 231. (Worldwide, including S. Africa). Bleeker 1860, 53 (S. Africa). Castelnau 1861, 42 (Cape Seas). Gilchrist 1902, 123 (S. Africa). Thompson 1918, 119 (Cape). Barnard 1927, 805, fig. 27 (Juv): (Cape seas; on skull). du Pont and Hornell 1927, 234 (Mauritius). Fowler 1936, 648, fig. 292 (W. Africa). Smith 1949, 314, Pl. 67, fig. 873 (S. Africa). Copley 1952, 169 (Kenya). Baissac 1954, 3; and 1956, 357 (Mauritius). Smith 1956, 25 (S.A. and Mozambique). Williams 1956 (Juv. Kenya). Adults show the following: D 30–40+3–5. Head length to tip of lower jaw about equals depth of body, about 4¼ in length from tip of lower jaw to end of mid caudal rays. Rostrum flattened, with sharp edges, its length before eye about 1¼ in trunk, about 35-38% of length to end of mid caudal rays, tapering to slender apex, its width at base about one ninth of its length before eye,

Pectoral about as long as falcate front dorsal lobe, about 1—1¼ in body depth. Eye about 3 in postorbital part of head. Interorbital about 2 in head. Mouth cleft extends well behind eye. No teeth in adult. No gillrakers. Caudal deeply lunate, lobes equal. Second dorsal little behind 2nd anal, both small. Generally dark purple or bluish above, silvery below. Fins with bluish shade. Sword dark above. Grows to at least 16 ft. overall length, some records state 20 ft. Appears to roam widely, mostly solitary, recorded from almost all warm seas of the world. The flesh of the Swordfish is greatly esteemed. There are considerable changes from the early stages which have often been described. The eggs are pelagic and hatch quickly. The newly hatched 5 mm long fish is a curious object but its upper jaw is more or less normal and not prolonged. As described in detail by Yabe 1951, 261, about 25 mm length (*Pl* 1) the young fish has a long slender body, with 4 lateral rows of bony scutes each side. There are spines above the eye and on the side of the lower jaw. Preopercle with two spines, a tricuspid spine on post temporal. Both jaws are greatly elongated, the upper almost trunk length, the lower somewhat shorter. A single row of sharp teeth in each jaw. Dorsal and anal single, long, of more or less uniform length. Pectoral rather short. Baudal pointed, hastate.

At about 100 mm the dorsal and anal are much the same, the lower jaw has shortened somewhat, the caudal is emarginate, the 4 series of scutes bear marked spines. The teeth in the jaws are almost obsolete. The pectoral is more elongate. At about 500 mm (*Plate I*) the fish has almost assumed the proportions and shape of the adult. The lower jaw is much shorter than the rostrum. The dorsal is elevated in front, the middle portion is very low and the hind part has become a small separate fin. The anal has changed similarly. The pectoral is falcate, about as long as the front lobe of the dorsal. The caudal is deeply lunate. The upper jaw is relatively longer. Scales and teeth have become obsolete. A keel has developed on the peduncle.

The Swordfish is not common in South African seas. Odd specimens have washed ashore, and remains of skeletons have been found at various parts of the coast from the Cape eastwards. (One 10′10″ specimen washed ashore in Algoa Bay in 1959). Occasional fishes have been seen at sea. An angler states that when fishing some distance from the shore off Durban he saw a 'Barrucuda' (*Scomberomorus commersoni*) leap from the water, followed at once by a huge Swordfish, that in mid air cut the fish in two with a sideways slash of its sword. The first specimen recorded as taken by an angler in South African seas was a 39 inch fish, captured on a metal spinner off Cape Point in March 1958. This is shown in *Plate* 3. Its weight was 4 lb. It was first considered to be a Marlin, only later was it realised that it was a Swordfish. The angler who caught it states that he saw four others of similar size. It is not unlikely that others have been caught and taken to be Marlins. In October 1961 a 10′6″ Swordfish was taken on a pilchard baited longline about 40 miles out off Cape Point. The Swordfish has been recorded from East African Seas, and Mr. W. van Rooyen of Zululand has given me an account of a fight he witnessed off the Kenya coast in 1960 between a Swordfish of about 160 lb. and a Mako shark of at least 1000 lb. weight, in which both fish sustained severe injuries, but ended in the shark biting off the tail of the Swordfish, which Mr. van Rooyen was able to gaff and pull aboard for certain indentification. The Swordfish has long been recognised as a pugnacious and dangerous beast. Broken swords have been recorded as found embedded in ships timbers. Copley 1952, 170 records the discovery on the Kenya coast of a 20 inch diameter tree trunk with the sword of a Swordfish right through it. Also of a bale of rubber with a broken sword that had penetrated 15 inches into the bale. Mr. van

Rooyen (mentioned above) has also told me of two anglers who in 1960 hooked a large Swordfish off the Kenya coast that soon turned and charged their motor boat, smashing a large hole in the side, then broke free, leaving them in an almost sinking condition so that they were able to reach the shore only after desperate efforts. Present available evidence however indicates that the Swordfish is not present in any numbers in South or East African seas.

Family Istiophoridae

Elongate compressed body covered with elongate pointed scales, often hidden. Upper jaw prolonged as a long slender to stout rod-like pointed spear. Teeth in jaws small, granular. Gills as in *Xiphias*, no gillrakers. Two keels on side of peduncle. Dorsal long, continuous or divided, the hinder fin small. Anal divided, the hind fin small. Pectoral falcate. Pelvics present, of 1-3 slender rays. Caudal lunate, the lobes equal.

Generally named " Bill-fishes ". Mostly large powerful fishes found in all warm seas. There has long been considerable diversity of opinion among systematists not only about the genera but also about the species in this family. There is still not complete unanimity about generic cleavage.

Most systematists recognise *Makaira* Lacepede, 1803, *Istiophorus* Lacepede, 1802, and *Tetrapturus* Refinesque, 1810 but are not in agreement about the allocation of the known species. Species of the three genera are generally named as follows :

Makaira : Marlins
Istiophorus : Sailfishes
Tetrapturus : Spearfishes

For convenience they are divided into three sub-families that may be defined as follows:

A. The spinous dorsal sail-like, front-part not the highest, area of fin much greater than that of body below. 2–3 pelvic rays longer than pectorals...*Istiophorinae*

B. Front part of spinous dorsal not lower than rest of fin, usually higher to much higher. Area of dorsal less than that of body below. Pelvics of one ray.

I. Spear short. Tip of lower jaw further from eye than from tip of spear. Mid rays of dorsal little lower than front lobe.....*Tetrapturinae*

II. Spear longer. Tip of lower jaw always further from tip of spear than front of eye. Front dorsal lobe always higher than mid and hind rays. Pelvics shorter than pectorals.....*Makarinae*

Sub-family Istiophorinae

Only one genus.

Istiophorus Lacepede, 1803 "Sail-fishes"

Smith 1956, 33. (Natal, Mozambique. W. Indian Ocean)

Type *Scomber gladius* Broussonet, 1786 Elongate, slender, compressed body. Spear slender, lower jaw slender and pointed, its tip nearer front of eye than tip of upper jaw. Fine teeth in jaws and on palatines. Scales elongate, rather rough. Dorsal spines greatly elevated, forming a sail-like fin, its area much greater than that of body below. 2 anal fins, both short. Pectorals falcate. Pelvics each of 2–3 slender rays.

Fairly large fishes found in surface waters of tropical seas, in parts abundant and among the best known and most esteemed of the larger game fishes, affording magnificant sport on light or moderate tackle. Despite this, there is considerable confusion about the species, and though numerous investigations have been carried out a great deal more needs to be done before the species in any one ocean can be clearly defined. Unlike the Marlins Sailfishes do not appear to be able to tolerate any but truly tropical temperatures and so are found only in the extreme north eastern waters of South Africa proper, *i.e.* off Natal shores and further north. Only one species appears to occur there, and is never abundant, being no more than an occasional capture.

Istiophorus gladius (Broussonet), 1786 (*Plate* 2)

Scomber gladius Broussonet, 1786, 545, Pl. 10 (Indian Ocean).

Histiophorus gladius Gunther 1860, 513, (Indian Ocean, Cape of Good Hope). Playfair 1867, 556 (Seychelles). Klunzinger 1870, 468 ; and 1884, 122 (Red Sea). Pike 1873, 27 (Mauritius). Bleeker & Pollen 1874, 100 (Seychelles, Mauritius). Sauvage 1891, 519 (Mauritius). Steindachner 1902, 164, (E. Arabia). Barnard 1927, 807 (Cape Seas). Copley 1952, 170, Pl. 14 (Kenya, Zanzibar).

Istiophorus gladius Smith 1949, 315, Pl. 67, fig. 874. (Natal). Fourmanoir 1953, 220 ; and 1954, 237, (Comores). Baissac 1956, 358, (Mauritius).

Histiophorus granulifer Castlenau 1861, 42, (Cape).

Istiophorus triactis Hemprich and Ehrenberg, 1899, Pl. 9, fig. 10 (Egypt). "Sailfish", Smith 1956, Pl. 1, figure J. (Durban).

Even though it accords well with the generally accepted diagnosis of *gladius* Broussonet. 1786 the identification of the South and East African fish as that species is provisional only as little basic investigation and correlation have yet been done. The species in the genus are in complete chaos and a revision of world material is greatly needed.

As far as can be determined only one species of *Istiophorus* occurs in the Western Indian Ocean, ranging from the Red Sea to south Natal. *Immaculatus* Ruppell 1835 from the Red Sea, is based on a juvenile too small to render identity certain.

One specimen, total length 2650 mm, from Natal was as follows :

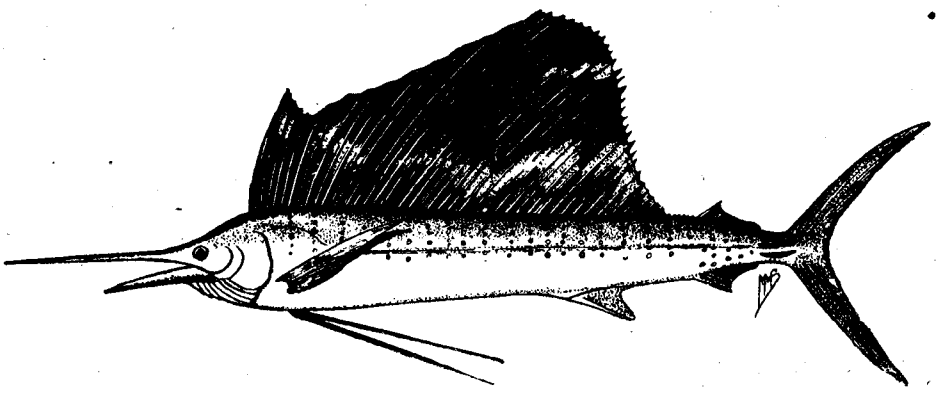


Fig. 1.—*Istiophorus gladius* Brouss. 2650 mm (Natal).

The first dorsal of 42 rays shaped as in fig. 1, the first four spines close set, short, the 24th longest, almost twice depth of body. Behind the front 42 spines are 6 low concealed spines, second dorsal of 6 or 7 rays. A 10+6 or 7. P. 19. Pelvics of a short spine as long as eye and one long ray, 1.5 times depth of body. Depth 5.6 (6. 0, see below) in distance from tip of lower jaw to hind edge of midcaudal rays, here taken as " standard length".

Total head length including spear 2.8, head to tip of lower jaw 4.2 (4.1) in standard length. Spear before eye 4 in distance from tip of spear to hind edge of mid caudal rays. Eye about 3.5 (3.3) in postorbital part of head. Pectoral 1.1 (1.0) in depth of body, pelvic 1.5 (1.8) times body depth. Upper caudal lobe 1.3 (1.3) times body depth. Least depth of peduncle about 4 (4) in body depth. Base of sail-like part of dorsal 1.8 (2.0) in standard length. The 9'6" (2850 mm) specimen from off Mombasa illustrated in Copley 1952, Pl. 14 (and reproduced here in *Plate* 2) is clearly identical. Its dimensions are those given in brackets above.

Colour : Dark blue above, grading to iridescent silvery below. 26 broken pale lines on upper fourth of side, mostly below the dorsal fin ; pelvic, pectoral and caudal black. Sail-like dorsal dark blue with many paler blue spots.

I have photographs of Sail-fishes caught over a wide area of East Africa, and Muritius and cannot find any characters to indicate them as other than all the same species. The movements of Sail-fishes in the Western Indian Ocean are not yet fully known. According to Copley, 1952, 171 they travel from India to Seychelles, where they are fairly abundant during December to March, reaching Kenya about December, remaining there only a few months. In Natal waters they are usually found mostly in the late summer months, though they have been caught even later. Though seen mostly out at sea, several have been caught from the shore in South Africa, notably one in 1961 at the Umtamvuna mouth (31°S), the southern boundary of Natal. There have been conflicting reports about the size attained by this species. All along East Africa the fishes normally seen rarely exceed 9 ft. in length. However, as reported (Smith 1956, 33), at Mozambique Island I saw chunks of a Sail-fish that I estimated could have been about 15 ft. long. Mr. E. Mackenzie, well known big game angler of Natal has told me that when out at sea off Bazaruto of Sail-fish cruised round their boat close by that he estimated at not less than 13 ft. length. It would not take any lure. Copley, 1952, 171 records having himself hooked off Tanga point, near Malindi, Kenya, a Sail-fish that was "a good 16 ft. long". As recorded also by Copley native fishermen constantly report even larger fishes, 20 ft. or more (Copley 24 ft.). At Shimoni I heard of two natives who hooked a great Sail-fish one afternoon that towed them at speed all night but got away next morning. However, so far, no fish over 13 ft. has actually been landed intact, or photographed, or seen by any reliable person but this may well happen. Sail-fishes have been constantly seen to leap from the water, covering a considerable distance in each leap and rising to at least 6 feet above the water. Unlike the Sword-fish, the Sail-fish is not esteemed as food, the flavour of the flesh being reported as rather harsh and unpalatable.

Sub-family Tetrapturinae " Spear Fishes "

Only one genus *Tetrapturus* Rafinesque, 1810, as defined in the key to sub-families above. Beak notably short. Known chiefly from the northern Atlantic and about Japan, smaller than the Marlins, rarely attaining 100 lb. in weight. No species has hitherto been

reported from the Western Indian Ocean or any part of the Indian Ocean. I have been sent a photograph (*Plate* 5) of a 46 inch long billfish of uncertain identity taken near the Island of Mozambique. This may fall here, but the beak is rather long for this genus.

Sub-family Makairinae " Marlins "

Mostly large wide—ranging chiefly surface fishes found in all oceans. Though some authors have described numerous species, most workers today accept only four: (1) The White Marlin, *albida* Poey, 1860 ranges over a wide area of the northern Atlantic from America to Europe and as far south as St. Helena, but nowhere near the Cape; * (2) The Black Marlin, *indicus* C. and V., 1831 and (3) the Striped Marlin, *audax* Phillipi, 1887 both now known to cover much of the Indo-Pacific to South Africa, but not ever found in the Atlantic; and (4) the Blue Marlin, *nigricans* Lacépède, 1803, that occurs in both the Atlantic and the Indo-Pacific, also in South Africa. A probable fifth species *bermudae* Mowbray, 1931, known only from a single large specimen taken at Bermuda differs widely from the others; it may have been a freak, but should not be ignored, as has been its fate with most workers on this group (see Smith 1956, 31, Pl.1, fig. 1). In South and East Africa three* species occur, the Black, the Blue and the Striped Marlins, described below.

There is little doubt that marlins use the bill to impale other fishes for food. Ingested fishes clearly so impaled have been found inside marlins. During the last war ships with cargos of rubber bales were torpedoed in the Western Indian Ocean, and bales have been cast ashore along a vast stretch of the south and east coasts of Africa. Of many dozens of bales examined, every single one was found by the author to contain portions of Marlin bills; in one case a bale washed up in Mozambique with the complete skull of clearly a Black Marlin firmly attached by the bill that had gone almost through the bale. In Plate 5 is shown a bale of rubber cast ashore near Port Alfred, South Africa. In it firmly embedded, is much of the spear of a Marlin, almost certainly a Black Marlin. I estimate this to have come from a fish of atleast 10 ft. length. The spear is so firmly embedded as to be virtually immovable. In my view the discovery of these broken spears in the rubber bales is clear indication of the pugnacity of marlins and that men in the water might be in danger from them. This has been decried by certain scientists who suggest that Marlins do not normally charge and impale strange objects, but that as in the open seas small fishes generally collect under the shelter of floating bales and boxes, it is probably these that attract the marlins. This view is scarcely tenable as the spears in rubber bales I have examined had clearly been driven in with such immense force as to show that the marlin must have been charging at great speed. Such force would scarcely be needed by large Marlins in pursuit of small fishes.

Hooked marlins have been known to charge boats. In one case a native fisherman in a canoe off Port Amelia in Northern Mozambique hooked a large marlin at dusk. As soon as it felt the drag of the line the marlin charged the canoe, jumped out of the water and drove its bill clean through the chest of the native. Although very weak from shock and loss of blood, he eventually reached the shore and almost unbelievably recovered after long treatment in hospital. While carrying out deep line fishing in Northern Mozambique using 5 lb. cylindrical lead sinkers, we found one of these when pulled up had a broken

* Since the above went to press, a White Marlin, *Makaira* (*Lamontella*) *albida* Poey, has been taken off Cape Agulhas, South Africa (see Talbot, *Nature* 1962, Vol. 193, No. 4815, pp. 559). All four known species of Marlins therefore occur about the Cape of Good Hope.

tip of a small marlin spear embedded in the lead. This happened while the line was being pulled in, for the jerk was clearly felt, and must have taken great accuracy and speed on the part of the marlin to hit so small a moving object in that way.

Nowhere in South African seas or in the Western Indian Ocean do marlins occur in such numbers as to have any economic significance. While general agreement about the species has been reached, systematists have not achieved the same with generic cleavage. Some accept only *Makaira* Lacépède, 1803, others recognise *Istiompax* Whitley, 1931 either as a subgenus or at full rank. The latter however clearly appears to merit full rank, as given here.

A. Pectoral freely movable.....*Makaira*

B. Pectoral rigid, almost immovable, set out from body.....*Istiompax*

Makaira Lacépède, 1803

Type *Makaira nigricans* Lacépède, 1803 (French coast, Atlantic). Robust, moderately compressed body. Dorsal elevated to a lobe in front, usually pointed. Dorsal and anal in two parts. Pelvics each of a single ray. Pectoral falcate, freely movable. Lateral line system simple or complex, forming honeycomb system on side, obscure in adults. Air bladder chambers usually in a single layer. Three species, one the White Marlin, confined to the Atlantic, known at St. Helena but not near the Cape, two in the Indo-Pacific, one the Striped Marlin, not known in the Atlantic, the other the Blue Marlin found in all major oceans. The Blue Marlin and the Striped Marlin occur in South and East Africa.

A. Height of front dorsal lobe at least 1.3 times the distance from origin of second dorsal to origin of upper caudal lobe. Anal origin nearer origin of lower caudal lobe than hind margin of head. Pectoral length exceeds depth of body. Lateral line simple.....*audax*

B. Height of front dorsal lobe less than 1·2 times the distance from origin of second dorsal to origin of upper caudal lobe. Anal origin about midway between origin of lower caudal lobe and hind margin of head. Pectoral length usually less than body depth. Lateral line complex.....*nigricans*

Makaira audax Phillipi, 1887

Striped Marlin (*Plates* 3 *and* 6).

Histiophorus audax, Phillipi, 1878, 535, Pl.8 (Chile).

Makaira mitsukurii, Morrow, 1954, 819 (E. African record on sight of specimen from boat).

Makaira indicus (*non* Gray) Copley, 1952, 172, fig. 115.

Makaira audax, Smith 1956a, 758 (First record for South Africa).

Marlin audax, Smith 1956, 31 (South Africa).

An unmistakable fish with high dorsal lobe. Up to recently named by most workers certainly of American origin, *mitsukurii* Jordan and Snyder, 1901. However Smith, 1956, 31 pointed out the undoubted priority claim of *audax* Phillipi, 1887 and this name has now

been universally accepted for the species. Described chiefly from a South African specimen 2800 mm. length. Dorsal spines 35—43, normally 42+6—7 soft rays. A 10—14+6—7. P 19—21. Standard length is taken as the distance from the tip of the lower jaw to the hind margin of the midcaudal rays. Depth 5·5, head from tip of lower jaw, 3·7, preocular length of bill 4, height of dorsal lobe 4, pectoral 4·2, pelvic 5·5 all in standard length. Chief characters in differentiation from other species are that the dorsal lobe equals or exceeds the body depth, and is markedly longer than distance between origins of 2nd dorsal and upper caudal lobe; the anal origin is nearer the origin of the lower caudal lobe than hind margin of head. The spear is relatively slender. The body is usually a brilliant blue above, variable in intensity, grades to blue silvery below; usually with narrow light blue bars, which are sometimes absent or obscure, possibly less obvious in colder seas. The dorsal is a bright cobalt blue, sometimes spotted. Striped Marlin as taken by anglers and commonly seen are usually less than 200 lbs. in weight. According to Fitzgerald and Lamonte 1949, the world angling record for the Striped Marlin was 13′ 5″ in length, weight 692 lb., taken off California, U. S. A. The first Striped Marlin found in South African seas was caught out at sea from Mossel Bay (34° 10'S) in February 1956. It weighed 163 lb. ; total length 9 ft. No further specimens have been caught until recently when Dr. F. H. Talbot has informed me privately that he got 3 more during longlining operations for Tunny near the Cape on the Atlantic side. It is curious that no Striped Marlin has been caught in Natal waters, for they are not uncommon off Southern Mozambique and quite plentiful in Kenya seas. I have seen photographs of *audax* from Mauritius. Robins and de Sylva 1960, 406 have recently allocated *audax* to *Tetrapturus* Rafinesque, an opinion that may not find universal approval.

Makaira nigricans Lacépède, 1803

Blue Marlin. (*Plates* 4 *and* 6)

Makaira nigricans Lacépède 1803, IV 689, Pl. 13, fig. 3 (France).

Tetrapturus herschelii, Gray, 1838, I, 313, Pl. 10 (Cape). There have been numerous records of *herschelii* and other species from South and East African seas, but in the absence of the specimen or of illustrations, it is not possible to identify any as the Blue Marlin. With the present knowledge, it is not difficult to identify this species, which grows to a large size atleast comparable with the Black Marlin. The Blue Marlin may at once be distinguished from the latter by the freely movable pectoral fin (rigid in *indicus*). From the Striped Marlin, which also has a movable pectoral fin, the Blue Marlin differs as shown in the key above. D 39—44+6—7. A 14—17+6—7. P 20—22. Standard length is taken as the distance from tip of lower jaw to hind margin of the mid caudal rays. Depth about 4·5—6, head to tip of lower jaw about 4, bill before eye about 3·5, height of dorsal lobe 6—7, pectoral 3·8—4·4, pelvic 5·5—7, all in standard length. The height of the dorsal lobe never exceeds the body depth, and the pectoral is usually less than body depth. The spear is stout. Colour in life dark blue above, silvery below, often with lighter cross bars on upper part of body that rapidly fade after death, when general colour above becomes very dark. Dorsal brilliant blue.

There has been much confusion about this species. The Blue Marlin has long been well known in the Atlantic, as it is by far the largest species of Billfish there, and it is easily distinguished from the only other that occurs there, namely the smaller White Marlin, *albida* Poey, 1860. It is only within the last decade that it has been realised

that the Blue Marlin occurs also in the Pacific. Royce 1957, 497 was the first to show that the Blue Marlin occurs there. Morrow 1957, 91 working on the pectoral girdle, was able to demonstrate a distinct difference in structure from the Black Marlin. On the same basis, Morrow 1957, 104 at first considered the Blue Marlin of the Pacific to be different from that of the Atlantic. However later work appears to have established beyond doubt that there is only one species in all oceans.

In recent times the presence of the Blue Marlin has been established in the Western Indian Ocean, off Kenya, at Mauritius in Southern Mozambique waters and also in South African seas. While it seems likely that this species occurs in South African seas about as frequently as the Black Marlin, this has only been realised in quite recent times. I have seen only one small Blue Marlin (from Durban), 1350 mm. total length, but Dr. F. H. Talbot has recently told me of a larger specimen taken on a long line on the Atlantic side of the Cape in deep water, so that its origin, Atlantic or Indian Ocean, might be in dispute, but Striped Marlin were taken in the same area, which clearly indicates the Indian Ocean as origin.

The record for rod and line for Blue Marlin is a 13′ 1″ fish that weighed 737 lbs., caught in the Bahamas, Atlantic, but the species almost certainly grows to a much larger size, especially in the Pacific. A so-called Black marlin, that weighed 1226 lb. that was stranded at Eden (New S. Wales) is shown in Roughley, 1951, Pl. 70. The pectoral is obscure but could be folded against the side and this could easily have been a Blue Marlin.

Morrow 1958, 356 examined the type of *herschelii* Gray, 1838 in the British Museum and states that the pectoral girdle shows it to be a Blue Marlin.

Istiompax Whitley, 1931

Type *Tetrapturus australis* Wall, 1854 (Australia)= *indicus* C and V, 1831 (India). In most respects similar to *Makaira* Lacépède, differs in having the pectoral girdle so constructed that the pectorals are set out rigidly at right angles to the body and cannot be folded against the side without force ; (Plate 5) : also the chambers of the airbladder are arranged in several tiers. Only the type species, *indicus* C and V, the well known Black Marlin, found throughout the tropical and sub-tropical parts of the Indo-Pacific. The Black Marlin probably attains a weight of close on a ton. The flesh is rather coarse but quite palatable, especially when canned or smoked ; it is of importance as food in parts of the Pacific.

Istiompax indicus (C and V), 1831

Black Marlin. (*Plates* 4, 5 *and* 6)

Tetrapturus indicus C and V 1831, VIII, 286 (Sumatra).

Tetrapturus brevirostris Playfair 1866, (Zanzibar). Smith 1949, 315, fig. 876 (S. Africa). Smith 1956 28—30, fig. 2, Pl. I fig. K (S. Africa).

Makaira herschelii Smith 1949, 315, Pl. 67, fig. 875 (Algoa Bay). The following records are not certainly identifiable between *Makaira nigricans* and *Istiompax indicus* :—

Histiophorus brevirostris Gudger 1929, 3 (Mauritius).

Makaira indicus Copley 1954, 172 (Kenya).

Makaira herscheli Baissac 1924, 3, (Mauritius). Fourmanoir 1954, 220 (Comores).

The identity, nature and nomenclature of the Black Marlin have been the subject of much controversy, and reasonable finality has been reached only in quite recent times. It has been described under many names from a wide area, for many years as *mazara* Jordan and Snyder 1901. Smith 1956, 27 disputed the validity of *mazara* and suggested *herschelii* Gray, 1838 (S. Africa) and *brevirostris* Playfair, 1866 (Zanzibar) as Black Marlins and so having priority. There was doubt about the identity of *herschelii* but using Playfair's data to reconstruct the outline of the type Smith showed that this could not be anything but the Black Marlin, so that *brevirostris* Playfair, 1866 has clear priority over any names of Jordan and his co-workers. Later work by Whitley and others showed that *Tetrapturus australis* Wall, 1854 with an illustration of an Australian specimen in a newspaper as type, was a Black Marlin, and hence might be granted priority over *brevirostris*. The only other possible earlier name for this species was *indicus* C. and V. 1831, whose data were insufficient for diagnosis. Eventually Morrow, 1959, 347, fig. following the method initiated by Smith 1956, succeeded in getting the original dimensions of the type of *indicus* C. and V. 1831 and by reconstruction from the data on the same lines has been able to demonstrate with reasonable certainty that *indicus* C. and V. 1831 was a Black Marlin, and this name, having clear priority, has now become established.

The Black Marlin has been observed to be rather variable in shape and dimensions, as well as to have a rather variable weight-length relationship. It is however in all but the smallest fishes readily recognisable by the rigidly extended pectorals, the body always deeper than the length of the front dorsal lobe, while the airbladder is composed of many tiers of cells. The beak is fairly short and stout. D. 33—41 spines and 6—7 rays. A. 10—14+6—7. P. 19—21. Standard length is taken as the distance from the tip of the lower jaw to the end of the mid caudal rays. Depth 4.2—5.6, head from tip of lower jaw about 4, pectoral 4.2—5. height of dorsal lobe about 7—8, pelvic about 8, bill before eye 3.3—4, all in standard length. The colour is a deep variable blue-black above, dirty white below. There are normally no light cross bars. The dorsal is dirty bluish, often blotched or even spotted. The back is usually black. In South Africa the Black Marlin has been known for probably 100 years. Never abundant, it is apparently always present along the shores as far as the Cape. Individuals tend to travel south with the warm Mozambique current and are often numbed and immobilised by the cooler seas about the Cape. The movements of the warm current in that part are poorly known, but quite often great "islands" of blue warm water may be seen in the greenish cooler parts and Marlins are not uncommonly found in such areas.

Dead Black Marlin are constantly thrown ashore all along the shores of South Africa, quite a number well on towards the Cape. The earliest rod and line catch I can trace was at Mossel Bay about 60 years ago when an angler hooked and subdued a fish of about 300 lbs. in weight. The present angling record for South Africa is a fish of 1002 lbs. taken in Natal but much larger fish have been seen and hooked. The all tackle world record for anglers was a 976 lb. New Zealand fish. The Black Marlin certainly exceeds half a ton in weight and probably grows still larger. Quite a number have been taken in recent times on long lines in deeper water on the Atlantic side of the Cape of Good Hope. Their origin is clearly the Indian Ocean, carried by or drifting in the west-flowing Agulhas (or Mozambique) current.

2. Family Scomberomoridae

Seerfishes. Spanish Mackerel. Serra (Mozambique).

Elongate well compressed body, torpedo-shaped, with minute scales. Large mouth with strong uniserial compressed cutting teeth, villiform teeth on palate. Gill openings wide, membranes free, rakers few, wide apart. Lateral line complete, often undulate. Dorsal long and low, of 14—27 spines in front, soft fin shorter, higher in front, and 8—12 detached finlets behind. No anal spines, the fin higher in front, of 12—20 rays with 8—12 detached finlets behind. Pectorals and pelvics short. Caudal peduncle slender, with a lateral keel, the fin deeply lunate. Two genera, (The rare *Gasterochisma* Richardson, 1845 probably also falls here). Famous moderate-sized game fishes found in all warm seas, ranging widely. The flesh of all is of the first rank and over a wide area some are of considerable economic importance. Being tropical in habit, these fishes, while well known on the coast of East Africa and beyond eastwards, in South Africa are mostly confined to Natal waters, though one species does at times penetrate further Southwest.

A. Not more than 20 spines in first dorsal. Maxilla not covered by preorbital. Gillrakers present.....*Scomberomorus*

B. 25 or more spines in first dorsal. Maxilla sheathed beneath preorbital. No gillrakers.....*Acanthocybium*

Scomberomorus Lacépède, 1802

(*Cybium* Cuvier, 1829).

Type *Scomberomorus plumieri* Lac, 1802, (Martinique). With the characters of the family and as defined in the key above. Only two species certainly identified in the Western Indian Ocean, both found in South African seas.

A. Body with distinct crossbars at all stages. L.1. strongly undulate 3 gill rakers..... ....*commersoni*

B. Body with longitudinal broken lines or rows of spots. L.1. more regular. 2+10—11 gill rakers.....*guttatus*

Scomberomorus commersoni Lacépède, 1800

Barracouta (Natal) Serra (Mozambique). (*Plate* 7).

Scomberomorus commersoni Lacépède 1800, 598, 600 Pl. XX fig. 1, (Indian Ocean), Barnard 1927, 802 (S. Africa). Fowler 1945, 121 fig. 4 (Red Sea). Smith 1949, 301, Pl. 65, fig. 840 (S. Africa). Fraser-Brunner 1950, 158, 161, fig. 34 (Red Sea). Marshall 1952, 240 (Red Sea). Morrow 1954, 815 (East Africa). Smith 1956, 722 (Aldabra). Williams 1956. 43 (East Africa). Williams 1958, 61 (N. Kenya).

Cybium commersoni Rüppell 1826, 94 Pl. 25, fig. 1 (Red Sea). Rüppell 1835, 41 (Red Sea). C. and V. 1831, 165 (Indian Ocean). Günther 1860, 370 (Cape Seas). Guichenot 1863, 26 (Reunion). Klunzinger 1871, 44 (Red Sea). Playfair and Günther 1866, 67 (E. Africa). Klunzinger 1884, 112 (Red Sea). Bleeker and Pollen 1875, 100 (Mauritius). Sauvage 1891, 350, 517 (Mauritius, Madag.). Day 1876, 255 Pl. LVI, fig. 5 (Red Sea. E. Africa). Steindachner 1902, 164, (S. Arabia). Gilchrist and Thompson 1909, 248 (Natal). Pellegrin 1914, 229 (Mauritius). Native common names: Nguru (E. Africa). Ngulu

(N. Mozambique). MBaasai or Angou (Comores). M'Twana (Lamu). Deirak, Yumbi, Guru (Ital. Somaliland). D XVI–XVII, 14—17, +9—12. A 15—17, +9—11. P 2,21. Depth 4.5—6.5, head 4—4.5 in body. Eye 5—6.5 in head, 2—4 in snout 1.0—2.4 in interorbital with age. Maxilla reaches to beyond eye. Some upper teeth very finely serrate. Fine teeth in rounded patch on vomer, a narrow row along each palatine. Gill rakers poorly developed, an indefinite number (7—8) of spinate low knobs on upper limb of arch, and 3—4 rudimentary rakers on lower limb near angle, front of arch bare. Keel on peduncle moderate, a faint keel above and below on caudal. Whole body covered with fine sharp scales. In life : steely-silvery. The young with 15—20 broken darker cross bars consisting of vertically elongated spots, these gradually change with age, the adult with more numerous irregular narrow darker cross bars, mostly below the lateral line. Front of first dorsal fin dark. Repeatedly stated to attain close on 100 lb. weight, but no reliable record of any over 50 lb. the larger fishes were probably malidentifications of the Wahoo, A. *solandri*, which also has crossbars in life, but is a larger fish. Williams 1956, 43 records greatest length observed in Kenya waters as 1250 mm. and weight 41 lb. I have seen many specimens, but none over 26 lb. in any part of the Western Indian Ocean. This fish is common throughout the warmer parts of the Western Indian Ocean, at times occurring in shoals, and affords excellent sport on baits or artificial lures, found both close to shore and out at sea. This was the commonest fish taken by trolling in our coastwise voyaging along northern Mozambique and Kenya. It is an important food fish in most of Mozambique and also in Kenya. It is quite abundant in Natal waters, especially in summer, numbers being caught from boats (mainly in the Natal Ski-boats) and it is greatly valued as an eating fish. In summer this fish sometimes wanders as far south as Algo Bay and Mossel Bay, where it is known as Katonkel and greatly esteemed as a sporting and table fish.

Scomberomorus guttatus (Bloch-Schn.), 1801, *Plate* 8

Common name "Snoek" (Natal). Note ; not the Cape Snoek (*Thyrsites*) *Scomber guttatus* Bloch Schneider, 1801, 23 (Indian Ocean).

Scomberomorus guttatus Weber and de Beaufort 1951, 232 (Indian Ocean). Smith 1956, 722 (Aldabra).

Scomberomorus leopardus Smith 1949, 301 Pl. 164 fig. 841 (Natal northwards). Morrow 1954, 815 (Pemba). Fourmanoir 1957, 227 (Madagascar).

Cybium lineolatum C and V, 1831, 170 (Malabar). Steindachner 1902. 164 (E. Arabia).

Scomberomorus lineolatus Gilchrist and Thompson 1917, 395 (Natal).

Barnard 1927, 803 (Natal). Smith, *Rec. Alb. Mus.*, 1935, 210 (South Cape coast). Weber and de Beaufort 1951, 235 (India). Williams 1960, 184, Pl. II (Kenya).

Scomberomorus sp. Williams 1956, 44 (Kenya).

D XV — XVI 15 — 17+9—10. A 16 — 20+7 — 10. P 2, 22. Gill rakers 2+1+8 — 10 Depth 4·3 — 5·1, head 4·8 — 5·2 in body. Eye 4·2 — 6 in head, 1·4 — 1·8 in snout, and 1·2 — 1·7 in interorbital. Maxilla reaches below or near hind edge of eye. Smooth-edged acutely triangular teeth in each jaw, 11 — 14 each side of lower and 16 — 20 each side of upper jaw. Patch of fine teeth on vomer and a band along palatines. Gillrakers not well developed, short and wide apart on lower limb. Feeble keel on peduncle, also feeble upper

and lower oblique keels on caudal base. Body mostly naked. In life steely-silvery with bluish iridescence. The young to about 450 mm. have a few rows of mostly horizontal but irregularly elongated dark spots forming rows along the body, some above but mainly below the lateral line (*Plate* 8). With age these tend to narrow and coalesce, gradually changing to the adult livery in the form of a series of irregular narrow broken lines along the side, of somewhat variable pattern as shown in *Plate* 8. First dorsal dark, sometimes only in front, fins darkish or dusky, variable. Often a yellowish patch on the cheek.

This is a smaller species than *commersoni* Lacépède. I have seen none exceeding 1200 mm, any over 400 mm are uncommon. We found this fish over a wide area of the W. Indian Ocean, rarely more than one or two ever being taken on lines. It seems to take bait or lures less readily than *commersoni.* The South African angling record is a fish of 19 lb., any over 15 lbs. are rare. This fish is less tolerant of cooler water than *commersoni.* Well known in Natal, it has been recorded further South only once (Smith 1935, 210:34°S).

It appears to travel in considerable shoals, even in Natal surf netters sometimes take numbers. Off the open shore near Inhaca Island in Delagoa Bay I saw surf netters enclose a shoal travelling along the shore. They took at least 500 fishes averaging about 5 lb. each in that one haul. *guttatus* ranks equal with *commersoni* as food, it is everywhere esteemed.

There has been a good deal of uncertainty about the name this fish should bear. The earliest possible name is *guttatus* Bloch and Schneider, 1801 while *leopardus* Shaw, 1803 has also been used, but is ill defined. Williams 1956, 44 working on Kenya fishes was at first unable to identify this species. Later, 1960, 184 he named it *lineolatus* C. and V. 1831, rejecting *guttatus* Bloch and Schneider, 1801, stating that in his opinion "*guttatus* Bloch and Schneider has been confused in the past with the present species *S. lineolatus*" but he gives no indication of how these supposed two species differ from one another, except that *guttatus* has rows of spots while *lineolatus* has interrupted lines. As indicated in the description above we find that juveniles all have spots: we have never found a fish less than 400 mm. length with the interrupted lines of the adult livery. Munro 1943, 71, in a revision of the Australian species lists *guttatus* as having 46 vertebrae, and *lineolatus* 50. Weber and de Beaufort 1951, 229, distinguish *guttatus* from *lineolatus* chiefly in the position of the second dorsal fin, in *guttatus* (they say) it is midway between the origin of the upper caudal lobe and the snout tip, whereas in *lineolatus* it is midway between the origin of the upper caudal lobe and the eye. On the latter basis Williams 1960, Pl. II. is *guttatus* and so are all I have seen. I have available at present (besides photographs of several specimens up to the adult stage, and data) 3 specimens, 320—350 mm from Durban and Delagoa Bay; all have rows of elongated spots as shown in Pl. 8: the second dorsal origin is midway between origin of upper caudal lobe and snout tip, and the largest specimen has 46 vertebrae, thus on the basis of the diagnoses by Williams and Munro these are *guttatus,* but all juveniles we have ever seen are like these, while all large fishes had lines as in Plate 8. The "six feeble gill rakers" for this species stated in Smith 1949, 301, is an error. All the fish I have examined (including the present 3 juveniles) have 2+1+8 — 10 rakers. Williams 1960, 186 states that this species is not recorded by Smith 1956, from Aldabra. It is however recorded from there (Smith 1956, 722) as *guttatus* Bloch, 1801. Analysis of all reliable data on *guttatus* Bloch and Schneider and *lineolatus* C. and V. shows close agreement in all significant features in these supposed two species.

Acanthocybium Gill, 1862

Type *Cybium solandri* C. and V. 1831. With the characters of the family. Distinguished from *Scomberomorus* Lacépède, by the greater number of spines in the front dorsal and by the absence of gill rakers. Only one species, found in all warm seas, grows to a considerable size, not known to occur in numbers anywhere.

Acanthocybium solandri (C. and V.), 1831

(*Plate* 9)

Serra (Mozambique). Wahoo (General).

Cybium solandri C and V 1831, 192 (Atlantic).

Acanthocybium solandri Smith 1949, 301, P. 164, fig. 843. (Natal: Mozambique). Fraser-Brunner 1950, 162 (Indian Ocean). Weber and de Beaufort 1951, 228 (Western Indian Ocean). Copley 1952, 168, fig. 113 (East Africa). Fourmanoir 1954, 220 (Comores). Morrow 1954, 819, (Pemba). Williams 1956, 45 (East Africa). Smith 1956, 722 (Aldabra). Fourmanoir 1957, 226, fig. 151 (Comores).

An unmistakable fish. D XXV - XXVII, 10 — 13 + 9 — 10. A 10 — 12 + 8 — 9. No gill rakers. Depth about 6 — 7, head about 4·2 in body. Eye 7 — 8 in head, 5 — 6 in snout. Mouth large, lower jaw projects, maxilla not or barely to eye, hind part of premaxilla sheathed by preorbital. About 50 triangular finely serrated teeth in each jaw. Villiform teeth on vomer and palatine. Whole body with small scales. In life steely blue with 18 — 20 or more variable narrow light cross bars that fade rapidly after death.

The Wahoo is a circumtropical fish, occurring in all warm seas of the world, not known in cool seas. It is a famous but rather rare angling fish of the first rank, sought by many but landed by few. Nowhere more than a rarity, it provides spectacular sport when hooked, often leaping high into the air. It is reported to travel in pairs.

The world record is a fish of 133 lb. taken at the Bahamas, Atlantic. We caught odd specimens by trawling along the East African coast and about Seychelles. It has been taken only rarely in South African seas and only once known south of Natal, one caught by an angler in Algoa Bay. The South African record is a fish of 63 lb. taken off Natal. The Wahoo has nowhere any economic significance.

3. FAMILY SCOMBRIDAE

Mackerels

Rather elongate fusiform body covered with small scales, sometimes as corselet on front part of body. Two dorsal fins, well separated, spinous part of 9—13 feeble spines, detached finlets behind soft fin. Anal of one spine and 11 or 12 soft rays with detached finlets behind. Airbladder present or absent. Gill rakers and pyloric caeca numerous. Pectorals and pelvics short, caudal deeply forked, with two small keels each side. The flesh is firm and oily, more or less reddish, soon spoils. As here restricted only two genera in the Western Indian Ocean.

A. Depth of body less than head length. Teeth on vomer and palatines...*Scomber*

B. Depth of body not less than head length. Palate edentate.....*Rastrelliger*

Scomber Linn., 1758

Mackerel

Type *Scomber scombrus*, Linn. 1758. With the characters of the family and as defined in the key above. Few species, possibly only two, widely distributed, only one in South Africa and the Western Indian Ocean.

Scomber japonicus Houttuyn, 1782

(*Plate* 10)

Scomber capensis C. and V. 1831, 56 (Cape).

Scomber pneumatophorus Gunther 1860, 359 (Cape seas). Gilchrist 1902, 127 (South Africa).

Scorber grex C and V 1831, 45 (Cape). Pappe 1853, 17 (Cape). Castelnau 1861, 38 (Cape).

Scomber scombrus Bleeker 1860, 53 (Cape), Gilchrist 1902, 127 (South Africa).

Scomber colias Gilchrist and Thompson 1917, 393 (Natal). Thompson 1918, 105 (S. Africa). Fowler 1919, 290 (Natal). Barnard 1927, 794, Pl XXX, fig. 2 (after C and V), (Cape to Natal).

Scomber japonicus Smith 1949, 300, fig. 839 (South Africa to Mozambique).

Scomber gigas Fowler 1935, 378, fig. 16 (Natal).

D IX—X+11—12+5. A I 11.12+5. P 2, 19. Gill rakers slender, 13—15+1+30—32. Depth 4·5—5·5, head about 3·5 in body. Eye 4—6 in head, 1·5 in snout, 1—1·4 in interorbital. Maxilla reaches to below pupil. Uniserial small sharp teeth in each jaw in the young ; fine teeth on vomer, small sharp teeth biserial along palatine, adult without obvious teeth. Scales minute, those about shoulder larger forming obscure corselet. In life with greenish metallic iridescence and dark wavy streaks above lateral line, often short vertical dark lines below. Fins light, sometimes with yellowish tinge. Attains 30 ins., average smaller. Occurs at times in great shoals on the Southern Cape Coast, large numbers are taken by nets on the Southwestern coast, the fish is progressively less abundant eastwards. Large numbers are eaten fresh and considerable numbers are canned. Greatly preyed on by larger fishes and much used as bait by anglers.

Rastrelliger Jordan and Dickerson, 1908.

Type *Scomber brachysoma* Bleeker, 1850. With the characters of the family and further defined as in the Key above. Has a more compressed body than *Scomber* and lacks teeth on the palate. Only one species *kanagurta* Russell, 1803, certainly found in the Western Indian Ocean. *Rastrelliger brachysomus* Bleeker 1850, which is said to differ from *kanagurta* Russell, in having head as high as long and with more gill rakers (40 or more), has been recorded from Natal by Gilchrist and Thompson, 1917, 393 and Barnard 1927, 796, but these authors apparently never saw an actual specimen nor did we ever find any that could be assigned to this species anywhere in the Western Indian Ocean.

Rastrelliger kanagurta (Russell), 1803

(*Plate* 10)

Common names : Maquereau (Mauritius) Kismayu (Somaliland), Maquereau Doux (Seychelles).

Scomber kanagurta Russell 1803, 28, Pl. 136 (India). Peters 1855, 437 (Mozambique). Playfair 1867, 861 (Seychelles). Sauvage 1891, 517 (Madagascar). Steindachner 1902, 142 (Aden). Gilchrist & Thompson 1909, 247 (Natal).

Scomber microlepidotus Bleeker and Pollen, 1875, 100 (Madagascar). Sauvage 1891, 517 (Seychelles). Meek 1899, 172 (Somaliland).

Rastrelliger kanagurta Smith 1949, 299, Pl. 68, fig. 837 (Natal and Mozambique). Weber and de Beaufort 1951, 212 (Kenya : Indian Ocean). Smith 1956, 721 (Aldabra).

D IX—X+11—12+5. A 1—11+11—12+5. P 2, 19. 1—15+1+32—24 long feathery gill rakers. Depth about equals head, 3·3—3·6 in body. Eye about 4 in head, equals snout, 1—1·3 in interorbital. Adipose eyelids well developed. Maxilla reaches to about below hind eye edge. Fine teeth in narrow band along sides of jaws. No teeth on palate. Dorsal origin over middle of pectoral. Pelvics about 2/3 of pectoral. Scales over whole body, distinct. In life bluish or blue green above, speckled darker, sometimes with a row of larger dark spots on back below dorsal, or narrow lines : Silvery with bluish iridescence below, and golden suffusion as narrow stripes along lateral line. Fine light yellowish, sometimes apex of 1st and 2nd dorsals and of caudal lobes dusky or black. A dusky spot beneath pectoral. Attains 300 mm. Ranges northwards from Natal throughout East Africa and beyond, not abundant, rarely as shoals.

Most of the work on which the above summary has been based was made possible by generous financial support provided by the S. A. Council for Scientific and Industrial Research. Also, valuable assistance was provided by the authorities of Mozambique, Kenya, Tanganyika and Seychelles.

For most of the illustrations I wish to express my gratitude to my wife, Margaret M. Smith, with whose permission they are reproduced here.

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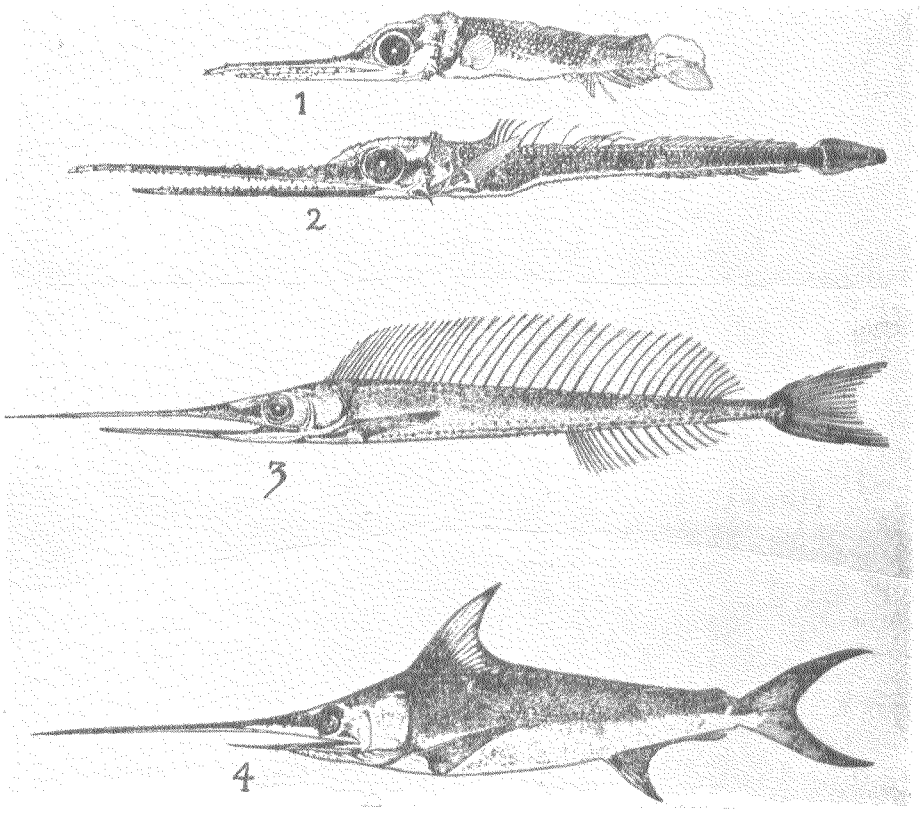
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THE PAPER WAS READ BY DR. S. JONES

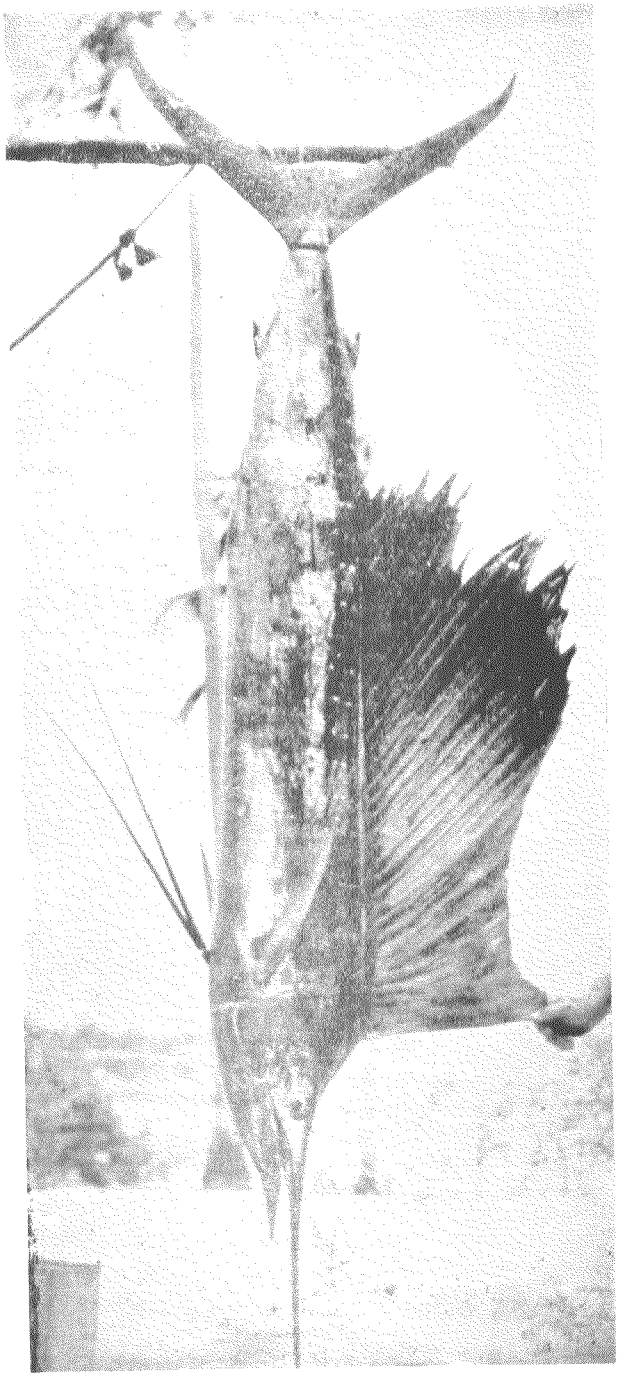
DISCUSSION

DR. E. G. SILAS. Dr. Smith recognises two species of seerfishes, namely, *S. guttatus*, and *S. commerson* from South African waters, while Mr. Williams reports *S. lineolatus* and *S. commerson* as occurring in East African waters. Although Mr. Williams has made an attempt to clarify the nomenclatorical status of *S. lineolatus* it is my feeling that the species of seerfishes occurring in the Western Indian Ocean (East African and South African waters) needs re-study, as undoubtedly some confusion still exists round the species reported from that area under the names *S. guttatus* and *S. lineolatus*. These two along with *S. commerson* occur in Indian waters.

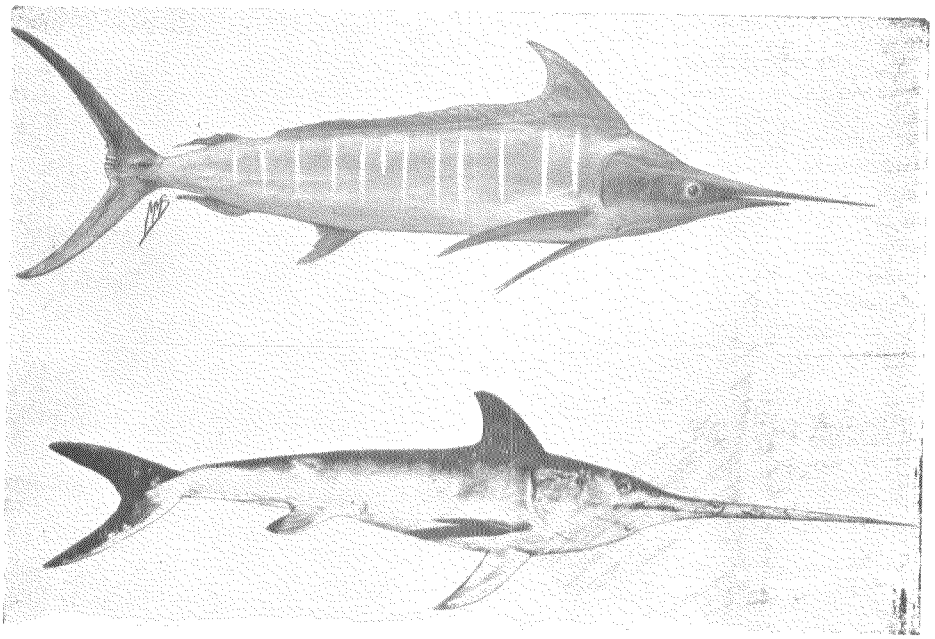
DR. S. JONES. Well, in this connection I should say that there is some disagreement between Dr. Smith and Mr. Williams regarding the existence of *S. lineolatus* from the African coasts. Perhaps if both could exchange material from east and South African waters the problem could be solved. In any case one thing that is certain is that *S. lineolatus* is present in the Indian Ocean.



Development of the Swordfish—(after Yabe). Lengths stated below :
1. 11 mm. 2. 27 mm. 3. 252 mm. 4 580 mm.



Istiophorus gladius (Broussonet), 9½ ft. (After Copley, 1952).

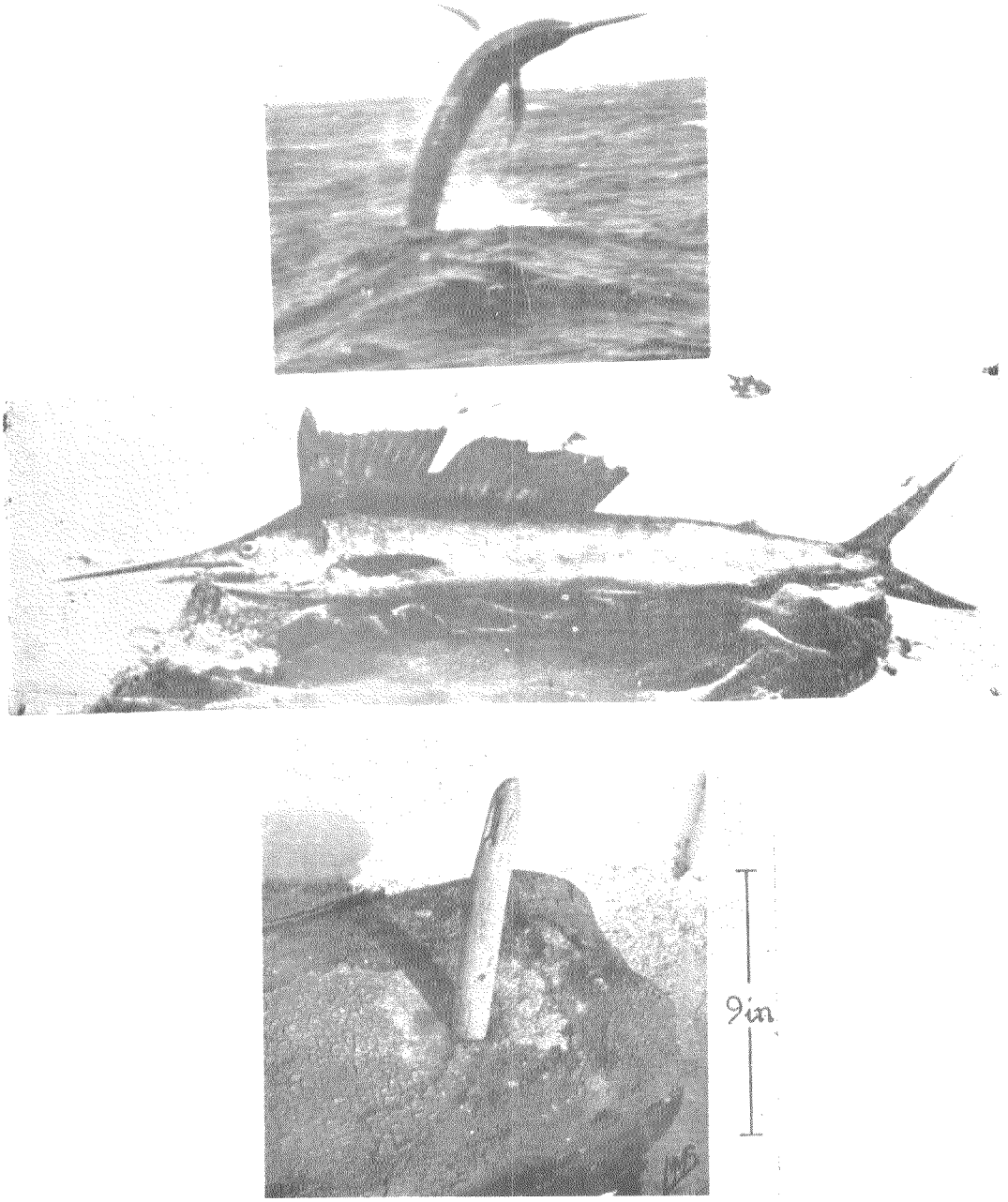


1. *Makaira audax* (Phillipi), 9 ft.
2. *Xiphias gladius* Linn, 39 ins.

(Both Southern Cape, S. Africa)



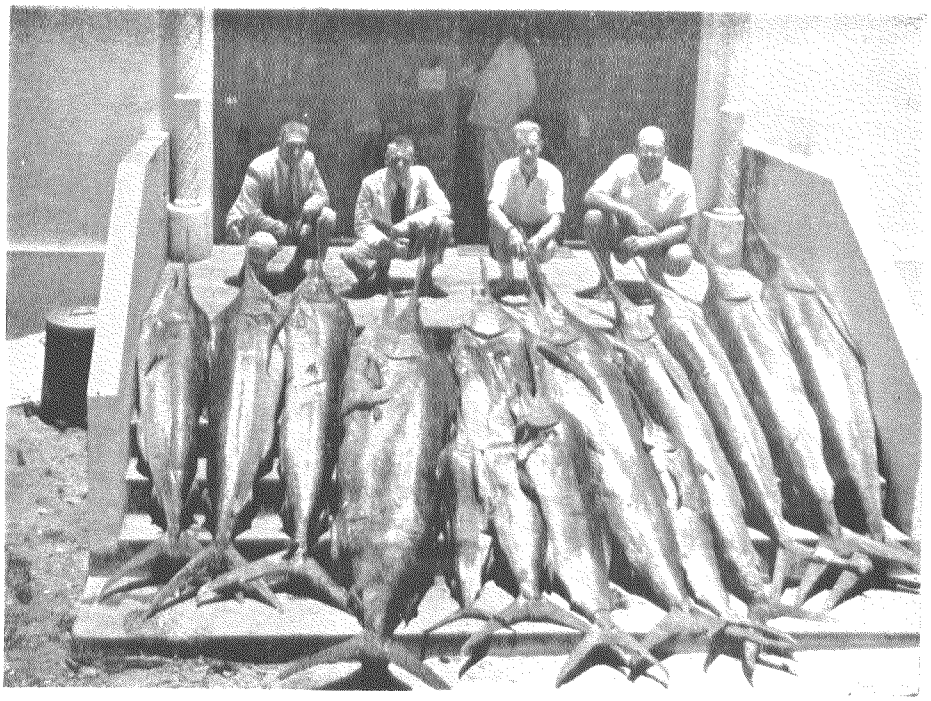
Left. *Makaira nigricans* Lacépède, 632 lbs. (Mauritius).
Right. *Istiompax indicus* (C. and V.), 368 lbs. (Mossel Bay).



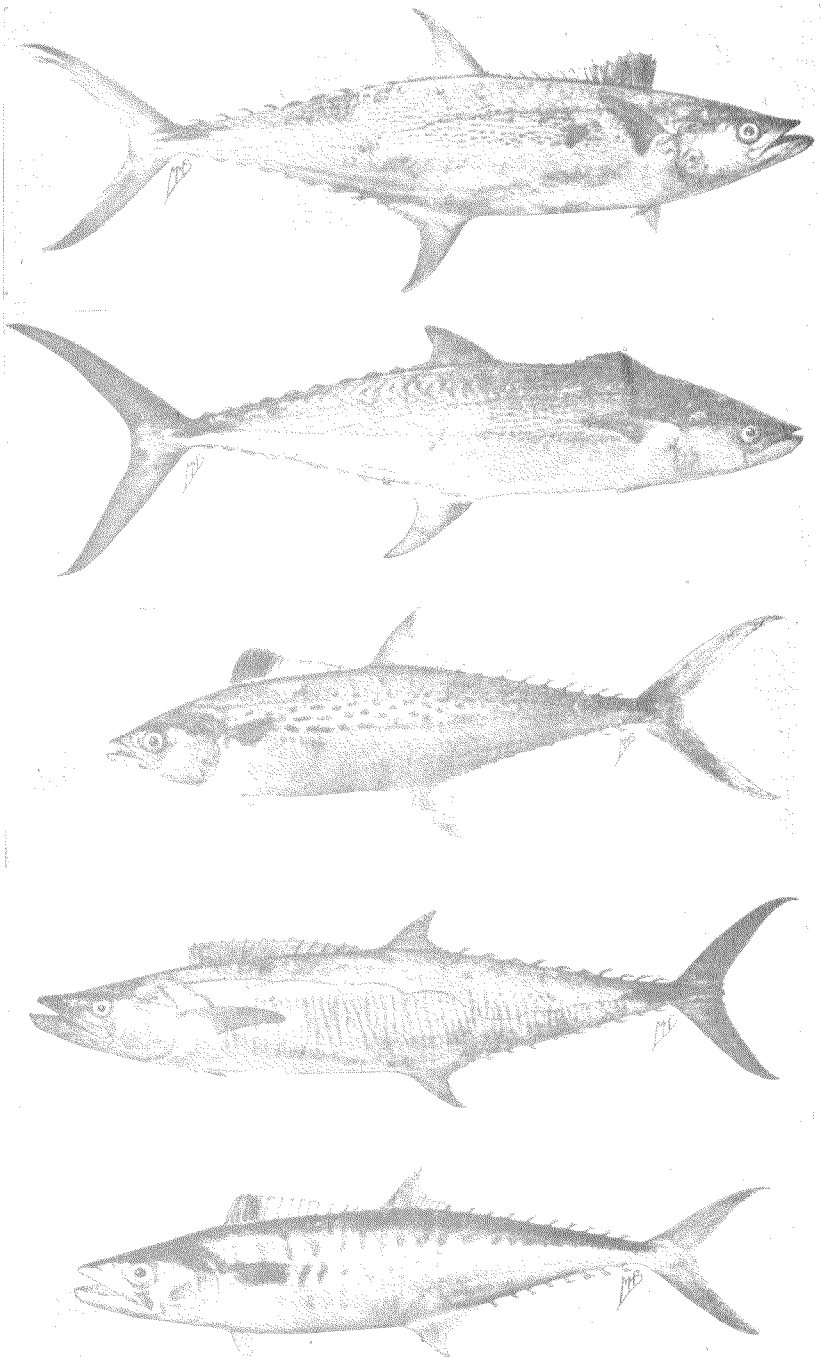
Above. *Istiompax indicus* C. and V. about 400 lbs., jumping, showingrigid pectorals.

Middle. Unidentified Billfish (Mozambique), 46 ins.

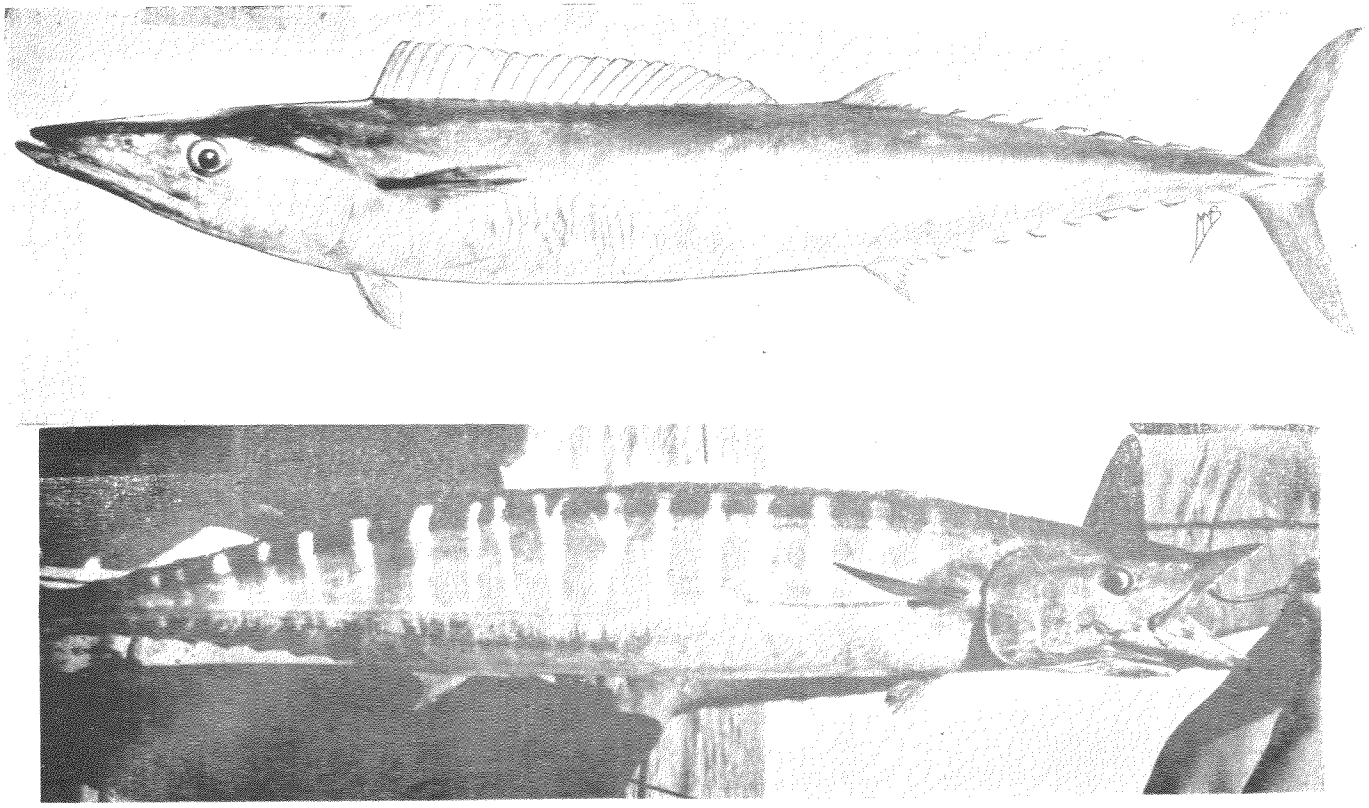
Below. Bale of rubber with embedded Marlin spear found cast ashore near Port Alfred, S Africa.



A catch of Marlins from Bazaruto, Mozambique, 1959, Black, Blue and Striped marlins.



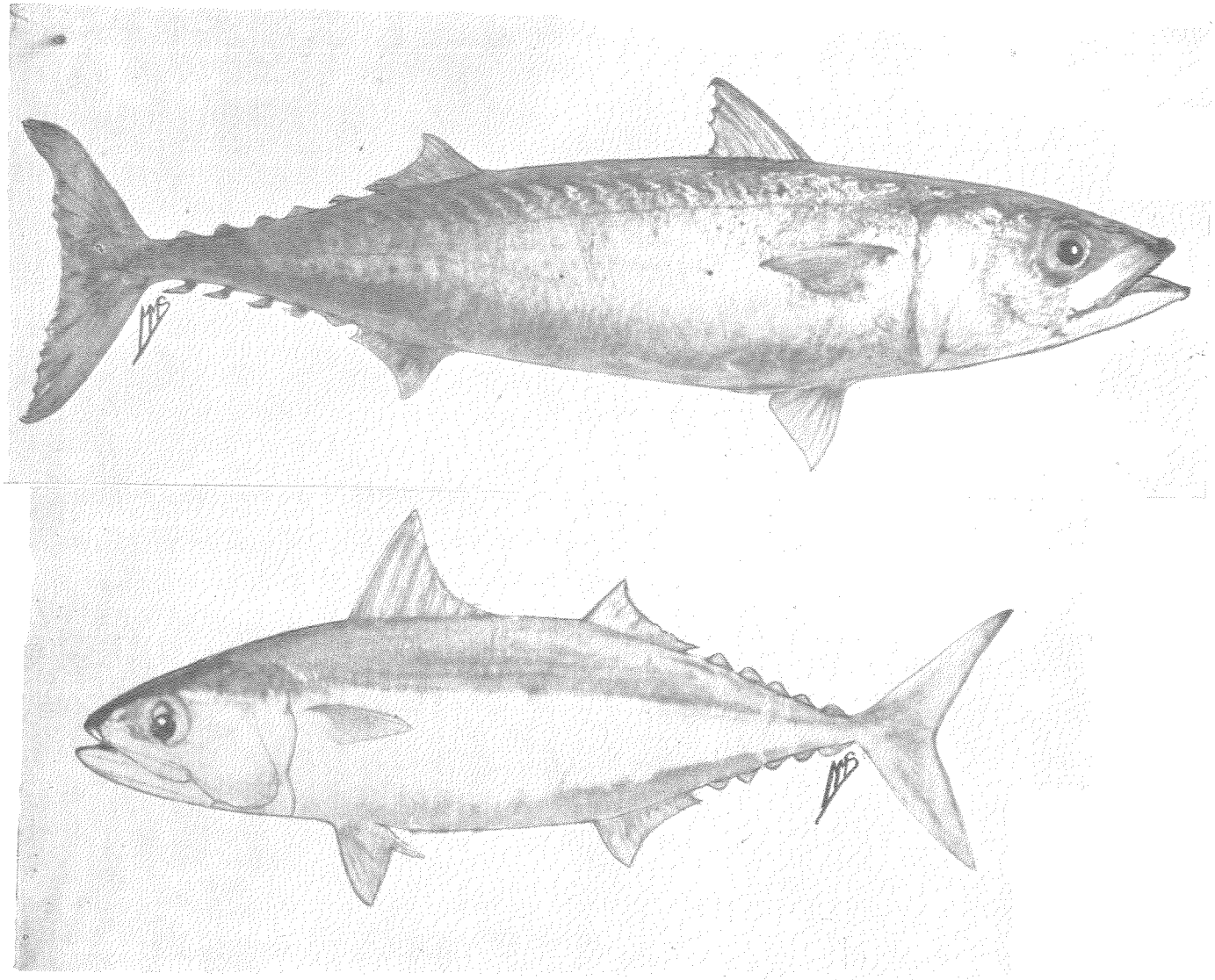
Scomberomorus commersoni Lacépède. 1. 12 ins. 2. 44 ins.
Scomberomorus guttatus (Bloch–Schneider) 3. 13 ins. 4. 40 ins.; to show variation in marking of adult. 5. 44 ins.



Acanthocybium solandri (C. and V.)

Above. 50 ins.

Below. 61 ins. to show markings just after death.



Above. *Scomber japonicus* Houttuyn, 24 ins.
Below. *Rastrelliger kanagurta* (Russell), 11 ins.

THE SCOMBROID FISHES OF MASCARENE WATERS

BY

JEAN DE BOUCHERVILLE BAISSAC
Department of Fisheries, Government of Mauritius

The Mascarene islands – Reunion, Mauritius and Rodrigues—are situated in the South-West Indian Ocean, between longitudes 55° and 65° East and on both sides of latitude 20° South.

They are volcanic islands which occupy the southern extremity of the Mauritius – Seychelles ridge, the other features of which are the two shoals of Nazareth and Saya de Malha and the small granitic archipelago of the Seychelles situated on a vast shoal which also bears a number of coral islands.

The Mascarene are under the general influence of the trade winds which blow from the south-east and are very strong in winter (southern) when the area of high pressures of the sub-tropics rise to the north; the trade winds then gather more strength from the establishment of the South-West Monsoon which, blowing from the Ocean towards the Continent of Asia, causes a lowering of pressure at the northern limit of influence of the trades. The average force of the wind is then 3-4 of the Beaufort scale.

In summer the trades only blow occasionally and with a more pronounced eastern component.

The mean sea surface temperature varies from 22.8°C in July-August to 27.7°C in January.

These islands are situated near the southern limit of the South Equatorial Current which increases in velocity during the winter season when it is reinforced by water from the Pacific entering the Indian Ocean by the North of Australia. This strong current may have helped in their southerly migration the young (10–15 lbs.) yellowfin tuna which are found in Mauritian waters.

Family *SCOMBRIDAE* Fraser-Brunner. *Thunnus* (*Neothunnus*) *albacares* Bonnaterre.
Fraser-Brunner, 1950, Annals Mag. Nat. Hist. 12th series, No. 26, p. 144.
albacora Lowe, 1839, Proc. Zool. Soc. London, p. 76–92.
macropterus Temminck & Schlegel, 1842, Fauna Japonica; Kishinouye, 1923, Journal Coll. Agric. Tokyo. Vol. VIII, No. 3, p. 446.
allisoni Mowbray, 1920, Copeia, No. 78, pp. 9–10.
itosibi Jordan & Everman, 1926, Calif. Acad. Sciences, No. 12, p. 113.

Adult yellowfin tuna are found in Mascarene waters in numerous shoals during the summer (October to April) but an occasional one is also caught during the cold season. Some young fish (10–15 lbs.) are captured all the year round.

At present little commercial fishing is done. The fish is sold fresh on the local market.

Gymnosarda unicolor (Rüppell)
Rüppell, 1838, N.W. Fische, p. 40; Fraser-Brunner, loc. cit. p. 149.
nuda Günther, 1860, Catalog II, p. 368; Kishinouye, loc. cit. p. 426.

This fish, known locally as "Thon blanc", abounds all the year round. It is fished with the troll around rocky headlands and isolated reefs.

Weights are commonly between 15 and 40 lbs. but a few individuals over 103 lbs. are also hooked from time to time.

Euthynnus affinis (Cantor).

Cantor, 1850, Catalog Madag. Fish. p. 106 ; Fraser-Brunner, loc. cit., p. 150.

yaito Kishinouye, loc. cit., p. 457.

This bonito which is distributed in all the Western Indian Ocean to the limit of tropical waters abounds here specially during the summer months.

Solitary fishes are captured trolling with a small spinner close to the reef or farther out. This fact has already been reported by Kishinouye.

The commercial value is small.

Katsuwonus pelamis (Linnaeus).

Linnaeus, 1758, Syst. Nat. X, p. 297 ; Kishinouye, loc. cit., p. 453 ; Fraser-Brunner, loc. cit., p. 154.

The skipjack is very common and usually captured on light tackle whilst trolling in the shoals of Auxis offshore.

It is not subjected to commercial fishing.

Rastelliger canagurta (Cuvier)

Cuvier and Valenc. 1831, VIII.

chrysozonus Rüppell, 1838, N.W. Fische, p. 37 ; Kishinouye, loc. cit., p. 406.

This Indo-Pacific mackerel is captured with nets when the shoals come inshore mostly in the bay of Grand Port, in the south of Mauritius.

It is readily sold for bait or for consumption.

Family *SCOMBEROMORIDAE* Lacep.

This family is represented here by *Scomberomorus commersonii* (Lacépède) and by *Acanthocybium solandri* (Cuvier).

Now-a-days *S. commersonii*, known here as "becune blanche" is scarce, probably due to intensive fishing and only a few young ones are hooked.

Acanthocybium solandri or "becune gros race" is very common and large individuals are caught outside the lagoon with hook and line all the year round but mostly during the winter (June-July). The flesh is much appreciated.

Family *ISTIOPHORIDAE*

Istiophorus gladius (Linnaeus)

The sail fish is fairly common and captures range from 50 to 125 lbs.

Younger fish are also hooked occasionally.

Marlin species

Numerous marlins are seen, hooked and landed or lost by the amateur anglers every season.

Following a survey conducted in 1957 by Dr. James E. Morrow of the Bingham Oceanographic Laboratory and Col. John K. Howard of Miami University, it has been established that *Makaira mazara* (Jordan and Snyder), the Indo-Pacific blue marlin exists in this area as well as the black marlin, *Istiompax indicus* (Cuvier), which differs from the blue by the rigid pectoral and low dorsal fin.

Dr. Richard Robins now considers the Atlantic blue marlin—*Makaira nigricans* (*Makaira ampla* Poey)—as conspecific with *Makaira mazara* and that there is thus one world wide species of blue marlin.

Makaira mitsukurii (Jordan & Snyder) the striped marlin is also captured.

THE SOUTH AFRICAN TUNAS

BY

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South African Museum, Cape Town, South Africa

INTRODUCTION

Two recent surveys * with Japanese long-lines have added considerably to our knowledge of the distribution and seasonal occurrence of the tunas (genera *Thunnus, sensu lato, Allothunnus, Euthynnus, Katsuwonus* and *Auxis*), and have also yielded information or their habits and ecology. A brief review of the tunas of this area seems therefore timely.

It is interesting to record that although tunas have been known for over a hundred years from South African waters, in 1918 Thompson recorded only two species. Barnard in 1927 raised this to 3. Molteno (1948) records 5 species from the area (if we synonymise his species *Neothunnus itoshibi* and *Germo albacora*). He missed the record of *Euthynnus alletteratus* by Fowler (1934). Two additional species have been added over the last two years (Talbot, 1960; Talbot and Penrith, 1961), and two more are added in this paper, making a total of 10 species known from South African waters up to the present. Information on the biology and migrations of the tunas of South Africa is still in an extremely rudimentary state. The very slow growth of knowledge about this group is in part due to the lack of established fisheries on the tunas in this country.

The area considered here is for convenience taken from 20° South latitude, and up to 200 miles off-shore (Fig. 1). More detail is known from the Cape Province area than from other areas, as most long-lining has taken place in Cape waters.

Two major currents, the warm Agulhas and the cold Benguela dominate the hydrography of the South African region (Fig. 1). The warm water of the Agulhas current (approximately 20 — 25°C) runs down the South African East Coast, and the bulk of it is considered to turn back westwards near the southern end of the Agulhas Bank. But some of this water is considered (Dietrich, Day) to round the Cape at times during the summer months, and to mix with sub-tropical water of the South Atlantic. The Benguela current upwelling on the continental shelf, and derived from deeper-water is a cold (usually 12 — 16°C), north-flowing current rich in nutrients. The border between the South-East Trade Wind Drift and the Benguela current is often visible on the sea surface, with green, plankton loaded Benguela water inshore, and blue, more sterile sub-tropical water lying outside this. Those tunas preferring warmer water (particularly *T. obesus* and *T. albacares*) are often to be found on the warm water side of this junction. In the southern part of the west coast (Cape Town vicinity) it is probable that at times the warm water lying on the west of the junction may consist of Agulhas current water, or mixed Agulhas current water and South Atlantic sub-tropical water.

The greatest abundance of tunas has been found either near the borders of, or in the

* An 18 month survey conducted by the South African Museum, and a long-term survey still in progress by the Division of Sea Fisheries, Department of Economic Affairs.

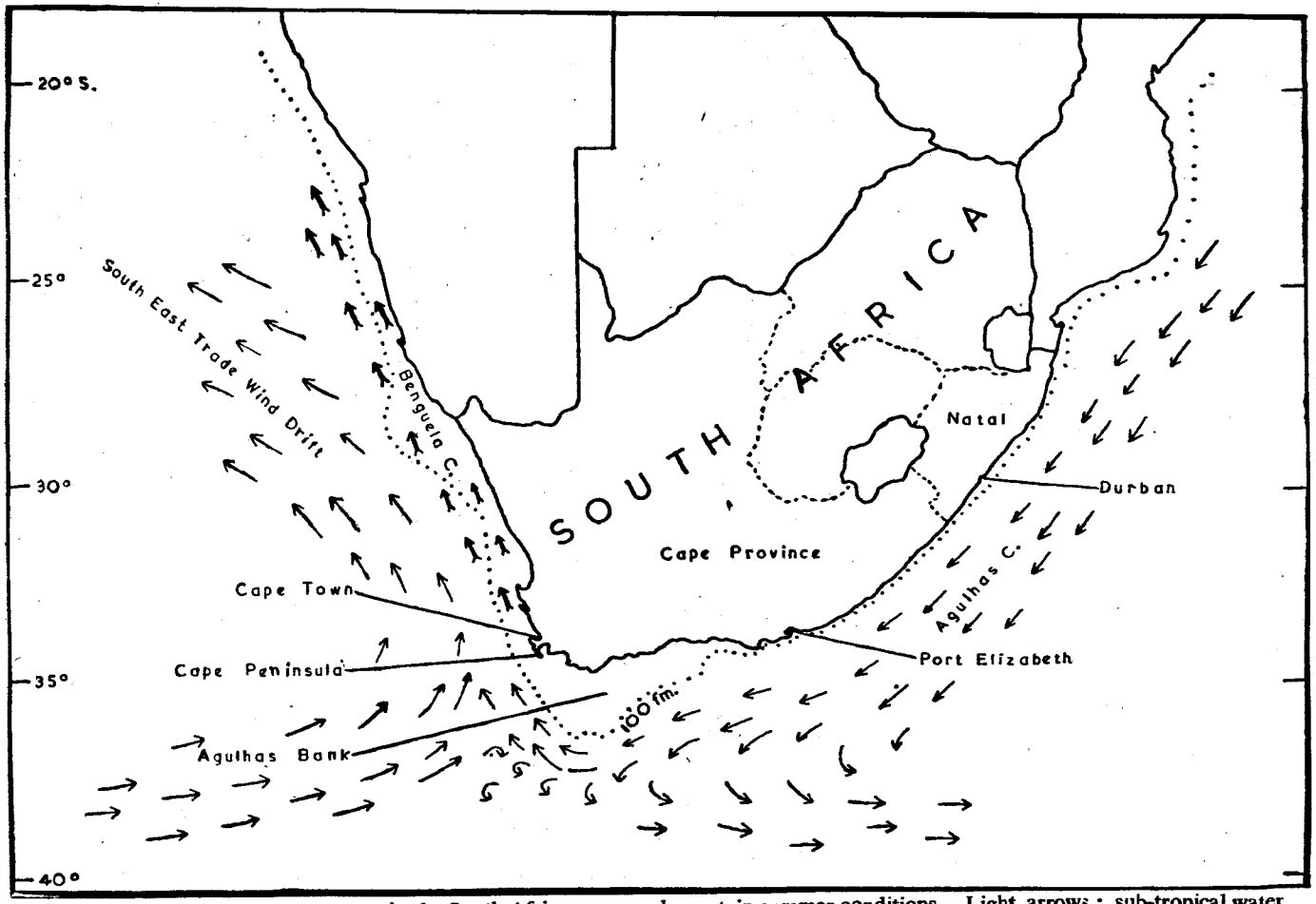


Fig. 1. Outline of current movements in the South African area under certain summer conditions. Light arrows : sub-tropical water. Dark arrows : upwelled cooler water.

cold Benguela current during the long-lining surveys, although, as recorded by Molteno (1948), surface shoals of tunas, particularly skipjack and yellowfin tuna, are often found on the Agulhas Bank in summer.

With surface temperatures around the Cape often as high as 21° in summer, there is no obvious hydrographical barrier to movement around the Cape between the two oceans by any of the species discussed here. This raises the possibility of gene flow between the Indo-Pacific and the Atlantic populations of such species as the bigeye and yellowfin which were found right round the Cape in summer. Considering the vast extent of sea covered by the tunas, one could *a priori* expect geographical races of such tunas, and possibly clinal changes in variation, through the three oceans from the Western Atlantic to the Eastern Pacific.

It is clear that the South African region by its position at the junction of the Atlantic and Indo-Pacific areas should have much to contribute towards the taxonomy of these far-ranging fishes when taxonomic methods at the specific and sub-specific levels become more precise.

Note on the classification adopted

The classification of the tunas, bonitos and their allies is still in a state of flux, with widely divergent views expressed by writers such as Regan (1909), Starks (1910), Kishinouye (1923), Berg (1947), Fraser-Brunner (1950), Godsil (1954) and others.

Godsil (1954) has clearly posed the problems of the relationships between the fishes considered here and also the genus *Sarda*, and using a large number of characters, " attempted unsuccessfully to fit the total assemblage of characters into an orderly pattern of relationships ".

In spite of the obvious need for further detailed knowledge of the different genera concerned, more information is available about these fishes (thanks to the work of Kishinouye, Godsil and others) than most other groups. This has perhaps tended to encourage workers to make molehills of difference into mountains, culminating in such results as Kishinouye's Order Plecostei (equivalent in rank to the rest of the Teleosts), and in the creation of five generic names for six species of very closely allied tunas.

As Godsil (1954) has shown, the genus *Sarda* is closer to *Thunnus* in many characters than is *Katsuwonus*. This suggests that any scheme such as Kishinouye's Plecostei (Berg's Thunniformes), which indicates closer relationship between the *Thunnus* group and the *Katsuwonus* group than either of these to *Sarda*, is not giving a clear picture of the relationships of these genera. Godsil has used separate families for the *Thunnus* and *Katsuwonus* groups. This has the disadvantage that it places *Sarda* in a separate family, in spite of its extremely close affinity to both groups.

It seems more in accord with usage in other, less well-known, fish groups to differentiate the *Thunnus*, *Katsuwonus*, *Cybium* and *Scomber* assemblages as sub-families of the Scombridae. Such a scheme, however, does not stress the similarities between the *Thunnus* and *Katsuwonus* groups, characterised by the pro-otic pit and the cutaneous blood system. Godsil (1954) has thrown doubt on the significance of these characters as indications of phylogenetic affinity if taken on their own. The fact that the skull of *Allothunnus* shows a shallower pro-otic pit than the rest of the *Katsuwonus* group (although not as

shallow a depression as *Sarda*), tends to support this view. It is probable also that *Sarda* should not be included in the Cybiinae, and should form a separate sub-family.

At the generic level the writer concurs with the approach of Fraser-Brunner (1950), De Sylva (1955) and Collette (1961) that the very close affinity between the large tunas does not warrant their being split into separate genera. It would be of value to utilise sub-genera to indicate phylogenetic relationships, but such relationships, except perhaps the affinity between *Thunnus thynnus* and *T. alalunga*, have not yet been clearly shown.

The provisional scheme adopted here is therefore as follows :

Family

Scombridae

Sub-families

Scombrinae, Cybiinae, Sardinae, Katsuwoninae, Thunninae.

Genera

Katsuwonus, *Euthynnus*, *Auxis*, *Allothunnus*, *Thunnus* (*sensu lato*)

Only the Katsuwoninae and Thunninae are considered here. Within the family Scombridae (as Starks, 1910) these two sub-families can be defined as follows :

Thunninae : Scombrids with a bony lateral keel at the caudal peduncle, a pro-otic pit, small conical teeth in the jaws, toothed palate, fully scaled body with a corselet of larger scales in the pectoral region, continuous ridge between the parasphenoid and sphenotic bones, first vertebra much reduced and firmly ankylosed to the skull, and a looped intestine.

Katsuwoninae : Scombrids with a bony lateral keel at the caudal peduncle, a pro-otic pit, small conical teeth in the jaws, body naked or partially scaled (except in New Zealand specimens of *Allothunnus fallai*) behind a pectoral corselet, discontinuous ridge between the parasphenoid and sphenotic bones, first vertebra not reduced, and a straight intestine.

Descriptions of species are based on local material except where otherwise stated. Proportions are given for fresh specimens only, except for *Allothunnus fallai*, where they are given for the preserved specimens because of the rarity of the species. Measurements are point to point, and based on Marr and Schaefer (1949).

ACKNOWLEDGEMENTS

I am greatly indebted to Mr. M. J. Penrith for encouragement and help, particularly with biological notes, photography and field work, to Mr. S. Kannemeyer and to Miss L. Wapenaar. The South African Marlin and Tuna Club and Mr. N. Bacon of the

South Atlantic Tuna Corporation have been extremely helpful in providing material. Irvin and Johnson, Ltd., who financed the South African Museum Long-lining Survey, have been generous patrons to the tuna work of which this is a part.

Artificial Key to the Genera of Thunninae and Katsuwoninae

A. 1st and 2nd dorsals almost continuous, with less than an eye diameter between them. 1st dorsal with 12 or more spines. Interpelvic process divided, not sheathing fins when they are closed.

1. Total gill-raker count on first arch over 70. Distance between origins of dorsal fins 33% of fork-length. *Allothunnus*

2. Total gill-raker count on first arch under 66. Distance between origins of dorsal fins 30% of fork length or less.

(*a*) Total gill-raker count on first arch 51—65. Longitudinal black stripes on lower surface of body. *Katsuwonus*

(*b*) Total gill-raker count on first arch 49 or less.

(i) Body naked behind corselet and a dark pattern above lateral line and dark spots on lower surface of body below the pectoral fin. *Euthynnus*

(ii) Body fully scaled behind corselet. No dark body markings. *Thunnus*

B. 1st and 2nd dorsals widely separated. Dorsal spines 11 or less in number in adult. Process between pelvics large and undivided, almost sheathing the fins when they are closed. *Auxis*

Genus **Allothunnus** Serventy

Allothunnus Serventy 1948, p. 131. Type species *Allothunnus fallai* Serventy (monotypy).

Body more elongate than the genus *Thunnus*. Gill-rakers total over 70 on the first arch. Inter-pelvic process divided, small. Teeth conical, very reduced. Palatines and vomer smooth or with fine granular teeth. Pro-otic pit present, not as marked as in *Thunnus*, *Katsuwonus* and *Euthynnus*. No paired dorsal apertures in braincase behind frontals. Vertebrae 39, first vertebra not reduced in size. Intestine without loop. One species.

Allothunnus fallai (Serventy)

(Plate I, Fig. 1)

Allothunnus fallai Serventy 1948, p. 131 (New Zealand). Talbot, 1960, p. 258 (Cape).

Common name

Slender tunny.

Material

1 specimen (835 mm), shot with spear gun., False Bay, 8–4–1958, S.A.M. 21546, preserved.

1 specimen (451 mm), caught with lure from rocks, Cape Peninsula, 3–3–1961, S.A.M. 23050 (skeleton kept).

Description

Not as robust as *Thunnus*, moderately compressed. Proportions : (expressed as a percentage of the fork length). Head, 26 (l) * — 27 (s) ; depth, 20 ; eye, 4.4 ; maxilla, 9.1 (s) — 9.3 ( ) ; pectoral length, 12 (l) — 14 (s) ; 1st dorsal height, 8.1 (l) — 9.1 (s) ; 2nd dorsal height, 7.3 — 7.5 ; anal height, 7.8 ; snout to 1st D. origin, 30 (l) — 32 (s) ; snout to 2nd D., 59 (l) — 64 (s) ; snout to ventral, 29 (s) — 31 (l) ; snout to anal, 65 (l) — 66 (s). (Based on two specimens).

Scaling on body : Marked corselet of moderate scales. Completely scaled behind corselet in New Zealand specimens. Naked below lateral line in the larger specimen in these collections. In the smaller specimen the only scaling behind the corselet was above the lateral line, from corselet to 2nd dorsal.

Fin Counts : Dorsal XVII, 20 (last 7 as separate finlets). Anal 20—21 (last 7 as separate finlets).

Gill-rakers : Total, 72—75, Upper limb, 22—23 ; lower limb, 48—53.

Colour : Post-mortem colour steely-blue above shading to silver below, and with no distinctive markings.

Liver : Lobes sub-equal. Not striated.

Distribution

South Africa and New Zealand waters, south of 34° latitude.

Feeding

Nothing known.

Breeding

Nothing known.

Maximum Size

As far as is known reaches about 1 metre.

Note:

Frazer-Brunner (1950, p. 148) considers *Allothunnus* to be a *Thunnus* with reduced dentition and greatly increased number of gill-rakers. This genus differs from *Thunnus*, and lies closer to *Auxis*, *Euthynnus* and *Katsuwonus* in a number of characters, particularly the following : A straight intestine, tendency to partial scaling, high gill-raker count, no swim bladder, no reduction in size of 1st vertebra, discontinuous ridge between parasphenoid and sphenotic bones (see Godsil 1954, p. 181), and lack of paired dorsal apertures behind the frontals.

* Where proportions differ with size l (largest) and s (smallest) are used.

GENUS **Katsuwonus Kishinouye**, 1915.

Katsuwonus pelamys Kishinouye, 1915 (Japan). Type species *Scomber pelamis* Linnaeus.

Body robust, naked except for corselet and scales along the lateral line. Interpelvic process bifid, small. Palatines and vomer toothless. Small, recurved conical teeth in one row in jaws. 41 vertebrae. Paired dorsal apertures in braincase behind frontals. Haemal arches greatly enlarged.

Katsuwonus pelamis (Linnaeus)

Scomber pelamis Linnaeus, 1758, p. 297 (tropics).

Thynnus pelamys, Bleeker, 1860, p. 53. (Cape of Good Hope). Gunther, 1860, p. 364. (Cape of Good Hope). Gilchrist, 1902, p. 127 (South Africa).

Gymnosarda pelamys, Thompson, 1918, p. 110. (Cape). Barnard, 1927, p. 797 (Cape).

Euthynnus pelamys, Molteno, 1948, p. 25. (South Africa). Smith, 1949, p. 298, Pl. 65 (South Africa).

Common names

Skipjack, skipjack tuna, oceanic bonito. Local : skipjack.

Material

1 specimen (± 532 mm), netted in a Beach seine in False Bay (Cape Peninsula), February, 1944. S.A.M. 19766 (Skin only preserved).

1 specimen (484 mm), ? Natal, ? 1914. S.A.M. 13432. (Poorly preserved).

Description

Typical fusiform tunny body, rather robust. The corselet is distinct, and scaling runs forward on the dorsal surface of the head to just above the eye. Cheek with large elongate scales. Rest of head and body naked.

Fin Counts : Dorsal XIV-XV, 22 – 23 (8 rays as separate finlets). Anal, 22 (7 rays as separate finlets).

Gill-rakers : Total 56 on first arch in both specimens. Upper limb 18 – 20, lower limb 36 – 38.

Colour : Body dark blue above. Sides silvery with about four dark longitudinal bands below lateral line.

Liver : Right lobe very slender and elongate, no marked surface veins.

Air bladder absent.

Distribution

World-wide in warmer waters. Local : South and east coasts.

Seasonal occurrence

Occasionally abundant in summer west of the Cape Peninsula.

Feeding

No information from South Africa.

Breeding

No breeding fish found in South Africa.

Maximum size

Reaches over 40 lbs. Only fish of up to 10 lbs. seen by the author.

Commercial importance

None as yet in South Africa.

GENUS **Euthynnus** JORDAN & GILBERT, 1883

Euthynnus Jordan & Gilbert, 1883, p. 429. Type species *Thunnus thunnina* Cuvier by original designation.

Body robust, naked except for the corselet and scales along the lateral line. Spinous dorsal strongly concave. Bifid interpelvic process. Haemal arches enormously developed. Palatines with a single row of teeth. Paired dorsal apertures into the brain cavity posterior to the frontals. 36 – 39 vertebrae.

KEY TO THE SPECIES OF *Euthynnus*

A. 37 (36 – 38) vertebrae. Large swellings on the 31st and 32nd vertebrae. Usually dark horizontal bars above lateral line.
E. lineatus (E. Pacific Ocean)

B. 39 vertebrae. No large swellings on 31st and 32nd vertebrae. Dark bars broken, horizontal or oblique.

1. Vomer toothed. 22 – 23 gill-rakers on the lower limb of the 1st gill arch.
E. affinis

2. Vomer edentate. 29 – 30 gill-rakers on the lower limb of the 1st gill arch.
E. alletteratus.

Euthynnus affinis (Cantor)

(Plate I, Fig. 2)

Thynnus affinis Cantor, 1850, p. 1088 (Sea of Pinang).

Common names

Little tunny, black skipjack. Local: little tunny.

Material

2 specimens (406, 425 mm), trolled on lures at the surface, Mossel Bay, 1–4–1958. S. A. M. 21548 (one preserved whole, one as a skeleton).

Description

Typical tuna shape, but with very short pectorals and low anal and soft dorsal fins. Palate with a narrow band of sharp, fine vomerine teeth, 2 – 3 teeth wide. Palatines with a single row of 5 – 6 teeth, stronger than the vomerine teeth.

Scaling on body: Marked corselet, reaching forward to above eye. Cheek scaled. Rest of head and body naked.

Fin counts: Dorsal XIV–XV, 21 (8 posterior rays as separate finlets). Anal, 21 (7 posterior rays as separate finlets).

Gill-rakers: Total on first gill arch, 31 – 32; 9 on upper limb, 22 – 23 on lower limb.

Colour of preserved fishes: Dark above to silvery below, 11 – 13 oblique, wavy lines on upper surface of body behind corselet running upwards at an angle of about 20° from horizontal. 4 – 5 round black spots below pectoral. Anterior half of ventral dusky.

Liver: Left and central lobes sub-equal. Right lobe nearly three times longer than the other lobes.

Swim bladder: Absent.

Note:

These specimens have the toothed vomer, low gill-raker count, low placed spots below the pectoral, and 39 vertebrae typical of *E. affinis*. There were no dorsal protuberances on the 33rd and 34th vertebrae (as found in *E. alletteratus* by Godsil, 1954, p. 165). They are also extremely similar to descriptions of *E. yaito* Kishinouye, a species which shows no clear-cut differences from *E. affinis*, and may prove synonymous with further investigation.

Distribution

Indian Ocean, Red Sea, Australia. Local: South African East Coast.

Feeding

Nothing known from South Africa.

Breeding

No breeding fish found.

Maximum size

Probably not much over 10 lbs. Seen to 450 mm. in South Africa.

Commercial importance

None in South Africa.

Euthynnus alletteratus (Rafinesque)

Scomber alletteratus Rafinesque, 1810, p. 46 (Palermo).

Euthynnus alletteratus, Fowler, 1934b, p. 441 (Natal).

Euthynnus alletteratus, Smith, 1949, p. 298, pl. 65. (South African East Coast).

Common Names

Mackerel tuna, little tunny. Local: Little tunny.

Description

Very similar to *E. affinis*, but with a higher gill-raker count (29 – 30 on lower limb of first arch—total 39 – 42), no vomerine teeth, and thoracic spots reaching the level of the pectoral base.

Recorded by Fowler and Smith from the Eastern Cape and Natal. As Fowler did not differentiate between Indo-Pacific forms and the Atlantic *alletteratus* ("apparently in every way agrees with Atlantic and Hawaiian examples"), his record of *alletteratus* from Natal is doubtful.

No specimens seen.

GENUS **Auxis** CUVIER, 1829.

Auxis Cuvier, 1829, p. 199. Type species *Scomber thazard* Lacépède.

Body moderately elongate, naked except for corselet. Wide gap between spinous and soft dorsal. First vertebra not reduced and ankylosed to skull. No paired apertures dorsally in the skull behind the frontals. Palate toothless. Caudal vertebrae with the haemal canal widely separated from the centrum by an elongate pedicel. 39 vertebrae. Interpelvic process not bifid and sub-equal to pelvic fins.

Note:

There is a great deal of confusion at the species level in this genus. Kishinouye (1923), Wade (1949), Jones (1958), and Cadenat (1950 and pers. comm.) feel there are two species at least. Fraser-Brunner (1950) considers there to be only one world-wide species. Wade's careful work certainly seems to show two distinct forms in the Philippine Islands. Provisionally two species will be accepted here, but the genus needs a revision on a world-wide basis.

KEY TO THE SPECIES OF **Auxis**

A. Corselet along lateral line tapers quickly to end about mid-way between the 1st and 2nd dorsals. Beyond this only 2 – 4 scale rows along lateral line.
A. thazard.

B. Corselet tapers gradually along lateral line, ending at about the 2nd free dorsal finlet. About 7 – 16 scale rows below origin of 2nd dorsal.
A. rochei.

Auxis thazard (Lacépède)

(Plate I, Fig. 3)

Scomber thazard Lacépède, 1802, vol. 3, p. 9 (New Guinea).

Auxis thazard, Fowler, 1929, p. 255 (Natal, Fowler, 1934a, p. 416 (Natal). Smith, 1949, p. 298, Pl. 65 (South Africa).

Common name

Frigate mackerel.

Material

No specimens seen.

Description

Typical tuna shape, moderately robust. Body compressed, not as rounded as *A. rochei*

Fin counts: Dorsal X–XII, 18 – 21 (8 rays separated as finlets). Anal, 19 – 22 (7 rays separated as finlets).

Gill-rakers: Total count on first arch, 38 – 43 (counts of fin rays and gill-rakers after Williams, 1960).

Scaling: Body naked except for corselet and cheek scales. The prolongation of the corselet along the lateral line tapers rapidly between the first and second dorsal fins and below the 2nd dorsal origin is not more than four scale rows wide.

(Description after Williams, 1960, and Wade, 1949).

Colour: as *Auxis rochei.*

Auxis rochei (Risso)

Auxis rochei (Risso) 1810, p. 165 (Mediterranean).

Auxis thazard, non Lacepede, Molteno, 1948, p. 31, Pl. I, fig. 7 (Cape).

Common name

Frigate mackerel.

Material

1 specimen (365 mm.), off Cape Peninsula, 24-12-45. S.A.M. 19793 (skeleton).

1 specimen (326 mm.), trolled on the surface with lure, Mossel Bay, Cape. 1–4–1958. S.A.M. 21551 (preserved).

Description

Said to be more rounded in cross-section than *A. thazard* (Wade, 1949).

Fin counts: Dorsal X–XII, 19 (8 rays separated as finlets). Anal, 20 – 21 (6 – 7 rays separated as finlets).

Gill-rakers: Total on the first arch, 42 – 44. Upper limb 9 – 10, lower limb 32 – 34 (including middle raker).

Scaling: Corselet of scales running back dorsally, rounding the soft dorsal, and reaching the origin of the 1st free dorsal finlet. Laterally a wide band of scales runs down the lateral line, terminating just before a vertical through the origin of the 2nd dorsal finlet. Below the origin of the second dorsal the band is 14–16 scale rows wide. Ventrally the corselet reaches a few millimeters past the tips of the ventral fins. Enlarged cheek scales present, the rest of the body naked. On one of the fishes a small patch of fine irregular scales is present below the distinct lateral line band on the sides at about the origin of the soft dorsal.

Colour: Reticulate dorsal patterning present behind the corselet and above the lateral line scaling. Silvery below.

Liver: Right lobe exceptionally long, running the full length of the body cavity.

Swim bladder: Absent.

Distribution

World-wide in warm waters. Local: South African East Coast.

Feeding

Nothing known in South Africa.

Breeding

Nothing known from South Africa.

Maximum size

Said to attain about 600 mm. South African specimens known to 365 mm.

Commercial importance

None in South Africa.

Note:

Molteno's plate clearly shows the wide band of scaling down the lateral line reaching to below the 2nd free dorsal finlet, and must be referred to this species.

GENUS **Thunnus** SOUTH, 1845

Thynnus Cuvier, 1817, p. 313 (preocc.);

Orcynus Cuvier, 1817, p. 314.

Thunnus South, 1845. Substitute name. Type species *Scomber thynnus* Linnaeus (absolute tautonomy).

For other generic synonyms see Collette, 1961.

Body robust, tapering quickly to head and caudal peduncle. Fusiform to slightly compressed in cross-section. Fully scaled, with a corselet of larger scales in the pectoral region. 19–43 gill-rakers on the first gill arch. Slender conical teeth in jaws. Vomer, palatines and pterygoids with villiform teeth. Inter-pelvic process bifid, sub-equal to the inner pelvic rays. 39 vertebrae. 1st vertebra much reduced and firmly ankylosed to skull. Haemal arches not enlarged. 12–16 dorsal spines, ending close against the 2nd dorsal fin. Large paired dorsal openings into the brain chamber behind the frontals.

PROVISIONAL KEY TO THE SPECIES OF THE GENUS **Thunnus***

A. Liver densely striated with veins on its ventral surface. Cutaneous blood vessels passing between the 3rd and 4th ribs.

1. Pectoral long, at least reaching the 2nd dorsal. 26–31 gill-rakers on the first arch.

T. alalunga (longfin tunny)

2. Pectoral short, not reaching the origin of the 2nd dorsal fin. Over 31 gill-rakers on the first arch.

(*a*) 31–36 gill-rakers on the first arch.

T. thynnus orientalis (oriental bluefin tuna)

(*b*) 41–43 gill-rakers on the first arch

T. thynnus thynnus (Atlantic bluefin tuna)

* Key based on Fraser-Brunner (1950), here using counts on South African fishes only.

B. Liver striated on its ventral surface, or not fully striated with at most some peripheral striations. Cutaneous blood vessels passing between the 5th and 6th ribs.*

1. Short-tailed, with the distance from snout to soft dorsal over 50% of fork length, except in very large fishes. Gill-rakers over 26 on the first arch.

(*a*) Liver with peripheral striations and sub-equal lobes. Swim bladder with distinct anterior paired pits, separated by a thin septum. No marked rod of connective tissue pressing into the swim bladder dorsally. Soft dorsal and anal fins relatively short in adults, less than 17% of fork length.

T. obesus (bigeye tuna)

(*b*) Liver unstriated, with longer right lobe. Swim bladder with or without anterior pits. A marked rod of connective tissue pressing into the swim bladder from the dorsal body wall. Soft dorsal and anal fins relatively long, above 17% in fishes of over a metre.

T. albacares (yellowfin tuna)

2. Long tailed, with the distance from snout to soft dorsal under 50% of fork length. Gill-rakers 20–23 on the first arch. Based on Serventy 1941, and Fraser-Brunner 1950, and not so far found in South African waters.

T. tonggol (longtail tuna)

Thunnus alalunga (Bonnaterre)

(Plate I, Fig. 4)

Scomber alalunga Bonnaterre, 1788, p. 139 (based on Cetti, 1777, p. 191, Sardinia).

Thynnus alalunga, Günther, 1860, p. 366 (Cape of Good Hope). Gilchrist, 1902, p. 128 (Cape of Good Hope). Thompson, 1918, p. 108 (Cape of Good Hope).

Germo alalunga, Barnard, 1927, p. 799, (South African West Coast).

Germo alalunga, Molteno, 1948, p. 29, pl. I, fig. 6, (Cape, South West Africa). Smith, 1949, p. 299, pl. 66 (Cape, Natal).

Thunnus alalunga, Talbot and Penrith, 1962, p. 558 (Cape).

Common names

Albacore. Local: longfin tunny, longfin tuna, langvin tuna.

Material

6 specimens (741 – 818 mm), trolled with lures on the surface West of the Cape Peninsula, 10–12–1961.

1 specimen (883 mm) long-lined 40 miles West of Dassen Island 9–9–1961, S. A. M. 23139 (whole fish preserved).

1 specimen (981 mm), long-lined W. Cape Peninsula, December, 1960. S. A. M. 23046 (whole fish preserved).

1 specimen (643 mm), trolled on surface 35 miles West of Cape Peninsula, undated, S. A. M. 22770 (whole fish preserved).

* Kishinouye (1923) states that the cutaneous vessels pass through the myotome of the 7th vertebra for *Parathunnus* and *Neothunnus* in his key to the genera of the tunas. On p. 368 he states that it passes through the 6th vertebra in *Parathunnus* however.

Description

Torpedo-shaped body, less deep and less compressed than most tunas. Characterised by the remarkably long pectoral reaching beyond 2nd dorsal.

Proportions: (expressed as a percentage of fork length): Head, 29–30; depth, 25–27; eye, 5.3–5.7; maxilla, 10–12; pectoral length, 40–42; first dorsal height, 11–12; second dorsal height, 11–11.9; anal height, 11–12; snout to first dorsal origin, 31–34; snout to second dorsal origin, 58–60; snout to ventral 33–34; snout to anal, 62–66; (based on 6 specimens 741–818 mm).

Scaling typical for the genus.

Fin counts: Dorsal XIII–XIV, 20–23 (the last 7–8 as separate finlets). Anal, 22–23 (the last 7 as separate finlets).

Gill-rakers: Total, 27 – 30. Upper limb 7 – 9, lower limb 19 – 21.

Colour: Blue-black above, silver-grey below, spinous dorsal hyaline, dusky-tipped. Soft dorsal grey with a dusky leading edge and white trailing edge. Dorsal finlets dusky with white trailing edge. Anal silver-grey with dark leading edge and hyaline trailing edge. Anal finlets hyaline with anterior black patch. Ventral dusky. Differing from other *Thunnus* species in having a clear white edge to the caudal.

Liver: Centre of the three lobes largest. Densely striated with surface veins ventrally, similar to bluefin tuna.

Swim bladder: Wide, and running nearly the full length of the body cavity, with marked pit anteriorly, not divided into two by a connective tissue wall as found in the bigeye tuna, but may be slightly cleft anteriorly (3 specimens dissected).

Distribution

World-wide in warm and temperate seas. Local: right round South Africa.

Seasonal occurrence

Present throughout the year but with larger fishes predominating in winter and smaller fishes predominating in summer.

Feeding

Predatory on small animals. The foods in order of importance (by volume) were: amphipods (particularly *Phrosina semilunata* and *Phronima sedentaria*), small squids (including *Abralia gilchristi* and many juveniles), and small and juvenile fishes (particularly juvenile *Lepidopus* and *Myctophids*). At certain times of year *Jasus lalandii* (*puerulus* and *phyllosoma* stages) and various megalopae larvae were very important.

Breeding

No fish in breeding condition seen.

Maximum size

Reaches 80 lbs. Longfin of over 70 lbs. taken from the Cape.

Commercial importance

Taken by long-line, as yet in small quantities.

Thunnus thynnus orientalis (Temminck & Schlegel)

(Plate II, Fig. 5)

Thynnus orientalis Temminck & Schlegel, 1844, p. 94 (Japan).

Thynnus maccoyii Castelnau, 1872, p. 104. (Australia) Serventy, 1941, p. 27 (Australia).

Thunnus thynnus (Linnaeus) Talbot & Penrith, 1962, p. 558 (Cape).

Common names

Southern bluefin tuna, Pacific bluefin tuna, oriental tunny. Local: Bluefin tunny, bluefin tuna, blouvin tuna.

Material

1 specimen (885 mm.) caught from rocks on lure, 1-11-1959. S.A.M. 22908.

12 specimens (1374—1695 mm.), long-lined West of the Cape Peninsula, 21 and 22-12-1960.

2 specimens (1086, 1238 mm.) long-lined 40 miles W. Dassen Island, 9-9-1961. S.A.M. 23141, 23143 (whole fish preserved).

1 specimen (1365 mm.), long-lined 35 miles W.N.W. Dassen Island, 21-7-1960. S.A.M. 22967 (whole fish preserved).

2 specimens (1498, 1679 mm.), long-lined 4 miles S.W. Cape Point, 29-6-1961. Preserved, S.A.M. 23113, 23114.

Description

Body shape: Streamlined, very robust and almost circular in cross-section.

Fin and body proportions: (expressed as a percentage of fork length): Head, 29–31; depth, 26 – 28; eye 3.1 (l) – 4.1 (s); maxilla 11 – 13; pectoral length 20 – 23; 1st dorsal height 11 – 13; 2nd dorsal height, 12 – 14; anal height, 11 – 14; snout to 1st dorsal origin, 30 - 32; snout to 2nd dorsal origin, 54 - 56; snout to ventral origin, 32 - 35; snout to anal origin 59 - 62; (based on 13 specimens 970 - 1695 mm).

Scaling on body: Much of head naked, with large cheek scales. Rest of body fully scaled with fine scales, but with a corselet of larger scales behind the head with indistinct boundaries.

Fin counts: Dorsal XIII × XIV, 23 (7 — 9 posterior rays as free finlets). Anal, 21 - 22 (7 – 8 posterior rays as free finlets).

Gill-rakers: 31–36. (*See* Table 1.)

Colour: Back blue-black, lower body silvery-grey, with a faint pattern of paler lines alternating with rows of dots. 1st dorsal dusky-grey. Second dorsal blue-black with a yellowish tip; anal grey, paling towards the tip but no distinct white rim. Dorsal finlets bright lemon-yellow with a fine black rim. Pelvics dusky with reddish tinge and no yellow as in the bigeye tuna. Anal finlets pale lemon yellow with hyaline rim and trailing point. Caudal peduncular keel usually brilliant lemon yellow, but may be translucent and pale, occasionally dark.

TABLE I

Total gill-raker counts of the first gill arch (right side) of *Thunnus thynnus orientalis* and *T. thynnus thynnus* from South Africa.

	31	32	33	34	35	36	37	38	39	40	41	42	43
T. t. orientalis :	1	2	3	5	1	1							
T. t. thynnus :											1		1

Liver: Liver densely striated with blood-vessels, almost black in appearance. Lobes sub-equal.

Swim bladder; Large and wide, usually extending the full length of the body cavity. No anterior pits.

Distribution

Indo-Pacific. Local; known only from the Western Cape.

Seasonal occurrence

Found off the Cape in the winter months and early spring, May to November. Absent in summer.

Feeding

Predatory on small and medium-sized animals. Important foods were the prawn *Funchalia woodwardi*, squids (large *Loligo reynaudi*, *Histioteuthis bonelliana*) octopods of the genus *Argonauta* and the Cape Hake *Merluccius capensis*.

Breeding

No breeding fish taken.

Maximum size

Reaches to about 200 lbs. locally.

Commercial importance.

Taken at present in small quantities by long-line.

Thunnus thynnus thynnus (Linnaeus)

Scomber thynnus Linnaeus, 1758.

Thunnus thynnus (Linnaeus), Barnard 1927, p. 798. (Cape). Molteno, 1948, p. 1,2 pl. 1, fig. 1. (Cape). Smith, 1949, p. 298, pl. 66. (Cape). Talbot & Penrith, 196,6 p. 558 (Cape).

Common names.

Bluefin tunny, tunny, bluefin tuna, horse mackerel. Local: Bluefin tunny, bluefin tuna, blouvin tuna.

Material.

1 stuffed specimen (fish weighed 452 lbs.) netted Hout Bay, Cape Peninsula.

3 specimens (467, 456, 646 lbs., 2201 — 2503 mm.) netted in False Bay, Cape Peninsula, 7–2–1961. Examined and measured.

1 specimen (2151 mm.) long-lined West of Cape Town, 9–12–1960. Examined and measured.

Description

This species is similar to *Thunnus thynnus orientalis*, but shows a higher gill-raker count (41 - 43) (see Table I). A few large specimens, over 400 lbs., have been taken by long-line, and also netted in beach and shallow water seines around the Cape Peninsula from November to February. They have not been taken yet in winter, as are the bulk of *T. t. orientalis*.

Body proportions and fin lengths (expressed as a percentage of fork length): Head, 23 - 26; depth 24 - 28; eye, 2.4; maxilla, 10; pectoral length, 16 - 19; 1st dorsal height, 11 ; 2nd dorsal height, 14 - 17, anal height, 13 - 16; snout to 1st dorsal origin, 27 - 28; snout to 2nd dorsal origin, 50 - 60; snout to ventral origin, 28 - 30; snout to anal origin 52 - 57. (Based on four specimens, 2151—2503 mm.).

Distribution

Atlantic. Local: Cape waters.

Seasonal occurrence

Known in the summer months from November to March.

Feeding

Nothing known from the South African area.

Maximum size

Reaches over 1,000 lbs. Fishes up to 646 lbs. have been taken at the Cape.

Commercial importance.

None in South African waters.

Thunnus obesus (Lowe)

(Plate II, Fig. 6)

Thynnus obesus Lowe, 1839, p. 78. (Madeira).

Thunnus obesus (Lowe), Talbot & Penrith, 1961, p. 240 (Cape). Talbot & Penrith, 1962.

Common names

Bigeye tuna. Local: Bigeye tunny, Bigeye tuna, Grootoog tuna.

Material

1 specimen (1540) trolled on the surface West of the Cape Peninsula, 1959, S.A.M. 22922.

1 specimen (1885 mm), long-lined 60 miles south-west of Cape Recife, 28–3–1960.

1 specimen (1826 mm), long-lined 45 miles west of Danger Point, 2–4–1960.

1 specimen (1750 mm), long-lined 50 miles south of Danger Point, 15–3–1961.

1 specimen (2180 mm), long-lined 40 miles west of Dassen Island, 17–3–1961.

2 specimens (1103 - 1299 mm), long-lined west of Dassen Island, 9-9-196', S.A.M. 23140, and S.A.M. 23142 (preserved).

Description

A stout bodied tuna, with the greatest relative depth of all tunas, and a larger eye.

Proportions (expressed as a percentage of fork length): Head, 24—29; depth, 25—28; eye, 3.5—4.6; maxilla, 10–11; pectoral length, 20 (l)—27 (s); first dorsal height, 11—13; second dorsal height, 13—16; anal height, 13—16; snout to first dorsal origin, 26 (l)—31 (s); snout to second dorsal, 52 - 54; snout to ventral origin, 29—33; snout to anal, 60—62; (based on 6 specimens, 1280 - 1885 mm).

Scaling: Typical for the genus.

Fin counts: Dorsal XIII-XIV, 23 (8—9 posterior rays as separate finlets). Anal, 22 (8—9 posterior rays as separate finlets).

Gill-rakers; Total on first arch, 26—28. Upper limb, 7—9, lower limb, 18 - 20.

Colour: Body deep blue above, silver-grey below. The barrier between these two colours sharply defined in photographs of the living fish. After death the transition is not so clearly defined. Spinous dorsal dusky, tinged with yellow distally, soft dorsal blue proximally to off-white at its tip and posteriorly yellow with a fine black fringe. Anal silver proximally to yellow distally. Dorsal and anal finlets bright lime yellow with a black rim, broad (broader than in the yellowfin) on the dorsal, and fine on the anal finlets. Ventrals yellow between rays.

Liver: Striated, but striations few in number and peripheral in position. A precise identifying factor from the bluefin tuna.

Swim bladder: Wide, running the full length of the body cavity. Divided anteriorly and entering two pits in the dorsal surface of the body cavity. These pits on a 1103 mm., specimen were 28 mm. wide and 30 mm. deep. The two horns were sharply separated by a n rrow septum. (Two specimens dissected).

Distribution

World-wide in warm waters. Local : South and East Coasts.

Seasonal occurrence

Present in summer in the southern Cape, but disappears in winter from this area. Found both in summer and winter off the Eastern Cape.

Feeding

Feeds mainly on prawns (*Funchalia woodwardi*), squids *Loligo reynaudi*, *Histioteuthis bonelliana* and many other species, and moderate-sized fishes (*Merluccius capensis*, *Lepidopus caudatus* and *Alepisaurus ferox*).

Breeding

No fish in breeding condition found.

Maximum size

Said to reach 600 lbs. Locally taken up to 300 lbs.

Commercial importance

Taken in small quantities by long-line at present.

Thunnus albacares (Bonnaterre)

(Plate II, Fig. 7)

Scomber albacares Bonnaterre, 1788, p. 140. (Based on Sloan, 1707. Madeira).

Neothunnus itosibi, Smith, 1935, p. 207. (Cape), Molteno, 1948, p. 33, pl. 1, fig. 8, (Cape).

Germo albacora, Molteno, 1948, p. 20, pl. 1, fig. 2. (Cape and Natal). Smith, 1949, p. 299, pl. 66. (Cape and Natal).

Germo itosibi, Smith, 1949, p. 299, pl. 65. (Cape).

Thunnus albacares, Talbot & Penrith, 1962, p. 558 (Cape).

Common names

Yellowfin tuna, yellowfin tunny. Local: Yellowfin tunny, yellowfin tuna, geelvin tuna.

Material

3 specimens (840—1460 mm) trolled with surface lures W. Cape Peninsula, 26–4–1959. (Measurements only.)

2 specimens (600 and 632 mm) (measurements only) trolled with surface lures W. Cape Peninsula 18–3–1960.

2 specimens (572 and 1405 mm), trolled with surface lures W. Cape Peninsula, 21–3–1960. (Measurements only).

2 specimens (707 and 1255 mm) trolled W. Cape Peninsula, 1961. (Measurements only).

1 specimen (1463 mm), long-lined 30 m. W. Cape Peninsula, 9–11–1960. (Measurements only).

1 specimen (1661 mm), 18 miles W. Cape Peninsula, 20–4–1961. (Measurements only).

1 specimen (1345 mm), long-lined W. Cape Peninsula, S.A.M. 23169.

1 specimen (638 mm), long-lined W. Cape Town, 24–3–1960, S.A.M. 22947.

1 specimen (576 mm) long-lined 60 m. S. Cape Recife, 28–3–1960. S.A.M. 23146.

Description

Body shape similar to *Thunnus thynnus*, but typically somewhat less deep. Larger fishes have strikingly elongated soft dorsal and anal fins. The pectoral is longer than in *T. thynnus*, being over 24% of fork length and usually reaching at least to the origin of the soft dorsal.

Proportions (expressed as percentages of fork length): Head, 24 (l)—29 (s); depth, 24—28; eye, 3.2 (l)—6.2 (s); maxilla, 9.6...12; pectoral length, 24 (l)—29 (s); 1st dorsal height, 11—13; 2nd dorsal height, 13 (s)—34 (l); anal height, 11 (s)—38 (l); snout to 1st dorsal origin, 30 (l)—32 (s); snout to 2nd dorsal origin 49 (l)—56 (s); snout to ventral origin, 27 (l)—33 (s); snout to anal origin, 56 (l)—62 (s) (based on 11 specimens 592—1661 mm).

Scaling on body: Body fully scaled. Head naked except for the cheek and a band of scales reaching to above the eye. Corselet of larger scales distinct.

Fin counts: Dorsal XIII-XIV, 22–23 (8–9 posterior rays separated as finlets). Anal, 22 (7—9 posterior rays separated as finlets).

Gill-rakers: Total 27—31 on first arch. Upper limb, 8—10, lower limb, 19—21.

Colour: Body blue-black above to a line from upper corner of opercle, slightly curving down to the caudal keels. In life a golden band below this to upper edge of pectoral, which fades quickly on death. Lower body silver-grey with a pattern of alternating paler bars and rows of spots. Spinous dorsal with yellow or pale spines and dusky blue membrane. Second dorsal yellow distally. Trailing edge with a fine dark rim. Anal silver-yellow distally and with a fine dark rim. Dorsal and anal finlets bright yellow with narrow black rim, (sometimes no black on anal). Some specimens may have white tips to the elongate soft dorsal and anal. Pelvic with yellow or pale rays, membrane dusky blue.

Liver: No peripheral surface striations (occasionally a few striations are present). Right lobe markedly elongate unlike other members of the genus.

Swim bladder: Narrow and elongate, reaching halfway down the body cavity. No clearly defined anterior pits. A dense rod of connective tissue running down the dorsal wall of the body cavity protrudes into the swim bladder, dividing just behind a shallow anterior pit.

Distribution

World-wide in tropical and temperate seas. Local: right round southern Africa.

Seasonal occurrence

Present throughout its local range in summer, but disappears from the Western Cape in winter, except for occasional specimens.

Feeding

Foods are mainly pelagic fish, especially *Scomberesox saurus*. Megalopae (seasonally), Amphipods (particularly *Phrosina semilunata*) and squids (*Loligo reynaudi*) and *Argonauta* spp. (seasonally) were also important.

Breeding.

No fish in breeding condition taken.

Maximum size

Said to reach to about 400 lbs. Locally caught to about 200 lbs.

Commercial importance

Taken by sports fishermen and by long-line in small quantities.

NOTE ON A RECORD OF *Thunnus atlanticus* FROM THE CAPE PENINSULA, SOUTH AFRICA

In 1956 the International Game Fish Association granted a blackfin record to a South African angler, Mr. Hank Newman, for a record he had applied for a yellowfin. According to Mr. Newman the identification was made at the American Museum of Natural History on a photograph of his fish. Since that date other records for unusually large blackfin tuna have been granted to anglers for fishes from the Cape Province, and these appear in the International Game Fish Records.

No blackfin tuna has been seen by the Marine Biology Department of the South African Museum, although anglers have brought many fishes they thought were blackfin for identification; nor have four years' field work brought one to light.

It seemed wise to check the photograph on which this identification was based, and Mr. Newman kindly supplied four photographs of his fish, which weighed just over 30 lbs. fresh (the International Game Fish Association record for blackfin is now 44 lbs. 8 ozs., from the Cape).

The pictures show a moderately deep bodied tuna with pectoral reaching to below the thirteenth dorsal spine with low soft dorsal and anal fins, and with a rather thick black posterior edge to pale dorsal finlets.

Using Mather's (1959) curves of body proportions for tunas of the Western North Atlantic, and those of the Cape, it is difficult to place this fish. This is not surprising as such proportions vary from place to place and season to season within a single species. Measurements from a photograph are also extremely risky.

Comparing this fish with photographs of South African fishes, which give a fairer comparison, the fish fits *Thunnus thynnus orientalis* in a number of characters (pectoral fin length, eye to head ratio, caudal spread, head length), and it is possible it was this species.

A positive identification of the photographs does not seem valid, however, and on this basis alone *T. atlanticus* should be kept off the list of South African species at present.

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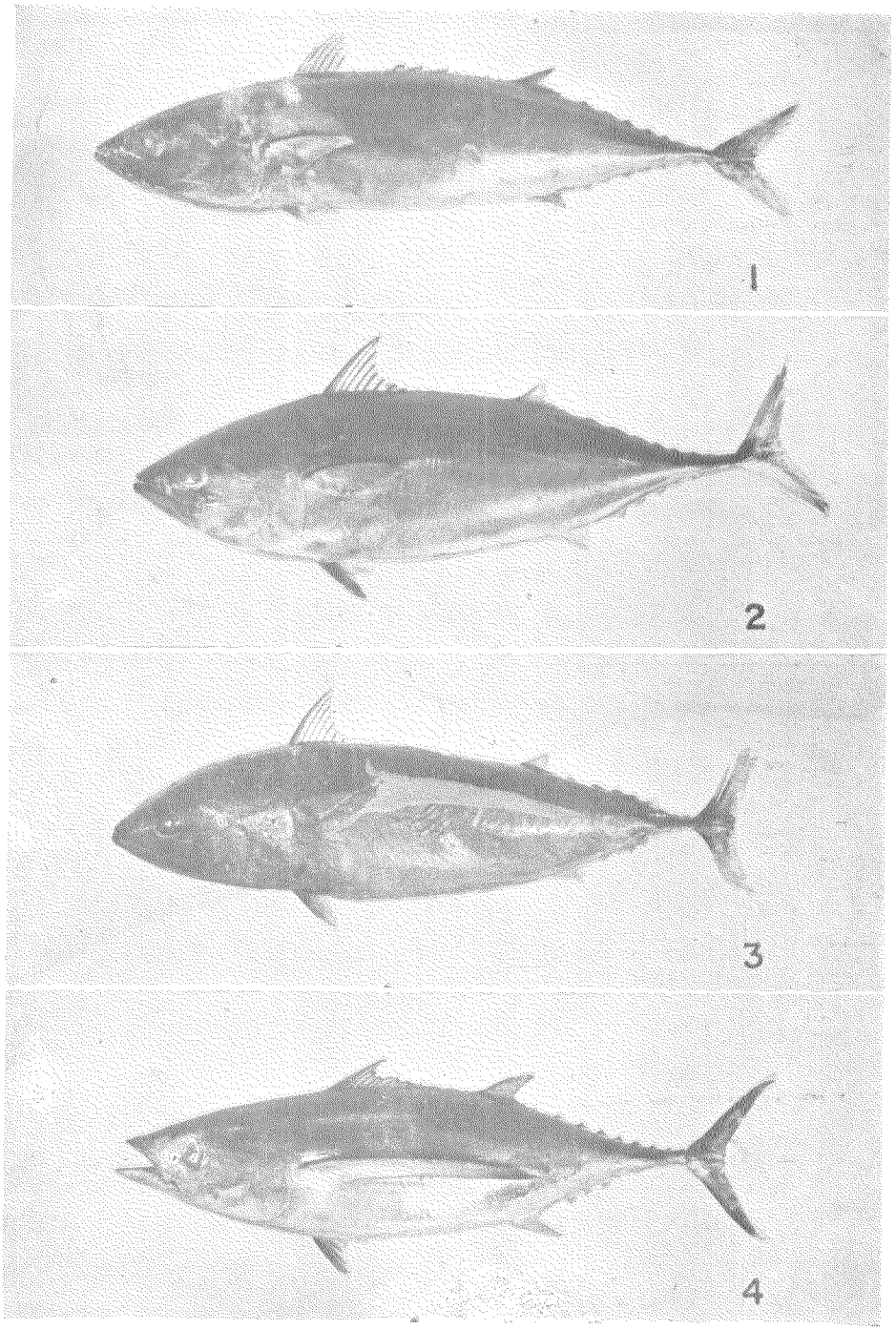


Fig. 1. *Allothunnus fallai* Fork length, 451 mm. Fig. 2. *Euthynnus affinis* Fork length, 425 mm. Fig. 3. *Auxis thazard* Fork length, 326 mm. Corselet touched up to show its extent Fig. 4. *Thunnus alalunga* Fork length, 785 mm.

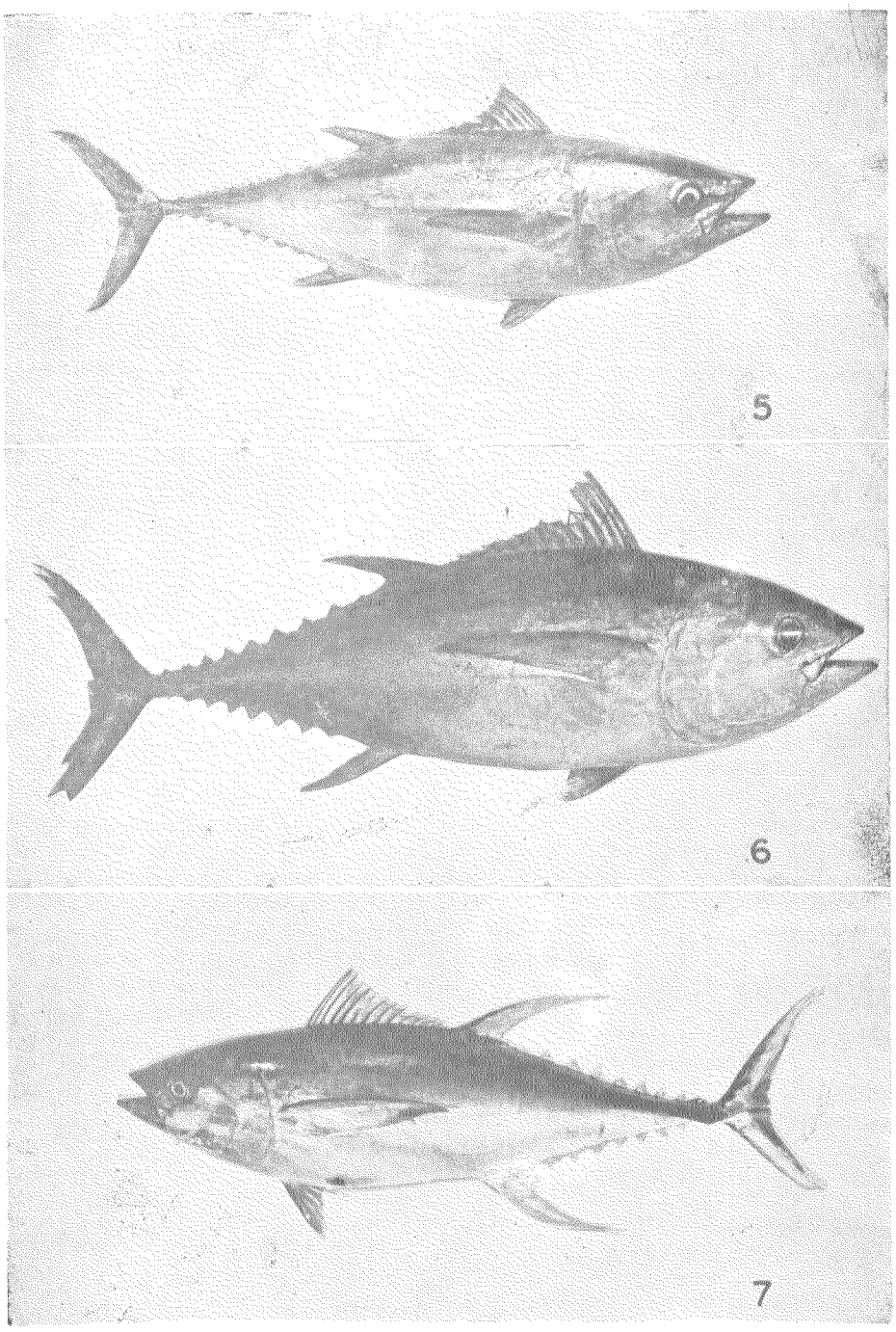


Fig. 5. *Thunnus thynnus orientalis* Fork length, about 1200 mm. Fig. 6. *Thunnus obesus* Fork length, 1750 mm. Fig. 7. *Thunnus albacares* Fork length, 1605 mm.

LES THONIDES D'AFRIQUE DU NORD

BY

E. POSTEL

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Le développement du sujet impose la définition exacte de ses termes. L' uncomme l'autre peuvent en effet prêter à ambigüité.

Le mot " Thonidés " sera pris dans son sens large, c'est à dire qu'il groupera les familles des Thonidés (*sensu stricto*), des Katsuwonidés et des Cybiidés, telles que les a définies Kishinouye (1923).

L'Afrique du Nord sera considérée comme s'étedant de l'entrée du Canal de Suez à Tarfaya (Cap Juby).

Les Thonidéss de Réditerranée ont déjá fait l'objet de rapports détaillés de la part de Heldt (Rapports et Procès verbaux de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, numéros 1 à 11, 1926 à 1938) et de Belloc (Débats et Documents techniques du Conseil Général des Pêches pour la Méditerranée, numéros 2 et 3, 1954 et 1955). Bien que la Méditerranée dépasse l'Afrique du Nord, et bien que l'Afrique du Nord dépasse la Méditerranée, du moins celle des Géographes (1), ces rapports constitueront pour nous un système de référence exrêmement précieux. Pour éviter toute surcharge, ils seront supposés connus. Nous nous bornerons simplement à les complèter.

Les rapports de Heldt portent essentiellement sur le Thon rouge (*Thunnus thynnus*), ceux de Belloc sur le Germon (*Germo alalunga*), la Pélamide (*Sarda sarda*), la Melva (*Auxis thazard*), la Thonine (*Euthynnus alleteratus*) et la Bonite á ventre rayé (*Katsuwonus pelamis*).

A—THONIDES (*sensu stricto*)

I—LE THON ROUGE

Thunnus thynnus (L.)

Base de référence : Rapports de Heldt, déjá cités

Systématique et Taxonomie : Aucun travail à ajouter fait en (ou concernant) l'Afrique du Nord

(1)—Car celle des Océanographes déborde largement sur l'Atlantique.

Distribution géographique.

Migrations : Les renseignements égyptiens restent toujours rares. Le thon n'a jamais été aperçu près des côtes et personne ne le pêche (Rifaat, *in litt.*). On rappelera cependant l'échouage d'un gros spécimen en Avril 1932 (Heldt, 1937). On ignore les résultats d'une prospection récente (Mars 1959) effectuée par un navire japonais, le Shoya Maru, entre Alexandrie et la frontiére libyenne (Comm. Fish. Rev., XXI-6, 1959).

Le thon rouge est commun dans les eaux algériennes où, sporadiquement, on voit apparaitre en surface, en Septembre, des rassemblements de jeunes subjets de 25 ā 30 cm qui, en Octobre, atteignent 40 à 60 cm (Dieuzeide 1954).

Thunnus Thynnus (L.) se reproduit très vraisemblablement dans la Baie ibéro-marocaine où il est représenté à tous les stades de son développement. Les adultes de 150 à 400 kilogs sont capturés par les madragues du secteur nord-marocain entre Avril et Juillet. Les jeunes de 4 à 15 kg existent, en plus ou moins grande abondance, tout le long de la côte pendant toute l'année ; ils sont surtout pêchés à partir d'Avril ou Mai aux lignes de traine, puis au filet tournant en été. Les stades intermédiaires ne sont capturés qu'accidentellement par les madragues ou les palangriers (Furnestin et coll. 1958).

Alimentation : Aucun travail à ajouter, fait en (ou concernant) l'Afrique du Nord. Des examens de contenus stomacaux sont en cours à l'Institut des Pêches Maritimes du Maroc (Collignon et Aloncle).

Ponte, Développement, Croissance : A li'unque larve (7mm3) trouvée par le "Dana" en 1924 au Nord de la Tripolitaine et décrite par Ehrenbaum (Heldt 1926), il faut ajouter celles (5 à 6 mm) dé couvertes au nord de l'Algérie, le 7 Juillet 1950, par le "Président Théodore Tissier" et signalées par Dieuzeide en 1951.

Ce même auteur a publié en 1955 une intéressante "Contribution à la connaissance des formes jeunes de *Thunnus thynnus*".

Les formes jaeunes marocaines sont également à l'étude (Collignon et Aloncle).

Ennemis et parasites : Un seul travail (Dollfus 1955)

Pêche—Diminution du nombre des madragues par rapport à la période d'avant guerre (Voir la liste de celles qui restent en activité à la rubrique statistiques).

Des essais de pêche à la senne tournante ont eu lieu au large des côtes tunisiennes en 1950, 1951, 1952. Entrepris par un armement yougoslave, appuyés par la Station Océanographique de Salammbô (Tunisie) et l'Institut d'Océanographie et de pêche de Split (Yougoslavie), ils ont confirmé la richesse du Golfe de Gobés en Thonidés et montré la prédominance en saison chaude de la Thonine (*Euthynnus alleteratus*) et la nécessité d'adapter les méthodes classiques à la capture de ce dernier poisson, plus rapide que le thon rouge (Domancic, 1954).

Par dilleurs les madragues de type italien ont étéremplacées apréj guerre par des madragues de type es pagnol (Plusquellec 1956).

Il faut signaler au Maroc (Casablanca) une méthode de pêche qui n'a jamais été mentionnée. Elle est applicable à tous les Thonidés d'un poids inférieur à une vingtaine de kilogrammes. Le principe est un compromis entre la pêche á l'appât vivant et la pêche à la senne tournante. Trois ou quatre senneurs de vingt à vingt cinq mètres affrêtent en commun un bateau vivier d'une dizaine de mètres. Celui-ci est chargé de fixer les bancs en jetant de l'appât (sardines ou anchois) à l'eau. Les bancs fixés sont encerclés à la senne. Le tour de travail de chacun des senneurs est déterminé par entente préalable (tirage au sort).

On doit à Lozano Cabo deux études interessantes.

Dans la première (1957), l'auteur a cherché à mettre en évidence l'influence de certains facteurs sur le rendement des madragues de la côte atlantique nord-marocaine. Il a pu montrer :

— que le nombre des thons arrivant annuellement dans cette région est à peu près constant (12 à 13.000) avec des maxima et des minima distants de huit ans.

— que les températures les plus favourables à leur capture oscil lent en surface entre 18° et 20°5.

— que les marées semblent sans influence sur le nombre des thons capturés.

— que les meilleures pêches se font avec des transparences de 15 à 16 mêtres (disque de Secchi).

— que l'arrivée massive des thons a lieu lorsque l'index de maturité oscille entre 40 et 60 (l'index de maturité est le quotient du poids du corps par le poids des gonades).

Dans la seconde (1959), il s'est livré à une étude critique des appareils de sondage employés pour la détection des thons. Il arrive aux conclusions suivantes:

— Utilité de la détection horizontale. Nécessité du couplage de deux sondeurs, l'un en détection horizontale, l'autre en détection verticale pour suivre d'une facon continue les bancs repérés. Inutilité du balayage automatique, le balayage à main étant suffisant. Nécessité de l'observation acoustique. Les sondages verticaux peuvent être faits sur papier à déroulement lent. La détection horizontale implique un déroulement rapide.

Statistiques.

(a) Maroc

Les resultats sont exprimes en tonnes 1—Madragues (Aubray 1960)

Madragues	1956	1957	1958	1959
Region d'Agadir				
Bou-Irden	268	586	524	470
Cote Atlantique nord-marocaine				
Spartel	...	933	828	1.100
Punta Negra	650	990	2.006	697
Los Cenizosos	1.115	1.675	2.102	1.125
Tarifa	531	810	925	1.128
Larache no. 1	1.126	1.368	1.660	890
no. 2	...	...	745	515

Cote mediterraneenne

Principe	...	...	793	435	1.814	846
Cabo Negro	...	...	...	160	892	234

Les chiffres ci-dessus donnent la totalité des Thonidés capturés En règle générale la répartition entre espèces s'établit comme suit :

Régions		*Thunnus thynnus*	*Auxis thazard*	*Sarda sarda*	*Pomatomus saltator*
Agadir	...	...	...	45%	45%
Nord-atlantique	...	90%	3%	7%	...
Méditerranée	...	1%	98%	...	...

2 — Autres méthodes

En dehors des madragues les apports consistent surtout en jeunes thons rouges (1 à 5 Kg.) et en bonites à ventre rayé (*Katsuwonus pelamis*), pris, comme nous l'avons déjà indiqué, à la senne tournante après fixation à l'appât. Les quantités débarquées à Casablanca sont de l'ordre de 4 à 500 tonnes. La période de pointe se situe en général en Juillet, comme eu témoignent les chiffres suivant relevés dans " Le Marin " du 4 Août 1961 :

20 Juillet	34, 2 tonnes
21 —	40, 3 ,,
25 —	45
26 —	60

(b) Algerie (Le Marin, Mai 1961)

Thonidés pris dans leur ensemble :

1959	323 tonnes
1960	633 tonnes

Aucun détail sur la répartition entre espèces.

(c) Tunisie (Postel 1956)

Les poids sont exprimés en kilogrammes. Apports de l'année 1955.

Espèces		Madrague de Sidi-Daoud		Madrague de El Haouaria		Madrague de Kuriat	
		Nombre	Poids	Nombre	Poids	Nombre	Poids
Thunnus thynnus	...	3.599	448.241	118	13.690	268	13.867
Sarda sarda	...	10.672	9.658	191	153	8.734	6.094
Auxis thazard	...	14.729	13.386	26	20	1.830	1.317
Euthynnus alleteratus	...	58.088	290.682	14.600	60.449	32.013	148.592

On constate que les Thons rouges de la côte Est (Madrague de Kuriat) ont un poids moyen (50 kilogrammes) nettement inférieur à celui des Thons rouges du Golfe de Tunis (Sidi Daoud : 125 Kg., El Haouaria : 115).

En dehors des madragues les apports sont négligeables.

(d) Tripolitaine (Comm. Fish. Review, Dec. 1955, Jan. 1960)

Apports en 1955 : 6.403 poissons pour un poids de 1.350.000 livres (la plus mauvaise pêche depuis 25 Ans.)

Apports en 1959 :

Madrague	Apports en tonnes	Madrague	Apports en tonnes
Zuara	400	Marsa Zunga	280
Zansur	300	Sidi Billiman	420
Kliton	300	Misaratta	250

Total : 1.950 tonnes

Aucun détail sur la répartition entre espèces.

Toutes les madragues sont situées en Tripolitaine.

En dehors des madragues les apports sont négligeables.

La comparaison des statistiques annuelles (or retrouvera celles d'avant guerre chez Heldt) montre des variations considérables d'une année sur l'autre, mais ne révèle pour le moment aucun signe d'appauvrissement progressif du stock.

La production moyenne annuelle de l'Afrique du Nord en Thonidés est de l'ordre de 10,000 tonnes.

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II — LE GERMON

Germo alalunga (Cetti)

Base de référence : Rapport de Belloc (1954) déjà cité.

Le Germon n'a jamais été signalé en Méditerranée africaine.

Sur la côte atlantique du Marcc il est rarement capturé dans les madragues (Lozano Cabo 1957). Il l'est également, toujours rarement, à la traine. Furnestin et ses collaborateurs signalent qu'il peut faire des incursions massives les années où l'expansion des eaux tropicales atlantiques est maximum. Ce fut le cas en 1949 où les pêcheurs d'Agadir en ont pris plus de 1,000 tonnes.

Rappe'ons que le jeune germon est souvent confondu avec le jeune thon à nageoires jaunes (*Neothunnus albacora*) et que les indications des pêcheurs demandent à être confirmées par examen direct.

Le germon marocain n'a donné lieu à aucune étude.

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III—LE THON A NAGEOIRES JAUNES

Neothunnus albacora (Lowe)

Base de refeerence : II n'existe aucune base de référence propre à la Méditerranée. Consulter : E. Postel—Contribution à l'étude de quelques *Scombridae* de l'Atlantique tropico-oriental. *Ann. St. Ocean Salammbo*, nº X, 1955.

Le thon à nageoires jaunes n'a jamais été sigalé en Méditerranée africaine.

Sur la côte atlantique du Maroc il est rarement capturé dans les madragues à la fin du printemps ou au début de l'été. En fin d'hiver et au début du printemps les palangriers espagnols en prennent parfois sur leurs lignes. D'une façon générale c'est une espèce du grand large.

Le thon à nageoires jaunes marocain n'a jamais donné lieu à aucune étude. Il semble qu'il soit souvent confondu (surtout lorsqu'il s'agit de formes jeunes) soit avec le Germon (*Germo alalunga*), soit avec le thou obèse (*Parathunnus obesus*).

IV—LE THON OBESE

Parathunnus obesus (Lowe)

Base de reference : Il n'existe aucune base de référence propre à la Méditerranée. Consulter : Frade F.: Le Thon patudo, *Parathunnus obesus* (Lowe) et sa pêahe. Junta de Investigaçôes do Ultramar. Estudes, Ensaios e Documentos, 69. Lisboa.

Le Thon obèse n'a jamais été signalé en Méditerranée africaine.

Sur la côte atlantique du Maroc il est rarement capturé dane les mêmes conditions que le Thon à negeoires jaunes (*N. albacora*).

Le Thou obèse marocain n'a jamais donné lieu à aucune étude. Il semble qu'il soit souvent confondu lorsqu'il s'agit de formes jeunes avec *N. albacora*, lorsqu'il s'agit de formes plus âgées avec *T. thynnus*.

B—KATSUWONIDES

IV—LA BONITE A VENTRE RAYE

Katsuwonus pelamis (L.)

Base de reference : Rapport de Belloc (1955) déjà cité.

Caracteres specifiques : Aucun travail à ajouter fait en (ou concernant) l'Afrique du Nord. Des études biométriques sont en cours à l'Institut des Pêches maritimes du Maroc (Collingnon et Aloncle).

Distribution geographique. Migrations : En 1954 Belloc dit la Bonite à ventre rayé abondante en Tunisie. En 1955 il ne l'y cite plus. En réalité elle y est extrêmement rare. Postel (1956) n'en a noté qu'un seul exemplaires en trois semaines d'observations à la ma drague de Sidi-Daoud.

K. pelamis est également exceptionnelle dans les eaux algériennes (Dieuzeide 1954).

D'après Furnestin et ses collaborateurs *K. pelamis* est présente toute l'année dans l'Atlantique marocain. D'après mes observations personnelles elle apparait en Mai au large de Casablanca. Elle y persiste jusqu'à l'automne, toujours assez loin des côtes. La température des eaux de surface au moment de son apparition se situe entre 18° et 20°. C'est une rare visiteuse des madragues de la région nord (Lozano Cabo, 1957).

Alimentation, Ponte, Development, Croissance : Aucun vail à ajouter fait en (ou concernant) l'Afrique du Nord. Des observations sont en cours à l'Institut des Pêches maritimes du Maroc (Collignon et Aloncle).

Peche et apports : Négligeables en Algérie, Tunisie, Tripoltaine.

Au Maroc quelques captures dans les madragues. Captures plus importantes à la traine ou à la senne tournante suivant lo méthode déjà indiquée pour le Thon rouge (*T. thynnus*). Les apports annuels sont de l'ordre de quelques centaines de tonnes.

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POSTEL, E. 1956. *Loc. cit.*

V—LA THONINE

Euthynnus alleteratus (Raf.)

Base de reference : Rapport de Belloc (1955) déj .àitcé

Caracteres specifiques : Une étude détaillée de Postel (1956) a permis de définir les caractères biométriques de la population tunisienne et d'isoler nettement cette population de celle du Sénégal (précédemment étudiée par le même auteur). La population tunisienne se caractérise par rapport à la population sénégalaise par une tête, une distance prédorsale et une distance préventerale plus petites. Elle possède un nombre de pinnules branchiales inférieur (38,28 contre 41,45) et les deux polygones de répartition ont une zone de chevauchement assez faible pour qu'on puisse considérer la différence comme caractèristique. La moyenne du nombre des rayons de la première dorsale est de 14,92 en Tunisie, de 15,53 au Sénégal.

Le coéfficient qui apparait dans la formule taille : poids (coefficient de condition des salmonidés) est également différent chez les deux populations. Il est de 16,3 en Tunisie, de 15,2 au Sénégal. A taille égale, les Thonines tunisiennes sont plus lourdes que les Thonines sénégalaises.

Distribution geographique. Migrations : En Tunisie la Thonine demeure à l'état erratique pendant toute l'année dans le Golfe de Gabès. Sur la côte nord, elle apparait au printemps, disparait à l'automne.

Au Maroc elle fait son apparition début Mai, dans des eaux dont la température se situe entre 16° et 18°. Elle disparait en fin Novembre. Les phénomènes d'"upwelling" qui interessent l'ensemble de la côte atlantique marocaine morcellent son aire de répartition qui est, de ce fait, discontinue et parait parfois anarchique, sa présence pouvant être signalée dans la zone nord, alors qu'elle est absente de la zone sud.

Alimentation : Les observations faites à Sidi Daoud (Tunisie) confirment le fait que la Thonine ne s'alimente pratiquement pas (en Méditterranée) à la pointe de sa période de maturation (Postel 1956).

Ponte, Developpement, Croissance : On trouvera chez Postel (1936) une brève étude du rapport gonado-somatique (RGS). Cette étude a permis à l'auteur de conclure que les *Euthynnus alleteratus* capturés dans les madragues tunisiennes sont des animaux mûrs. La période de ponte se situe en Juin-Juillet-Août.

Des mensurations précises ont porté à 1.015 mm. (13.900 gr.) le record de taillle enrégistré en Méditerranée. Au dessus de 900 mm. tous les poissons examinés étaient des mâles.

Les essais yougoslaves signalés en Tunisie à propos du Thon rouge ont surtout porté sur la Thonine. C'est en effet cette espèce que les prospecteurs ont trouvé en majorité dans e Golfe de Gabès. On rappelera que son encerclement à la senne tournante semble plus délicat que celui du Thon rouge, en raison de sa plus grande vélocité (Domancic 1954).

Les apports de Thoniue sont : en Tunisie de l'ordre de 4 à 500 tonnes par an, an Maroc de 2 à 300 tonnes (voir Thon rouge).

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POSTEL, E. 1956. *Loc. cit.*

VI—L'AUXIDE OU MELVA

Auxis thazard (Lac.)

Base de référence : Rapport de Belloc (1954) déjà cité.

Caractères spécifiques : A signaler une brève étude biométrique de Postel (1956) portant sur quelques exemplaires tunisiens, l' échantillonnage étant trop réduit pour permettre de caractèriser la population.

L'étude biométrique de la population marocaine est en cours (Collignon et Aloncle).

Répartition géographique. Migrations : Sur la côte atlantique du Maroc les périodes de capture de la Melva sont celles de capture du Thon rouge. Les indications manquent pour savoir si ces périodes de capture se superposent exactement aux périodes de présence ou si elles n'en représentent qu'une fraction.

Dieuzeide (1954) confirme la présence d'*Auxis thazard* en Algérie.

Ponte, Développement, Croissance : Etude du R.G.S. chez Postel (1956). Les poisons capturés dans les madragues tunisiennes sont à maturité. La période de ponte se situe en Juin-Juillet-Août.

En Algérie la Melva pond en Août (Dieuzeide 1954).

Pêche. Statistiques : La Melva constitue une fraction importante des captures des madragues atlantiques du Nord-Maroc (Lozano Cabo 1957, Collignon 1960—voir statitistiques au paragraphe Thon rouge). Elle y est parfois confondue avec la Thonine (Collignon, comm. verb.).

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LOZANO CABO, F. 1957. *Loc. cit.*

POSTEL, E. 1956. *Loc. cit.*

C — CYBIIDES

VII — LA BONITE A DOS RAYE OU SARDE

Sarda sarda (Bloch)

Base de référence : Rapport de Belloc (1954), déjà cité.

Caractères spécifiques : A signaler une brève étude biométrique de Postel (1956). Malgré le petit nombre d'exemplaires examinés, il semble que la population tunisienne (qui fait l'objet de cette étude) soit assez différente de la population sénégalaise (objet d'une étude antérieure du même auteur, 1955). Les indices présentent des differences marquées. La tête des Bonites tunisiennes est plus petite que celle des Bonites sénégalaises (Indice 4,22 contre 3,88). Il semble également que le nombre de leurs pinnules branchiales soit inférieur de un unité (mode 20 contre 21).

Répartition géographique. Migrations : Postel (1955) a discutté les périodes de présence de *S. sarda* en Méditterranée en fonction des isothermes de surface. Il arrive à la conclusion que la température de 15° marque le seuil au dessous duquel l'individu moyen ne peut descendre.

Ponte, Dévelopment, Croissancc : En Algérie la ponte à lieu de Mars à Mai (Die-u zeide 1954).

En Tunisie l'étude du R.G.S. a permis à Postel (1956) de confirmer qu'aucun des poissons capturés en Juin à la madrague de Sidi-Daoud n'était en période de maturité.

Au Maroc la Bonite à dos rayé se reproduit en Juin-Juillet (Furnestin et coll., 1958). Les jeunes de 10 à 25, cm sont parfcis capturés en Automne avec la sardine.

Peche. Statistiques : Voir le paragraphs consacré au Thon rouge

VIII—LA PALOMETTE

Orcynopsis unicolor (Geoffroy St Hilaire)

Base de référence : Il n'existe aucune base de référence propre à la Méditerranée. Consulter : Postel E. Essai sur la Palomette, *Orcynopsis unicolor* (Geoffroy St Hilaire, 1809). *Bull. IFAN*, T. XVIII, Sér. A, no. 4, 1956.

Il s'agit d'une monographie consacrée à l'espèce dans l'ensemble de son aire de répartition (De l'Egypte au Sénégal). Aucum travail ultérieur n'est venu la complèter.

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SCOMBROID FISHES OF AUSTRALIA AND NEW ZEALAND[1]

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Australia and New Zealand are gigantic island outposts from which, in a desultory fashion, forays have been made to sample the varied inhabitants of the surrounding seas. Very little exploration has been done far from land and fishing boats inshore are not very numerous. In some families of fishes there is strong endemism but in the case of ocean wanderers like the Scombroids it is doubtful whether most of the Australasian species are very different from those of other parts of the world. Only very close examination and comparison of specimens will show whether this is so or not and whether the differences are on the specific, subspecific or merely racial level and if there are separate breeding stocks. In this paper I review the genera and species, indicate the names available for species and subspecies and give a brief precis from a museum ichthyologist's viewpoint of what is known of their characters and distribution. These large fishes should be studied in the field rather than in a museum and some of my work on them has been done at sea when time allowed. References to seasons are for the Australian summer, winter, and etc. which are of course opposite to those of the Northern hemisphere.

The Scombroids dealt with here fall into four, well-known groups :

(*a*) Tunas.

(*b*) Billfishes.

(*c*) Mackerel.

and (*d*) Seerfishes.

Excluded from consideration here are the Trichiuridae (frostfish, hairtail, etc.), of no great commercial value in Australia and the gempylids or Acinaceidae which include the important " barracouta " (*Leionura*), with its deepsea relative the Barraconda (*Rexea*) and four or five rarities of no fisheries significance.

Keys.—A key to the genera of tunas, mackerels and seerfishes has been given in Fraser-Brunner's " The fishes of the Family Scombridae " [Ann. Mag. Nat. Hist. (12) 3, 1950, p. 131.] The only genus in his key which has not so far been found in Australia is *Orcynopsis* which seems restricted to the Atlantic and Mediterranean. I feel that a finer subdivision of the genera is useful so that some of the names regarded by Fraser-Brunner as synonyms or subgenera of his rather broad genera are used below, as indeed they are separated out by most modern fisheries workers. *Thinnus* has also been shown to be the proper spelling of *Thynnus* (preocc.) or *Thunnus* (Whitley, 1955 Proc. Roy. Zool. Soc., N. S. Wales, 1953–4, p. 51).

Brief descriptions of the species will be found in Munro's Handbook of Australian Fishes, 27–28 (*Fisheries Newsletter*, Sept.—Nov. 1958), pp. 110–115, figs. 740–766.

[1]Contribution from the Australian Museum.

Allothunnus from New Zealand has been treated separately by Serventy (1948, Rec. Canterb. Mus. 5, pp. 131–135, pls. 28–29).

With these minor modifications, the keys of Fraser-Brunner cover all the Australian members of groups *a*, *c* and *d* above. In the case of (*b*), the billfishes, I have drawn up an independent key to these based on local material. This was first published in Athel D'Ombrain's " Game Fishing off the Australian Coast ", 1957, p. 76, but is repeated (revised as a result of examination of further specimens) in this paper.

Common Names:

The vernacular names used for scombroid fishes in Australia do not differ greatly from standard usage in English, but seerfishes are usually loosely referred to as ' kingfish ' or ' spanish mackerel ' and billfishes which used to be called swordfishes, are nowadays separated into broadbill, sailfish, and marlins of several kinds. An interstate conference of fisheries inspectors in 1947 endeavoured to stabilize common names for at least the common commercial fishes of Australia ; as far as tunas are concerned the vernaculars recommended by Serventy have been adopted.

Aboriginal and Maori names are obsolete.

Historical :

The aboriginal inhabitants of Australia ate various fishes which they obtained with spears, nets and other devices but they did not exploit scombroid fishes in particular.

The New Zealand Maoris had better boats and fishing appliances but little information seems to have been handed down as to how they dealt with scombroids.

Early Asiatic, Portuguese and other visitors to Australia left practically no zoological observations, so that it is not until the 17th century that we hear the first news of Scombroids from European voyagers.

A Spanish explorer, Don Diego de Prado, in the ship *San Pedrico* sailed through Torres Strait in 1606 and in his *Relacion*, published in H. N. Steven's *New Light on the Discovery of Australia* (1930, p. 159) we read of " albacora " at islands near Papua. In the same waters between New Guinea and Queensland, the Dutchman Carstenszoon in 1623 " encountered sharks, swordfishes and the like unnatural monsters " (Heeres, 1899, the part borne by the Dutch in the Discovery of Australia, 1606–1765, p. 29). However the " swordfish " referred to may have been a long tom or garfish since natives are described as threading their fangs through holes in their noses !

Details of fishes obtained by Tasman when he discovered New Zealand and Tasmania in 1642 and when he sailed in northern Australia in 1644 are not forthcoming.

On the second visit of the Englishman, William Dampier, to Australia in 1699, Dampier had an artist aboard who figured " a fish of the tunng kind taken on ye coast of N. Holland ", probably *Cybium commerson* (Dampier, 1703, Voy. New Holland, 3, plate 3, fig. 5.)

In Mercury Bay, New Zealand on November 9th, 1769 a number of Maori canoes came to Lieut. Cook's vessel " loaded with mackerel of two sorts, one exactly the same with those caught in England, and the other somewhat different " (Hawkesworth, 1773, Acc. Voyages 2, p. 336). In Wharton's edition of Captain Cook's Journal (1893, p. 169) we read,

" The Mackerel are in every respect the same as those we have in England, only some are larger than any I ever saw in any other Part of the World ; although this is the Season for this fish, we have never been able to catch one with hook and line." On Cook's third voyage mackerel were also encountered.

Elsdon Best, in his " Fishing Methods and Devices of the Maori " (Dominion Museum Bull. 12, Wellington, 1929, p. 46) mentions mackerel taken on a hook decorated with a strip of rag, and by net.

On June 4, 1770, Lieut. James Cook, in the Whitsunday Passage, Queensland, " saw several albecores " (Histor. Rec. N. S. Wales, 1, 1893, pp. 126, 199 and 257), probably *Kishinoella* or *Euthynnus*.

The Frenchman, Marion du Fresne, left no records of scombroids ; he was killed and eaten by the Maoris in 1772 at the Bay of Islands, New Zealand.

Although it came from slightly outside Australian waters, the naming and describing of *Auxis thazard* by Lacépède (1801, Hist. Nat. Poiss., 3, 9, as *Scomber*) from Choiseul Bay, New Guinea is worthy of recall here.

The first mention of spearfishes in Australian waters was Peron's account of battles between swordfishes and whales which he observed off Eendracht Land, Western Australia in 1801 or 1802 (Girard, 1857, Peron Sa Vie, p. 157). It was not until 1854 that the first Marlin was caught by a fisherman in Australia (by William Newton at Broken Bay, New South Wales).

It was Peron too who first observed the southern bluefin tuna in Australia (Peron, 1807, Voy. decouv. Terres Austr. i, p. 322) for, near Rivoli Bay, South Australia, on April 5th, 1802, he sighted " une troupe nombreuse de Scombres de la grandeur de nos Thons (*Scomber thynnus*, Lacépède), mais dont il me faut impossible de distinguer exactment l'espece."

Serventy (1956, Austr. Journ. Mar. Freshw. Res., 7, p. 54) considers that it was probably *Kishinoella tonggol* that Captain P. P. King (1826, Narr. Survey Coasts Austr., 2, p. 218) reported as *Scomber thynnus* in north-western Australia in March 1822 :

> " . . . we were in latitude 18°45′ 18″, and longitude 111°4′ 15″, when a breeze sprang up from the S. E.....and advanced us on our passage, but carried us to the westward. On this course we were accompanied by immense shoals of albiccores, (*Scomber thynnus*, Linn.), but they were of small size ; very few measured more than twenty inches in length, and the average weight about ten pounds . . . ".

The early naturalists were prone to identify Australian fishes with those of European seas. It was not until 19th century zoologists studied specimens that the scombroid fishes of the Antipodes were distinctively named.

Australians and New Zealanders are largely meat-eaters and do not consume as much fish as inhabitants of many other countries with extensive sea-coasts. The fishing industry was slow to develop and even now is not expanded to anything like its capacity. Consequently there is no traditional mackerel fishery and although seerfishes are taken in large quantities in Queensland, the capture of billfishes and tunas is mainly a sporting activity. In recent years, however, Japanese longliners have entered Australasian seas to capture scombroids for food.

In the 1920's Scombroids from Australia, Hawaii and Malaya were sent to Kishinouye but he did not complete his work on them or publish anything about them and the specimens were returned to the Australian Museum eventually through the good offices of another Japanese zoologist, Kishinouye having been murdered by Chinese bandits.

Knowledge of the various species has been built up piece by piece: from finding stranded specimens or odd occurrences, or records in newspapers or natural history magazines, as well as in zoological literature, so it is not surprising that, at least until the 1930's, practically nothing was known about the biology of our scombroids and the Check-list of fishes recorded from Australia of that period (McCulloch, 1929, Austr. Mus. Mem., 5, pp. 261–267) listed nine mackerels and tunas, four seerfishes (two of them spurious species), the aberrant *Gasterochisma*, and five nominal billfishes. Such important species as the yellowfin tuna (*Neothunnus*), the northern bluefin (*Kishinoella*), and several marlins and seerfishes and the wahoo were then quite unknown in our seas, to say nothing of the others which have been recorded since 1930. The main factor increasing our knowledge was the establishment of the Division of Fisheries in C.S.I.R.O. and the voyages of the *Warreen* and later fisheries vessels in search of pelagic fish. The earlier emphasis in Australian fisheries had been on inshore fishes and trawling along the continental shelves.

At least until recent years, New Zealand has always been more concerned with fisheries matters, in proportion to her size, than Australia yet as late as 1927 (Phillipps 1927, N. Z. Mar. Dept. Bull. i, Bibliogr. N. Z. Fishes, p. 45–47) that country had only occasional records of eleven scombroid species, a number increased only to thirteen in the latest list (Whitley in Graham, 1956, Treasury of N.Z. Fishes, 2nd edition, p. 409-410), but one does not expect a large variety as only the tip of the North Island supports such subtropical fishes, though the cold southern waters have given rise to the recently discovered *Allothunnus fallai* Serventy, 1948, since found also in South Africa.

Scombroid fishes are forming an increasing proportion of Australian fisheries. Australia's 1961-62 fish catch* totalled 88,212,681 lb. live weight. Mullet formed the bulk of this (15%), tuna coming third on the list with 12%.

The States of the Commonwealth featuring tuna are South Australia with 7,420,000 lb. and New South Wales 3,130,843 lb. Tuna (47.4%) were the principal fish of the year in South Australia. Catches of other Scombroids were insignificant in Australian commercial statistics.

A bibliography of the scombroids of Australasia would list many scattered references and would occupy much space so only the more important treatises are quoted here.

Much information has still to be collated from logbooks of research vessels and from returns volunteered by anglers or submitted by fishermen. This work is done by C.S.I.R.O. officers and in the Fisheries Departments of the various Australian States, and there are many unpublished biometric and other observations by fisheries biologists.

Size: The maximum known length and weight are given for each species but the two do not necessarily apply to the one specimen of the fish.

Range: (Figs. 3–6) The type-locality for each species are given. Our knowledge of the distribution of scombroids is still very incomplete. Ranges given here include records in scattered literature and my own field-observations but much unpublished material in the form

*Fisheries Newsletter, March 1963, p. 21, latest published figures.

of logbooks, fishermen's returns, records of angling clubs, and data from fisheries departments are outside my scope at present. Records are not available concerning Australasian scombroids caught by Japanese fishermen and frozen for taking to Japan for canning or to the Pacific Islands for processing for the American trade, though such activities date from the 1950's or perhaps earlier.

I am grateful to Mr. J. P. Robins, of C.S.I.R.O., Cronulla, who was a guest aboard the Japanese vessel " Shoyo Maru " in February and March 1960, for information on the offshore distribution of Australian tunas. Mr. Robins also showed me the publication edited by Nankai Regional Fisheries Research Laboratory, " Average Year's Fishing Condition of Tuna Long Line Fisheries ", Appendix Atlas, 1958, which charts monthly occurrences of tuna over a vast Indo-Pacific area. I have accordingly been able to plot far more extensive ranges for some of the tunas than were apparent from published sources or museum specimens. Some ranges are dotted on my maps to show new localities which either Mr. Robins or Mr. M. Olsen, of Tasmania, have in manuscript. I do not wish to anticipate the papers they are preparing by premature publication here.

For helpful advice and information I am also indebted to Dr. D. L. Serventy and Mr. Ian S. R. Munro of C.S.I.R.O. and Mr. Athel D'Ombrain.

Food :

Studies on the food of scombroids have not been published in detail. As a random sample in 1943, I identified many fishes from the stomatch contents of Australian tunas furnished by Dr. D.L. Serventy. Many of these were too digested for specific determination. Most were about 30 mm.—60 mm. long, ranging up to 100 mm. but a few *Scomberesox* up to 190 mm. and two *Seriolella* of 220 and 241 mm. were included. The principal recognizable kinds of fishes fed upon were :—

Family	...	Genus, etc.
Clupeidae	...	*Sardinops neopilchardus*
Clupeidae	...	Postlarval specimens
Gonorynchidae	...	*Gonorynchus greyi*
Leptocephalidae?	...	Leptocephalus - larva of eel.
Macroramphosidae	...	*Macroramphosus elevatus* and *molleri*
Scomberesocidae	...	*Scomberesox forsteri*
Hemiramphidae	...	*Reporhamphus australis*
Macrouridae	...	*Lepidorhynchus denticulatus*
Atherinidae	...	*Pranesus*
Nomeidae	...	*Seriolella*
Pomatomidae	...	*Pomatomus pedica*
Carangidae	...	*Trachurus mccullochi* and *novaezelandiae*
Carangidae	...	*Usacaranx nobilis* and *Selaroides* sp.
Chandidae	...	*Velambassis jacksoniensis*
Arripidae	...	*Arripis trutta*
Emmelichthyidae	...	*Emmelichthys nitidus*

Mullidae	...	*Upeneichthys porosus*
Histiopteridae	...	*Zanclistius elevatus*
Cheilodactylidae	...	*Nemadactylus*
Scombridae	...	*Pneumatophorus australasicus*
Acinaceidae	...	*Leionura atun*
Uranoscopidae	...	*Gnathagnoides innotabilis*
Scorpaenidae	...	Postlarvae
Aleuteridae	...	*Nelusetta* and other genera
Ostraciontidae	...	*Strophiurichthys*? - postlarval.
Tetraodontidae	...	*Aphanacanthus.*

It may be observed that these are either continental shelf fishes or the pelagic young of inshore kinds. Squids, prawns, larval stomatopods and other crustacea, krill, chaetognaths and other invertebrates were also eaten with the above, as well as unidentified marine growths. Further details are given by Serventy (1956, Austr. Journ. Marine Freshw. Res., 7, pp. 38-41).

As regards the mackerel (*Pneumatophorus*) found in tuna-stomachs, many specimens from eastern Australia measured 25 to 60 mm. in total length eaten in October 1940 and others 95 to 103 mm. were taken in November 1940.

Sea-temperatures : Sea temperatures and water-movements, knowledge of which is so important when dealing with migratory fish, are still incompletely understood in Australasia. Aurousseau (1959, J. Proc. Roy. Soc. N. S. Wales, 92, pp. 104–114) recorded surface temperatures of Australian seas but had no data for much of northern Australia. From the Northern Territory to Thursday Island, Queensland, in October 1949, I noted sea-temperatures of 26.8 to 28.6°C. In July 1949, in the same region Serventy (MS.) read 24.5 to 25.6°C. At the Abrolhos Islands, Western Australia in December 1945, the surface temperature ranged from 21 to 23°C. Australian sea-surface temperatures in relation to shark attacks were shown in Coppleson (1958, Shark attack, pp. 114-115). A chart of sea temperatures was prepared by the Royal Dutch Meteorological Institute at De Bilt, Ref. No. 124 and one of ocean currents by the United States Navy Hydrographic Office, Publ. No. 568. Work is continued by scientists of the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, New South Wales, some indication of the measures being adopted having been published in Fisheries Newsletter, Nov. 1961, pp. 19–22, figs. 1–3.

Scombroids—Fishing Grounds

Anonymous authors have provided, in Fisheries Newsletter [13 (2), Feb. 1954, pp. 7-8] a division of Australia into geographical areas wherein tuna resources are known. These are as follows :

(1) Queensland (east coast) and New South Wales north of Sydney.

(2) South-east Australia from Sydney southwards to and including eastern Victoria, Bass Strait and Tasmania.

(3) South Australia including western Victoria and the west coast of South Australia to the Head of the Great Australian Bight.

(4) Western Australia, from Head of Bight to Shark's Bay.

(5) Western Australia north of Shark's Bay to Lacépède Islands.

(6) Northern Australia - from Lacépède Islands to Torres Strait.

(A) TUNAS

Family SARDIDAE

Slender Tunny or Falla's Tuna

Allothunnus fallai Serventy, 1948.

Like *Katsuwonus* but more elongate, with minute scales outside of corselet, gill rakers 24 to 25+48 to 51; D. xvii, 12+7; A. 14+7; P. 25. Teeth minute on jaws, none on palate; vertebrae 41. Colour fairly uniform, bluish-black above, grey below, with reddish-brown blotches, perhaps a post-mortem effect. Grows to about 3 feet and 16 lb.

" This very interesting fish is, in effect, a *Thunnus* with greatly increased number of gill rakers and reduced dentition (evidently a plankton feeder)," states Fraser-Brunner [1950, Ann. Mag. Nat. Hist., (12) 3, p. 148]. It has been recorded from Tasmania and cold southern New Zealand waters and was recently recorded from South Africa. Several New Zealanders had encountered the species before Dr. Serventy named it in 1948 but were reticent about publishing accounts of it. It is evidently the " *Auxis thazard* " of New Zealand authors (non-Lacépède). The type-locality is Timaru, south island of New Zealand, whence the female type was taken on July 17, 1916. Other New Zealand examples were caught on 4th October 1911, in the 1920's, in March 1933, on 4th February 1938 and the species is also known from the Auckland Islands.

Type-locality : Southern New Zealand.

Frigate Mackerel or Leadenall.

Auxis thazard (Lacépède, 1801).

" *Auxis thazard* " has been recorded from various parts of Australia and New Zealand but it is only in recent years that it has been realised that more than one species was involved and it is likely that all the New Zealand records refer to another genus, *Allothunnus*. The species *A. thazard* was first discovered on 30th June, 1768 near Choiseul Bay, New Guinea. In 1875, Castelnau recorded it from the Swan River district of Western Australia and in 1879 distinguished a second species obtained April 6, 1878 from Sydney Markets (as *ramsayi* Castelnau, 1879, Proc. Linn. Soc. N.S. Wales, 3, p. 382). In the late 1880's Johnston noted a Tasmanian occurrence and Stead recorded small shoals in Port Jackson Feb. 3, 1903 (Addit. Fish-Fauna N.S.W. 1907, p. 20). Others came to Woolwich Dock, Sydney, February 1910 (Austr. Mus. Regd. No. I. 10593). Larval and juvenile *Auxis* are common in the Tasman Sea where the " Dana " in 1929 obtained two types, probably *thazard* and *thynnoides*; similar ones have been washed up on Collaroy Beach in August and September, 1958, and Colefax in 1930 noted small *Auxis* as constituting a noteworthy proportion of the stomach contents of the commercial Tiger Flathead, now known as *Neoplatycephalus richardsoni*. On April 23, 1938, schools of *Auxis* came into Balmoral, Sydney. Serventy notes *A. thazard* as common in summer months in Western Australia, subtropical Australia and southern New South Wales.

The Australian Museum has one (no. IB. 1855) from Woolwich, Sydney, taken March 10th, 1947. In May, 1950, two fish each of 1 lb. 9 oz. were netted in Proper Bay, Port Lincoln, South Australia (Fisheries Newsletter, June 1950, p. 27); they might have come from either eastern or western Australia. The 3rd Annual Report of C.S.I.R.O. mentions Western Australian fish caught by ringnet after having been traced by echosounder, and Fisheries

Newsletter (11,(I), 1952, p. 15) records the species from between Tor Bay and Doubtful Island, Western Australia in 30 fathoms between March and June. Athel D'Ombrain reported it from off Port Stephens, N.S.W. in August 1954 when *thynnoides* was also present.

Maru.

Auxis thynnoides Bleeker, 1855.

Differs from *A. thazard* in having a band of scales above and below the lateral line extending for a considerable distance behind the pectoral fin-tips. This second kind of frigate mackerel may have been confused with *A. thazard* in early records. It was first definitely recorded from Newcastle, N.S.W. by Whitley (1954, Proc. Roy. Zool. Soc. N.S. Wales, 1952-53, p. 28) but larvae, possibly of this species, had been netted in 1929 out in the Tasman Sea, though not identified or recorded until 1959 (by Matsumoto, 1959, Dana Rept. 50, p. 19, fig. 18) and others were found on Collaroy beach in Aug.-Sept. 1958. *Auxis ramsayi* Castelnau 1879 (Proc. Linn. Soc. N.S. Wales, 3, p. 382), which appeared in Sydney market on April 6th, 1878 may be this species rather than *A. thazard.* The Australian Museum has several specimens from off New South Wales taken in January, August and September over the years. Shoals were seen in Middle Harbour, Sydney, in Aug. 1958 when I also obtained one from the stomach of a thresher shark caught off Manly. Possibly the species breeds in August as in that month and September juvenile *Auxis* were found stranded on Collaroy beach. In another paper for this Symposium, Watanabe records *A. thynnoides* from Queensland for the first time.

Colours of a specimen freshly washed ashore near the Spit, Middle Harbour, Sydney, 10th August 1958, coll. G. P. Whitley:

[Schools evidently of this species had been seen during the past week in Middle Harbour].

Blackish along back. Shining steel-grey elsewhere or silvery with rainbow-iridescence of pink, blue and green. Dark grey edge to gills and mouth-parts. Eye black; pupil burnished grey. On posterior part of back a series of dark grey spots and bars on a light ground with green and blue reflections. First dorsal fin; grey spines and white membranes. Second dorsal and finlets grey with white tips. Caudal silvery with grey margins. Anal fin and finlets white. Pectorals dark grey. Ventrals brownish grey with broad white edge.

13½ inches=2 lb. Stomach crammed with small fishes (anchovies and young mullet) swallowed whole, Munro gives 3 lb. as maximum weight of *A. thynnoides.*

Type-locality : Ternate, Indonesia.

Synonym : *ramsayi* Castelnau. 1879, from Sydney markets.

Leaping Bonito or Watson's Mackerel; Gowilla (Queensland aboriginal).

Cybiosarda elegans (Whitley, 1935).

(Plate II-b)

The systematic position of this tuna is uncertain. It seems nearer *Sarda* than *Scomberomorus;* Fraser-Brunner unites it with *Gymnosarda.* Dr. Serventy remarks, this species is an excellent sporting fish for its size and is the one tuna whose flesh is appetising in the fresh condition; the meat is white and may be smoked quite well.

Back with mackerel-green iridescence, the spots and stripes (as figured) grey. Soft dorsal fin and finlets greyish. First dorsal black and white. Anal lobe yellow, finlets white. Eye dull yellow, the pupil black with a subvertical pearly central mark. Branchiostegal membrane black with a white margin.

Grows to 17½ inches and 3 lb.

The State Fisheries Department of New South Wales presented several specimens of this novel tuna to the Australian Museum in 1927. The new gamefish was caught in hundreds off Shellharbour, N.S.W. in March 1927 and many were sold in Sydney markets about that time. A specimen was sent to Kishinouye in Japan who considered it to be a new species of *Sarda* which he intended to name in honour of the present writer. However, he met his unfortunate death at the hands of bandits in China and the specimen which he had studied, but not named, was returned to Sydney by Japanese colleagues. In 1935 (Whitley, 1935, Rec. Austr. Mus., 19. p. 236) I called it *Scomberomorus* (*Cybiosarda*) *elegans*, subg. and sp. nov., from Moreton Bay, the type-locality in Queensland, and a year later (1936, Mem. Qld. Mus., 11, p. 42, pl. iv, fig. 1 and text figure 5) gave more details from examples I collected at Lindeman Island, Queensland, on 23rd. July 1935 and other specimens from Queensland, New South Wales and Western Australia. In May 1939, Dr. Serventy (in lit.) reported Port Hacking (N.S.W.) fish which leapt from the water, unlike *Sarda australis* which was swimming underneath at the same time. The species appears from February to May in New South Wales, June to July in Queensland, but is sometimes absent for several seasons.

Dr. D. L. Serventy (in lit.) kindly informs me:—

Cybiosarda elegans: The species occurs only in Australia and in two geographically separated populations. In eastern Australia it occurs between Townsville (Queensland) and Shellharbour (N.S.W.). In Western Australia it occurs from the mouth of the Murchison River to Albany.

Mackerel Tuna, Little Tunny, Bunny.

Euthynnus wallisi (Whitley, 1937).

(Plate II-a—holotype of *wallisi*)

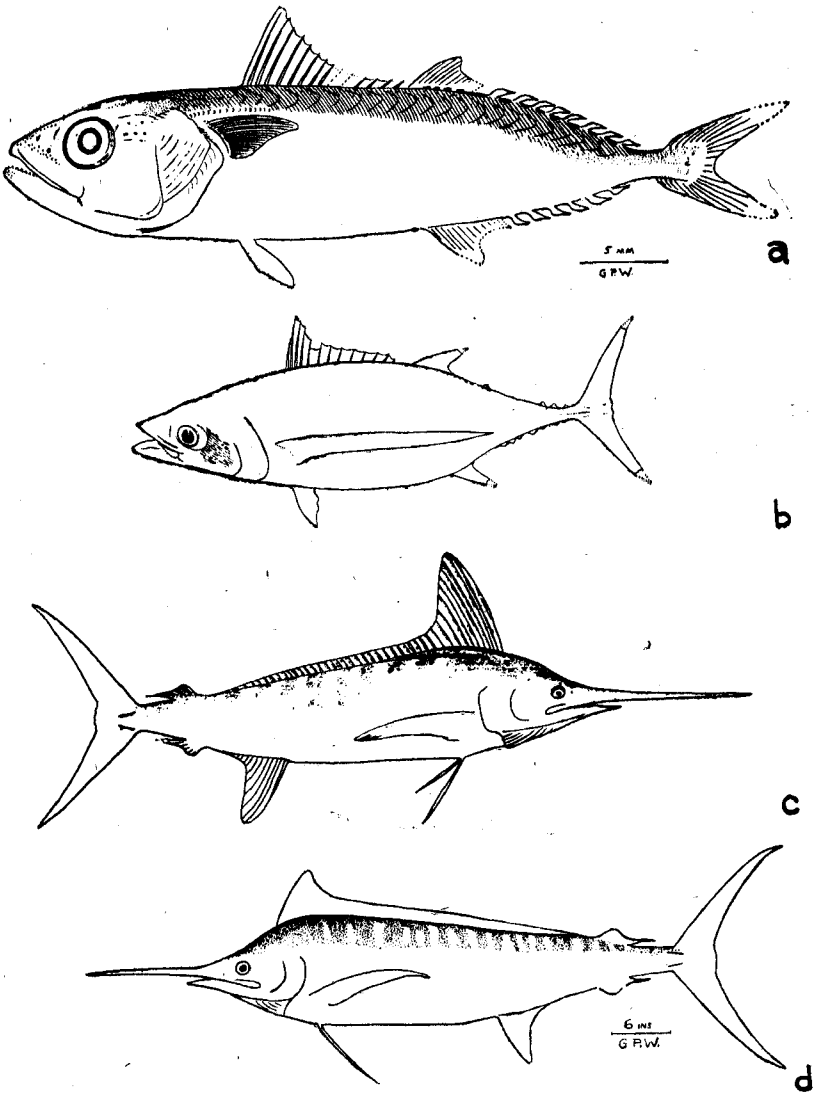
The Australian Museum has specimens of *Euthynnus* from New South Wales and Bombay which key to *E. affinis affinis* in Fraser-Brunner's paper on the Fishes of the genus *Euthynnus* [1949, Ann. Mag. Nat. Hist. (12) 2, p. 623, fig. 1a.] but Cantor's name, *Thynnus affinis*, is preoccupied in Insecta so I use *wallisi* (Whitley, 1937) for our form. An example of *E. yaito* from the Hawaiian Islands is also in the Australian Museum.

A model of a small striped tunny noted in de Prado's MS. from the Gulf of Papua in 1606 may have been this species [Stevens, 1930, New Light on the Discov. of Australia, Hakluyt Society, (2) 64, p. 159] or perhaps *Katsuwonus*.

Macleay in 1881 catalogued "*Thynnus affinis*" from Port Jackson but the species was wrongly considered to be rare (doubtless because no outside fishing for it took place) until in April 1916 an "enormous shoal" was reported from Port Stephens (McCulloch, 1917, Rec. Austr. Mus., 11, p. 183), one fish being 30 inches long. About April 1927 a fish from Shellharbour was sent to Sydney Markets and later became the holotype of *Wanderer wallisi*, which I also described from one caught 2nd May 1936 off North Brothers Mountain, N.S.W. It was not until C.S.I.R. in 1938 investigated our tuna resources that we realised what a common species it is ; very numerous notices of it in logbooks and field data have yet to be collated so that length-weight ratios can be

graphed, specimens sexed and stomach-contents recorded. The species feeds on a variety of small fishes, larval crabs and macroplankton.

The mackerel tuna is very common in waters to the north of Australia and down each side to Shark's Bay (and occasionally to the Murchison River) in Western Australia and to New South Wales in the east becoming rarer below Sydney but sometimes reaching Twofold Bay in summer. I have seen great schools between north-western Australia and Timor and obtained two juveniles, one about 43 mm. t.l. (Fig. 1-a), the other damaged, which seem to be *Euthynnus*, from off Peron Island, Anson Bay, Northern Territory on



Text Fig. 1. (*a*) *Euthynnus* sp. Juvenile, about 43 mm. total length from off Peron Island, Northern territory of Australia, 25th September 1949. C.S.I.R.O. Collection. (*b*) *Germo germon steadi* Whitley. Holotype of subspecies from N. S. Wales. (Redrawn from Australian Museum photograph). (*c*) *Marlina audax zelandica* Jordan and Evermann. An 8 ft. specimen from Baleman's Bay, N. S. Wales. (*d*) *Istiompax dombraini* Whitley. An immature specimen, 6 ft. overall, 63 lb. weight from off Port Stephene, N. S. Wales, 12th March 1961. The pectoral fin is rigid but shown here in the conventional adpressed position.

25th September 1949. However they do not quite agree with published descriptions and figures and require further study. Matsumoto in 1958 and 1959 figured a series of juveniles but none of them came from Australia.

Maximum size 4 feet and 30 lb. but usually about 14 to 17 inches and less than 20 lb.

Albacore or Longfinned Tuna.

Germo germon steadi Whitley, 1933.

(Figure 1 b)

Some authors consider this to be a form of *alalunga* Gmelin (usually amended to *alalonga*) ; the elongate pectorals are characteristic. It is apparently an open ocean or deep sea fish which approaches the southern half of Australia and the northern half of New Zealand in warmer months. It grows to about 3 ft. 7 in. and 62 lb., but average ones caught go from 5 to 9 lb.

The type-locality of *germon* was between Easter Island and Chile. The Longfinned Albacore has an enormous range and has been found in all States of Australia (except the Northern Territory) and New Zealand. The first record from New Zealand was in a surveyor's drawing of an 18¾ inch fish from Turanganui River reported upon by Waite in 1913. Stead (1906) recorded it from Port Macquarie, N.S.W. and there have been numerous reports from our colder seas.

I have not seen Isii and Inone's paper, quoted in the 1956 Zoological Records, reporting the spawning of this species in the Coral Sea.

Dr. D. L. Serventy (in lit.) kindly informs me :—

Thunnus germo (Albacore). The same remarks on fishes found in deeper water by modern techniques apply to this species. In my Pamphlet 104 (1941) this species was known only from the east Australian coast, from Port Macquarie to southern Tasmania. Then we had that extraordinary beachstranded specimen at Quindalup, W. A. in March 1945, which you examined. This was followed by the 9½ lb. fish trolled by the Derwent Hunter 50 miles south of Cape Wiles, South Australia [see Fisheries Newsletter, 12 (5), May 1953, p. 3]. Possibly even more extraordinary than the Quindalup find was the stranding of a large 57 lb. albacore at Denham, Sharks Bay on December 30, 1957. I wrote this up in the Monthly Service Bulletin of the Fisheries Department of W. A., February 1958.

Some recent records of albacore in N.S.W. waters are given in Report 5 F.R.V. "Derwent Hunter", C.S.I.R.O. Division of Fisheries and Oceanography, 1957, pp. 3-5 (by J. P. Robins).

Germo apparently spawns in the northern limits of its range in the warm waters between Samoa and Torres Strait, according to the findings of the Japanese. Mr. J. P. Robins (in MS.) has considerably extended the known range of this fish, well off the Victorian and South Australian shores, and between Bass Strait and New Zealand.

The type-locality of the subspecies *steadi* was New South Wales.

Large-scaled Tunny, Salmon Mackerel, Shark Mackerel, Westralian "Albacore" or Lowlat.

Grammatorcynus bicarinatus (Quoy & Gaimard, 1825).

(Plate IV b)

The large scales and two lateral lines on each side are distinctive. Yellowish-green. White below. Some scattered dark spots or a series of round, dark blotches along belly.

Discovered by the French "Uranie" Expedition in Shark's Bay, W. Australia, in Sept. 12th to 27th, 1818. Closely related, if not identical, species or races have been named from the Red Sea (*bilineatus* Rüppell, 1836), and the Philippines (*piersoni* Evermann & Seale 1907). It is known from temperate Australian seas (W.A., Q. and N.S.W.) and from Papua but has a wide extralimital range.

Length to 48 inches, weight 25 lb.

The fish has been found in February and June in N.S.W. and in winter months in Queensland, but logbook records of occurrences have yet to be tabulated.

Dogtooth Tuna, Scaleless Tunny, White flesh Tuna.

Gymnosarda unicolor (Rüppell, 1836.)

In 1941 I saw a 3 ft. example in the Queensland Museum. It was very like Kishinouye's figure (1923, J. Coll. Agric. Imp. Univ. Tokyo, 8, p. 426, pl. xxii, fig. 37) but had a larger eye and different course of lateral line; the pectoral length went 6 in the total length to the level of the tailtips. It was more like Rüppell's figure of the type as regards the lat. l. but had narrower body and pectoral notably shorter than head.

The Dogtooth Tuna was reported from North Queensland as *Gymnosarda nuda* by Marshall (1941, Mem. Qld. Mus. 12, p. 61) and figured by Coates (1950, Fish. Bar. Reef. p. 22, fig.). Serventy [1950, Austr. Fisheries, p. 65 and Fisheries Newsletter, 9 (3), p. 19] gave Queensland and north-western Australian localities. The species was also found in Papua. Dunstan (1961, Papua N. Guinea Agric. Journ. 13, p. 151→) discovered a Papuan spawning-ground east of Samarai in March 1958.

Exact dates of capture and measurement are few and far between, but I have noted :—

L. C. F.	wt.	
28″	11 lb. 13 oz	Lady Elliott Island, Q. 20/6/1941 Serventy's MS. photo.
3 ft.		Off Scotland Island, N.S.W. Austr. Mus. regd. No. IB. 4291. *New record for N.S.W.*
		The type-locality is the Red Sea.

Striped Tuna or Watermelon.

Katsuwonus pelamis (Linne, 1758).

(Plate I a).

The type-locality of *Katsuwonus pelamis* seems to have been in the vicinity of Java since Osbeck was thereabouts when he wrote on 26th January 1752, " we caught two *bonets* (*Scomber Pelamis*). Its two pectoral fins were put upon a fishing hook, to represent a likeness of a flying fish, which the *bonet* often pursues ". Linne's name is based, in part, on Osbeck.

This well-known and widely-ranging fish is known from every State of Australia and occurs at Lord Howe Island and New Zealand. Count Castelnau (1879, Proc. Linn. Soc. N.S. Wales, 3, p. 352) included it in a list of Sydney fishes and Waite (1907, Rec. Canterb. Mus., 1, p. 24) from New Zealand. Stead realized that it was common. Phillipps (1921, N. Zeal. J. Sci. Tech., 4, pp. 118 & 124) reports it as common in Dunedin markets yet rarer in northern New Zealand; it appears in Auckland market in April. Fuller knowledge came from C.S.I.R. investigations from the 1930's to date.

The results of fishing tests in S. E. Australia are described by Serventy (1947, Journ. C.S.I.R. 20, p. 4). It was not taken in 1943, but caught during Nov. 1944 according to Sheard. An account of the Australian fishery is given by Blackburn & Rayner (1951, C.S.I.R.O. Div. Fisher. Tech. Paper 1, p. 7). Occurrence in abundance is seasonal in any specific area off the [eastern Australian] coast, according to Robins [1952, Austr. J. Mar. Freshw. Res., 3(2), p. 101, note especially his figure 4].

Movement to the south from the mid north coast of New South Wales began in late spring; movement north from the east Tasmanian coast began in mid autumn.

Striped tuna were taken in eastern Australian waters of temperature ranging between 14.7 and 20.8°C., but occurred most plentifully between temperatures of 16.0 and 18.0°C. They had a preference for water of specific temperatures in the areas in which they occur seasonally. Seasonal movement north and south showed a strong correlation with seasonal changes in water temperatures. Commencement of movement northwards from the south appeared to be influenced by downward change in temperature, which brought about the lower limit of the critical temperature tolerated; this change was coincident with the onset of the seasonal westerly winds. Degree of southerly penetration is related to temperature, whose seasonal fluctuation could explain 'abnormal' years.

In Western Australia *K. pelamis* has been found at the Abrolhos in February to April, and in New Zealand in April and May.

Northern Bluefin Tuna

Kishinoella tonggol (Bleeker, 1851)

(Plate I b)

The sighting of " Albicores " in the Whitsunday Passage, Queensland, by Cook in 1770 might refer to this species which has been confused in earlier Australian ichthyological literature with *Thinnus maccoyii*. The first New South Wales record seems to be Stead's report of a school of tuna entering Port Hacking on 5th June 1907 (Stead, 1907, Town & Country Journal, June 12, 1907, p. 37 and figure); one was said to have been 5 feet long and to have weighed 139 lb., but this species rarely reaches 4 feet and 60 lb. Full accounts of *Kishinoella* have been published by Serventy, notably in 1956 (Austr. J. Mar. freshw. Res., 7, p. 44, illustr.). *K. tonggol* is present all the year round in tropical seas but is commonest in New South Wales from January to May. Surface schools agitate the water, many fish causing a mane-like spray, or may even leap clear into the air.

D. xi to xiv, 14 to 15+8 to 9; A. 13 to 14+8 to 9. Gill-rakers 5 to 6 / 14 to 17 (*i.e.* less than 23 on first arch). More slender and fusiform than Southern Tunny (*Thinnus maccoyii*). Pectoral fin much shorter than head. Outline of spinous dorsal fin markedly concave. Liver smooth, not striated. No swim-bladder, even in adults.

Colour bluish-black above, silvery to white below. Finlets yellow. Sometimes a violet streak along each side, evanescent.

Around the top of Australia, descending in the west at least to Fremantle and in the east to Twofold Bay. *K. tonggol* feeds on small fishes and crustacea, takes garfish, live bait or a lure and is occasionally seined when it approaches beaches.

Type-locality : Batavia.

Synonym : *Thunnus nicolsoni* Whitley, 1936, from Lindeman Island, Queensland.

Yellowfin Tuna, Allison's Tuna

Neothunnus macropterus (Temminck & Schlegel, 1844)

(Plate I c)

Neothunnus macropterus is probably common at all times well off the Australian coasts but it was not until February 26, 1936 that Zane Grey caught the first recorded example, a 91 lb. fish (Whitley, 1937, Rec. Austr. Mus., 20, p. 13 & 273, pl. ii, fig. 1) from 30 miles off Bermagui, N.S.W.

Earlier, in New Zealand, one had been stranded in Whangaruru Harbour (New Zealand Herald, May 19, 1930). It was said to have been about 180 lb. in weight and 5 ft. 8 in. in length with 3 ft. 10 in. girth. A second New Zealand record, from Tokomaru Bay, was featured in the Auckland Weekly News, Oct. 28, 1936, p. 49, fig. In June 1937 a 70 lb. fish 4 ft. 7 in. long was caught at Lord Howe Island and eight of about 30 lb. in February 1938 (G.M. Kirby, in. lit.), the first tunas known from Lord Howe Island. Stanley Fowler [1938 Rod Fishers Gazette, 6(5), p. 9] noted the species from Townsville to Gladstone in Queensland, a 4 ft. fish from the latter place was caught in August 1938, and a number of "goldfin tuna" in September that year.

Stead (1938, Austr. Nat., 10, p. 124) mentioned a number of localities in N. S. Wales where this fish had been taken. From the 1940's onwards there are many reports of Australian yellowfin tuna, which may be a permanent resident of the open ocean and which comes inshore in any month along the eastern Australian seaboard, whence, according to D'Ombrain, game fishermen have taken fish up to 250 lb. and more in weight. A 6 ft. 2 in. fish from New Zealand weighed 187 lb. (Powell, 1937, Trans. Roy. Soc. N. Zeal. 67, p. 80, pl. 17, figs. 2–3).

The first scientific records from Western Australia were in Serventy's pamphlet and a record from as far south as off Gabo Island, Victoria was made by the same author in 1941 (Serventy, 1941, Vict. Nat. 58, p. 51).

Dr. D.L. Serventy (in lit.) kindly informs me:—

Neothunnus albacora macropterus (Yellowfin Tuna). Distributed along both the eastern and western coasts of Australia, to Cape Naturaliste in the west and Gabo Island in the east. It has not, so far as I know, been taken along the southern coast nor was it encountered in northern Australia between Torres Strait and the Sahul Shelf by the Warreen and Stanley Fowler during the 1949 tuna survey. It occurs fairly plentifully, however, in south-east New Guinea and the Warreen observed it off the south coast of Timor in 1949.

Probably a different picture is presented by long-line catch records. These would certainly show that large fish are more abundant in Australian waters than is evident from

surface (trolling) catches. Thus in April 1947 a 57-lb. fish was caught on at Bunbury, W.A.

The yellowfin tuna (*Neothunnus*) occasionally travels well south. Mr. Robins informs me that it has been found near Lakes entrance, Victoria, and even off Tasmania, in 40 or 41° S. Lat. by 148° E. Long. (new extensions of range).

The type-locality is south-western Japan.

Big-eyed Tuna

Parathunnus argentivittatus (Cuv. & Val., 1831)

I follow Rivas (1961, Ann.Mus.Civico. Stor. Nat. Genova, 72, pp. 131 & 141) regarding the specific name of the big-eyed tuna which Munro [1957, Ich. notes 1(3), p. 145, fig. 1], Collier (1957, Anglers' Digest, Dec. 1957, p. 7 fig.) and I (Whitley, 1958, Proc. Roy. Zool. Soc. N. S. Wales 1956-57, p. 37) have recorded from eastern Australia as *P. mebachi*; according to Rivas, the true *mebachi* equals *sibi*. Dunstan (1961, Papua N. Guinea Agric. Journ., 13, p. 151) notes Papuan occurrences (see addendum at the end of this paper).

February to April is the season when, since 1939, they have been caught in northern New South Wales, the fish being about 12 lb., and working north in very great shoals.

D. xiii to xv, 13 to 14+8 to 10; A. 13 to 14+8 to 9; P. 30 to 32. Gill rakers 5 to 10 / 16 to 18. Eye large. Body scaled; corselet present. Pectoral reaches beyond vertical of origin of second dorsal fin.

Black above, leaden or silvery grey below. Tips of dorsal and anal fins and finlest yellow. Pectoral fin black. Tail yellowish.

The big-eye tuna (*Parathunnus*), until recently unrecorded from Australia, is shown on Japanese charts to have an enormous range, embracing the Coral Sea, Shark's Bay, Western Australia, etc. I shall not anticipate Mr. Robins' records more than to say that he has found the species eastward of New South Wales down to east of Bass Strait (in January and February), well south of the Great Australian Bight in February and March, off south-western Australia in early March; and he has received juveniles from off Jervis Bay, New South Wales (taken Dec. 1959–Jan. 1960).

3½ feet, may reach 6 ft.

Type-locality, Malabar.

Bonito

Sarda spp.

There are two species of *Sarda* in Australasian seas: the "Horse Mackerel" or bonito, *Sarda australis* and the oriental bonito, *Sarda orientalis serventyi*. Dr. Serventy has an account of these in manuscript for publication elsewhere but he has kindly furnished me with a map of their distribution and permitted me to reproduce it here (Fig. 2). The former species may be a form of the South American *chilensis*, under which name it has been described in literature.

KEY

A. Head smaller, 3⅔ to 4 times in length to end of caudal keels. Maxillary less than half length of head. Gill rakers 6 to 8+12 to 14.....*australis*.

AA. Head larger, 3¼ to 3½ times in length to end of caudal keels. Maxillary more than half length of head. Gill rakers 2 to 4+7 to 9.....*orientalis serventyi*.

Bonito or 'Horse Mackerel'

Sarda australis (Macleay, 1881)

(Plate II c)

Macleay (1881, Proc. Linn. Soc. N. S. Wales 5, p. 557; Cat. Austr. Fish. 1, p. 192) named *Pelamys australis* as a new species from Port Jackson and Ogilby in 1886 remarked its resemblance to *chilensis*, which had erroneously been recorded from New Zealand by Sherrin in the same year. Shortly afterwards, McCoy (1888, Prodr. Zool. Vic. pl. 155) named *P. schlegeli* as a new species from Port Phillip Bay, Victoria. Lucas in 1890 thought *schlegeli* might be *orientalis*. Ogilby (1893, Ed. Fish. N. S. W. pp. 97 & 206), Waite (1899, Austr. Mus., Mem., 4, p. 70) and Stead (1908, Ed. Fish. N. S. Wales, p. 94, pl. 64) furnished further notes. It is also known from South Queensland and Norfolk Island. Nowadays quantities are measured by the ton.

F. de Buen (1958, Rev. Biol. Mar., Valparaiso, 7, p. 12) recognizes subspecies of *Sarda* from Chile, and Godsil (1955, Calif. Fish. Bull. 99, pp. 7-43 and figs.) described and figured Peruvian fish in detail. A forthcoming publication by Dr. Serventy will doubtless clarify some of the problematical points raised by Godsil concerning the distinction of species.

Sarda australis is common at practically all times off eastern Australia from about the Capricorns to Sydney or even Gabo Island, but as D'Ombrain remarked, may be in abundance one week and absent the next. It is used as bait for sharks and game fishes. It sometimes ventures into Victoria in summer months (Jan. to April), some fish having large roes there, but it moves northwards along N. S. W. in the winter. Fish ready to spawn have been found in February and March off New South Wales. The smallest fish in the Australian Museum (19.8 cm. L.C.F.) was caught in New South Wales in June or July 1940, thus perhaps four months old (Regd. no. IB. 1203).

Oriental Bonito

Sarda orientalis serventyi Whitley, 1945

(Plate II d)

This species was regarded as a synonym of *australis* or *chiliensis* by authors, but occurs off the south-western Australian coasts whence I named it as a subspecies *serventyi* (Whitley, 1945, Austr. Zool. 11, p. 41 *et. ibid.* 1947, p. 146, pl. xi, fig. 4).

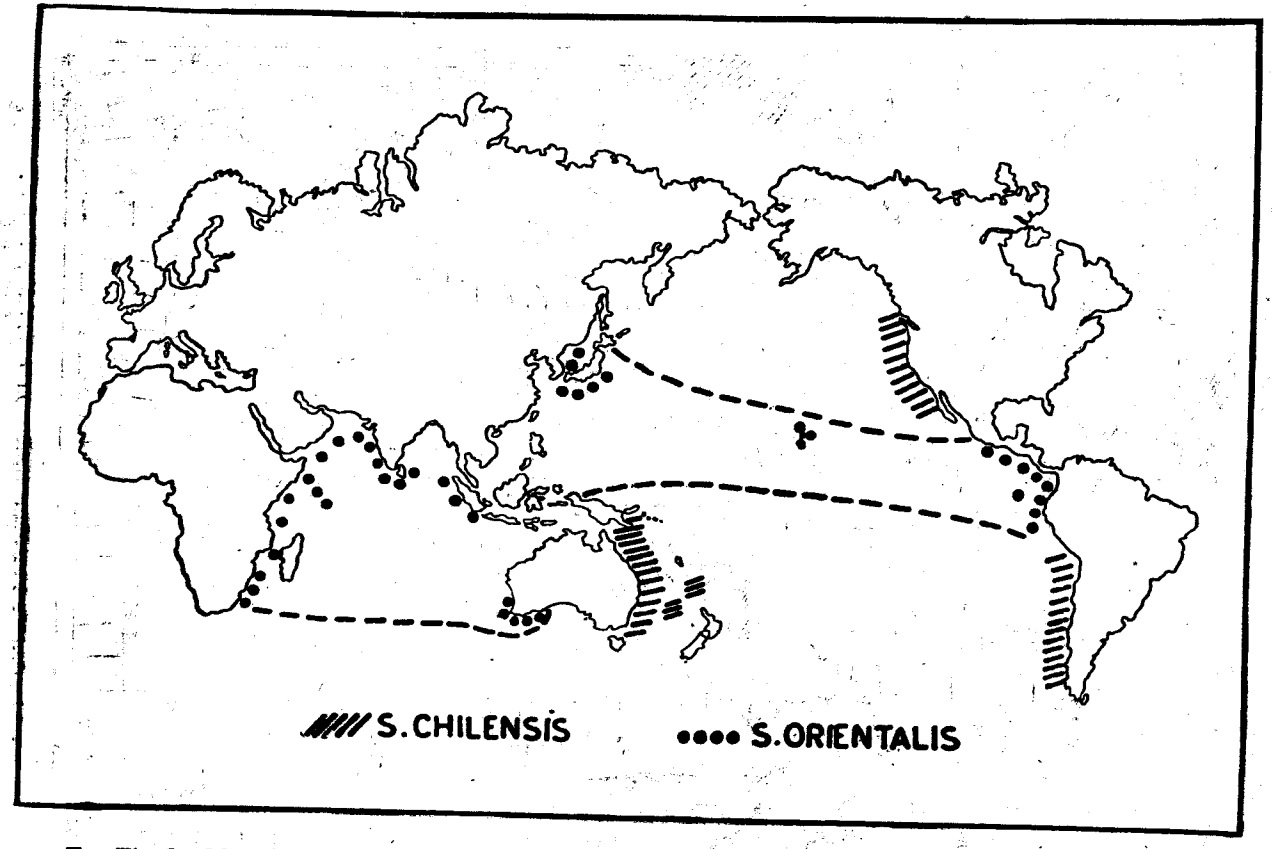
The type-locality of *orientalis* is Japan, of *serventyi*, Albany, Western Australia.

Dr. D. L. Serventy (in lit.) kindly informs me:—

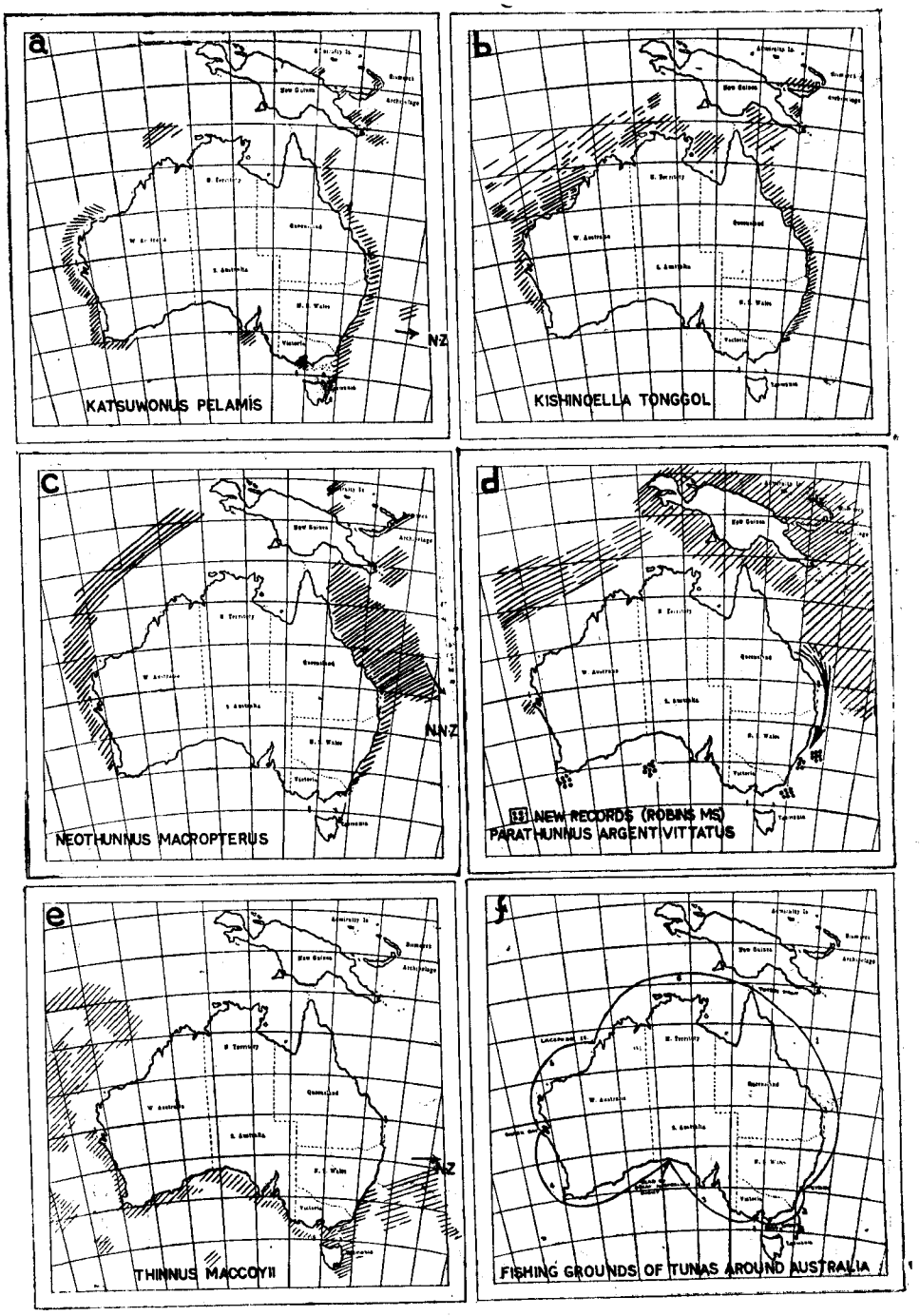
Sarda spp. (the Bonitos). *Sarda chilensis australis* occurs along the east coast from southern New Guinea waters to eastern Bass Strait, but rarely ventures westward beyond Wilson's Promontory. It occurs at Lord Howe and Norfolk Islands but not in New Zealand. *Sarda orientalis* has, in Australia, only been found around the south-west corner of Western Australia, from Rottnest Island in the north to as far east as Doubtful Island Bay. The normal northern limit appears to be Busselton.

Some general remarks on the distribution pattern of these two species:

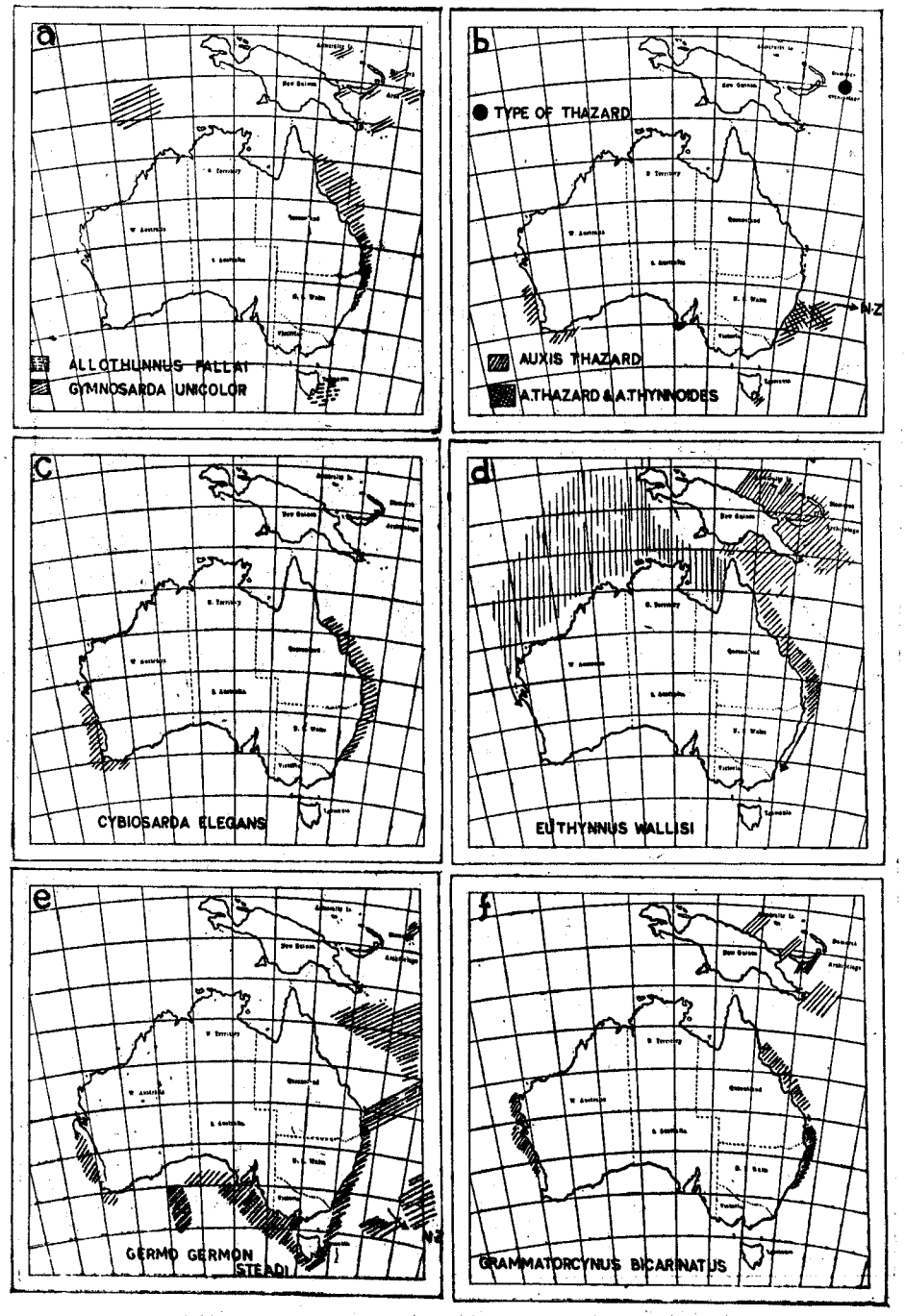
Only one occurs in the Indian Ocean but both are found in the Pacific. Figure 2 is a map I prepared some years ago but not yet published though my ms. is ready. In the Pacific Ocean *S. chilensis* is a temperate to warm-temperate species which exhibits the phenomenon of bipolarity or anti-tropicality (vide Hubbs). The northern and southern



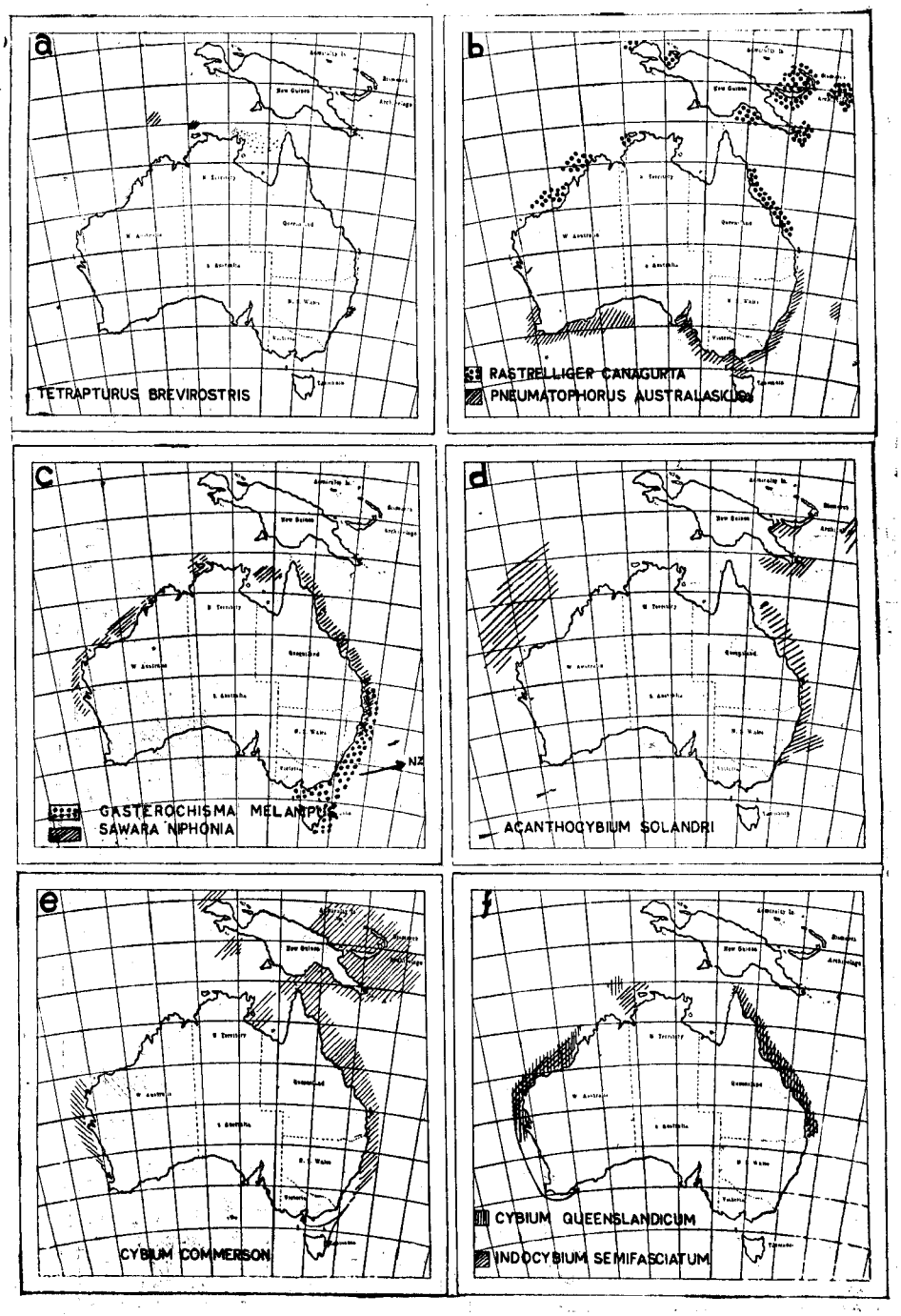
Text Fig. 2. Map showing distribution of *Sarda chilensis*, and *S. orientalis*, represented respectively in Australia by *S. australis* and *S. orientalis serventyi* (after Serventy, MS.)



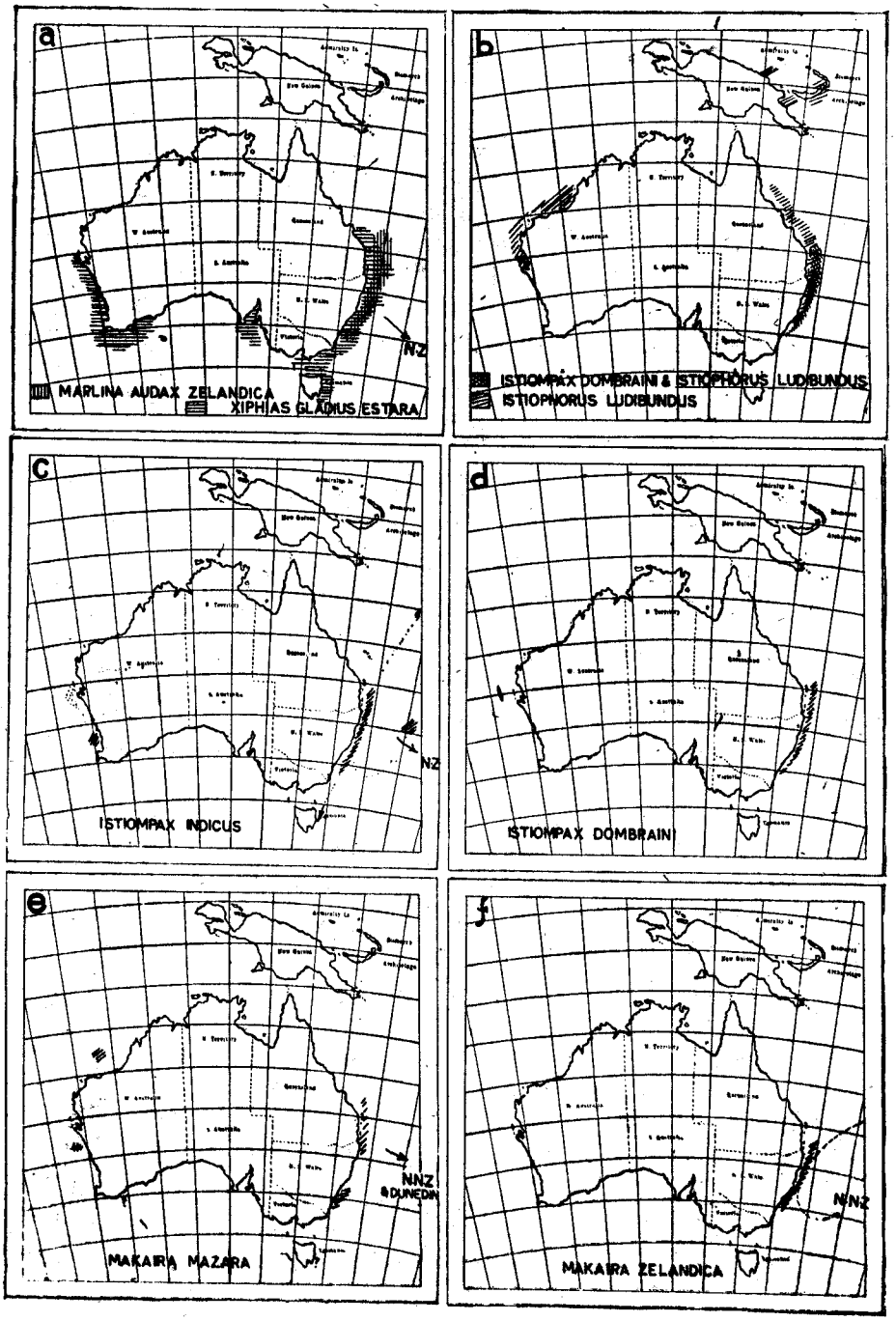
Text Fig. 3. Australasian distribution of Scombroid fishes.



Text Fig. 4. Australasian distribution of scombroid fishes.



Text Fig. 5. Australasian distribution of scombroid fishes.



Text Fig. 6. Australasian distribution of scombroid fishes.

hemisphere populations are separated by *S. orientalis* (syn. *velox*) which in this ocean has a pan-tropical distribution. Walford (1937, Marine Game Fishes of the Pacific Coast, p. 21) believed that the various forms were limited by physical factors and that the tropical form could not withstand cool waters. That this is by no means the whole story is evident from the distribution pattern in the Indian Ocean. There are no forms of the *chilensis* complex and instead of being confined to the tropical belt as it is in the Pacific, *Sarda orientalis* extends both north and south into more temperate waters—into waters where, in corresponding parts of the Pacific, a form of *chilensis* might be expected to occur. This indicates that temperature limitations need not prevent the occurrence of *S. orientalis* in any particular habitat and that biological competition from similar species has to be reckoned with. It is clear that the optimum environment of *Sarda orientalis* is the region of the tropics, from which it can exclude the penetration of its allies of the *chilensis* complex. On the other hand they can successfully resist the entry of *orientalis* into their optimum environment, the temperate waters. In the Indian Ocean, where *S. orientalis* alone occurs, it inhabits alike tropical and temperate waters.

Southern Bluefin Tuna or Southern Tunny

Thinnus maccoyii (Castelnau, 1872)

(Plate I d)

D. XIII to xiv, 14 to 15+8 to 9 ; A. 14 to 15+7 to 8 ; P. 28 to 34. Sc. 207 to 235. G/R. 9 to 13/21 to 28=31 to 40 (mode 11/22 to 23=33 to 34).

Operculum rounded. Body plump. Pectoral fin much shorter than head. Liver striated. Adults with swimbladder.

Blue-black above, silvery below. First dorsal grey with yellow tinge. Finlets yellow, bordered with black and edged with white.

Before 1890, a stranded specimen was reported from Glenelg, S.Australia, reputed to have weighed 800 lb. Rare over 300 lb. Average caught weigh between 40 and 50 lb. Believed to spawn off S. W. Australia.

8 ft. 800 lb.

Open coastal waters of south Queensland, N. S. Wales, Victoria, South Australia, Western Australia and New Zealand.

This commercial species has been dealt with in detail by Serventy (1956, Austr. J. Mar. Freshw. Res., 7, pp. 1-43, pls, i-ii, figs. 1-10). Dr. Serventy informs me by letter that he personally has no further distributional data to add to that published. However, since he left the Division of Fisheries, new techniques have been adopted "and much new information on the occurrence of the tunas has emerged. In the old days we used only surface catching gear, mainly trolling lines. Then after World War II the long line technique of the Japanese was adopted and this showed that the tunas were also bottom and mid-water animals and occurred below the surface in geographical areas where they never, or rarely, revealed themselves at the surface. Thus off the N.S.W. coast the Fisheries Division of C.S.I.R.O. is catching the very large size groups on the bottom".

"It would appear from Tokiharu Abe's paper (Bull. Jap. Soc. Scientific Fisheries, 21 (1) 20, 1955) that our *maccoyii* extends, as a subsurface fish, to the waters between North-Western Australia and Indonesia. I would have thought this incredible a few years ago."

The scope of the southern bluefin tuna's activities has been greatly enlarged by the Nankai Research Station's maps. In the "Indo-maguro" stage, Mr. Robins informs me, these fishes are apparently all over 137 cm. in L.C.F. and found in the Indian Ocean north-west of Western Australia. Though distribution is continuous down the Western Australian coastline, there is a perceptible gap between the big Indo-maguro fish and smaller size-groups further south-west, perhaps caused by water-conditions off the North-West Cape area. Japanese fishermen obtain this tuna far to the west of Australia and early in 1962 some 10,000 to 300,000 kg. of Southern Bluefin Tuna were landed daily at a fishing port near Tokyo (T. Abe, in lit.).

The type-locality of *maccoyii* was Victoria (Melbourne markets) and a synonym, ***phillippsi*** Jordan & Evermann, 1926, was described from New Zealand.

(B) BILLFISHES

Artificial Key to the Australasian Billfishes

A. Sword broad across and flat, not circular in cross-section. No scales. One dorsal and one anal fin. No ventral fins. 26 vertebrae.

The Broadbill Swordfish, *Xiphias gladius estara*

AA. Sword almost circular in cross-section. Scales present. Two dorsal and two anal fins. Ventral fins present, strip-like. 23 or 24 vertebrae.

B. First dorsal fin extensive, sail-like, much higher than the depth of the body, which is cross-barred. Sword elongate.

Sailfish, *Istiophorus ludibundus*.

BB. First dorsal fin lobed in front, not high and sail-like.

C. Body with cross-bars, robust, not very compressed. Lobe of first dorsal fin higher than the body is deep, which depth is less than one-fifth of fish. Vertebrae 12+12. Lateral line simple. Pectoral fin adpressible. Eye-diameter goes about 11½ in sword. Origin and end of second anal fin before levels of those of second dorsal fin.

Striped Marlin, *Marlina audax zelandica*.

CC. Body usually plain, or with indistinct cross-bars. Dorsal lobe shorter than depth of body, which is more than one-fifth length of fish. Vertebrae 11+12 to 13 or 12+12. Lateral line indistinct or complicated.

D. Pectoral fin rigidly erect, difficult to lay alongside body.

E. Spear thick, upturned; shoulders often heavy or hunched. Generally no colour-bars; no blue patch near pectoral fin. Size very large, may exceed 1,200 lb.

Black Marlin, *Istiompax indicus*.

EE. Spear slenderer, more tapering and horizontal; shoulders more sloping. Pale blue bars on upper parts of body and a blue patch near pectoral fin. More numerous, large blue spots on first dorsal fin than in Black Marlin. Generally less than 200 lb. Vertebrae 11+12. Airbladder in several layers.

D'Ombrain's Marlin, *Istiompax dombraini*.

DD. Pectoral fin can be pressed down alongside body.

F. Middle dorsal spines short. Lateral line indistinct. Ventral fin shorter than pectoral. First dorsal fin spotted.

Howard's Marlin, *Makaira mazara howardi.*

FF. Middle dorsal spines long. Lateral line distinct. Ventral fin longer than pectoral. First dorsal fin dark, sometimes with lighter basal portion, but not spotted. May be young Black Marlin?

Short-snouted Spearfish, *Tetrapturus brevirostris.*

Family XIPHIIDAE

Broadbill Swordfish

Xiphias gladius estara Phillipps, 1932

(Plate III a)

Early records and reports of sighting *Xiphias* may have referred to marlins, but the Broadbilled Swordfish was reported from New Zealand in 1874 and New South Wales in 1908. Specimens are rarely preserved; it grows to 15 ft. and nearly 1,000 lb. in New Zealand. Australian records are as follows:

Western Australia: City Beach, Perth; 30 March, 1955 (found dead). Geraldton, 1935 (W. A. Museum no. P. 1298). Quindalup; 13 March 1951 (a 400 lb. fish harpooned during a run of Salmon, *Arripis*) Albany, Hopetoun, Abrolhos and Shark's Bay. Shoalwater Bay, 8 October 1962.

South Australia: Kingston; 3 Dec. 1948 (length 13 ft. 2 in. Spear in S. Aust. Mus.). Windsor, St. Vincent's Gulf (Skull in S. A. Mus.). Port Pirie, 1949. Kingston, 1949. Port Augusta and Spencer's Gulf. Lowly Point, near Whyalla, 20 Jan. 1950 (290 lb.).

Victoria: Frankston, Port Phillip; Nov. 1950 (Stranded, about 8 ft.)

Tasmania: East Inlet, Stanley; 7 April 1952 (Stranded, about 10 ft. long; sword, 3 ft.)

New South Wales: Kiama; 23 Nov. 1908 (9 ft. 4 in. long, pursuing Mulloway, *Sciaena*). Crookhaven, 35° S. Lat. About 1931, stranded. Trawled off northern New South Wales, Aug.-Sept. 1931 (Austr. Mus. regd. no. IA. 5124). Off Montague Island, January 1936 (10 ft. 4 in.). Cronulla, 1936 (10 ft. 6 in.). Several small ones reported in the 1930's off Port Stephens. Off Morna Point (reported 1939, 1940 & 1947). Bermagui, 1941 and 1954. 50 fathoms, off Sydney, 20 April 1963 (18 inches).

Queensland: Odd reports from the Great Barrier Reef (doubtful), Rockhampton and Moreton Bay. In July 1947 a 250 lb. fish was washed ashore in South Queensland; another earlier at Stradbroke Island. At the end of 1955 Japanese fishermen had obtained examples from well offshore, south Queensland. The species is probably not tropical and Zane Grey's Gulf of Carpentaria report has not been confirmed by anyone else.

Xiphias has been taken on a number of occasions southward to Hokitika and Otago. In Australasia, therefore, it ranges between about 20° to 43° S. Lat. and at various depths.

Type-locality of *X. gladius* in European seas, of *estara*, New Zealand.

Family ISTIOPHORIDAE

Sailfish

Istiophorus ludibundus Whitley, 1933

(Plate III b and c)

Australasian occurrences of the Sailfish have been recapitulated from about 1900 to 1955 in an article of mine in the Australian Museum Magazine, 11, 1955, p. 381, but the record therein from Ulladulla, New South Wales, must be cancelled since it referred to *Coryphaena*, not *Istiophorus*. A sailfish 9 ft. long and weighing 62 lb. was taken off Port Stephens, N.S.W. on March 1960. Another (9 ft. 1 in., 52 lb.) off Currumbin, Queensland. One of about 100 lb. was caught at Lord Howe Island (Anglers' Digest, Dec., 1960, p. 28 & fig.).

The species is not often caught, ranges south in December to April from the tropic to Port Stephens in the east and Shark's Bay in the west. Papuan references were given by Munro (1958, Papua—New Guinea Fisher. Bull., 1, p. 264). There are no authentic records from the Northern Territory of Australia or New Zealand*, but several from Fiji, Tonga, the Solomons and Tahiti. Goode (1883) mapped it from the Gulf of Carpentaria.

It is said to reach 10½ feet and about 200 lb. weight.

Type-locality, Port Stephens, N. S. Wales.

Striped Marlin

Marlina audax zelandica (Jordan and Evermann, 1926)

(Fig. 1 c)

The first Striped Marlin caught in Australia appears to have been the 230 lb. fish taken off Montague Island, New South Wales, on February 12th. 1934 [Rod Fishers' Gazette 2 (6), p. 3 and 2(12) p. 6, fig.], an example soon followed by many anglers' captures. The species had previously been known from New Zealand. Phillipps (1926, Trans. N. Zeal. Inst., 56, p. 536, pl. 92) and Griffin (1927, Trans. N. Zeal. Inst., 58, p. 143, pl. 14, fig. 6) described and figured North Island examples for which Jordan and Evermann's specific name *Makaira zelandica* is applicable (1926, Occas. Pap. Calif. Acad. Sci., 12, p. 65, pl. 19, fig. 2), the fish figures on the 1933 fivepenny New Zealand stamp. Lindauer (1935, Nature, Nov. 16, p. 797) recorded a 238 lb. female, caught in the Bay of Islands, February 28, 1935, which had well filled ovaries, but the general consensus of opinion indicates that Australian fish are not fully mature. Detailed measurements of our Striped Marlin were provided by Gregory and Conrad (1939. Bull. Amer. Mus. Nat. Hist., 76, p. 443) and the allometric growth was discussed by Morrow (1952, Pacific Science, 6, p. 53) who also regarded the New Zealand population as distinct from those of Peru and elsewhere (Morrow,

* Since this was written, Moreland (1961, in Neil Illingworth's "Fighting Fins", p. 71) noted, "There is a single record of a sailfish from New Zealand waters. This was a 41 lb. fish chased ashore at Pataua, near Whangarei, in February 1948."

1957, Bull. Bingham Oceanog. Coll., 16, pp. 44 et. seq.). Kamimura and Honma (1960, Charles F. Johnson Gamefish Invest. Progr. Rept., 6, append. i and ii) showed that north and south Pacific populations are independent. It is noteworthy that the Striped Marlin has not yet been taken in Western Australian waters, as far as I know. December to April is the season in New Zealand, most fish being caught in February. In New South Wales, D'Ombrain notes that " whilst most are taken from late December to early May, it is not unusual for an early appearance to be made off Port Stephens in September ", and I have noticed it in June off Sydney. The species perhaps grows to about 14 feet long and 976 lb. but most Australian specimens are around the 230 lb. mark and up to 10 ft. long. New Zealand fish are larger, possibly through the same stock migrating and growing from eastern Australia.

Range: Southern Queensland, New South Wales and North Island of New Zealand. Occasionally down to Stewart Island, southern New Zealand.

Type-locality to Bay of Islands : New Zealand.

Black Marlin

Istiompax indicus (Cuv. and Val., 1832)

The first Black Marlin taken by an Australian angler was one 9 ft. 2 in. long and over 200 lb. weight, handlined on February 21st., 1854, the holotype, now no longer extant, of *Tetrapturus australis* Macleay. The Maoris of New Zealand used to catch some marlin and the swords of others were found in the hulls of wooden ships. Hector recorded a western New Zealand specimen seen in June 1867 and about 1887 a large one was stranded in Tasmania. There are reports from Western Australia and Queensland, but few specimens have been studied. Fish of various sizes come to New South Wales in December, or more usually mid-January, and their numbers may taper off in April. Some large ones have been stranded in July to September, the largest having been 14 ft. 9 in. long and 1226 lb. in weight. D'Ombrain (1952, June Outdoors and Fishing, p. 101 & figs.) says they bite well in rough weather with clouds and rain and that it is a waste of time seeking them when westerly winds flatten the sea under clear skies. The best time of day is between 10 a.m. and 2 p.m., then again towards 4.30 p.m.

Most of the Port Stephens fish are between 6½ and 9½ feet long and weigh 50 to 200 lb. Northern New Zealand fish are larger but they are smaller than some Peruvian ones which have been reported. Lindauer (1935, Nature, Nov. 16, p. 798) reported a 436 lb. female in roe from the Bay of Islands, New Zealand, taken on March 12th, 1935.

Type-locality : Sumatra.

Synonyms : *Tetrapturus australis* (Wall) Macleay, 1854, from Broken Bay N.S. Wales and *Istiompax australis* (Wall) Whitley, 1933 from Wollongong, N. S. Wales and probably *I. australis glauca* Smith, 1956, from Eden, N. S. Wales.

D'Ombrain's Marlin

Istiompax dombraini Whitley, 1954

(Fig. 1 d)

Game-fishermen in New South Wales have difficulty in identifying some smaller fish which seem to be distinct from the true Black Marlin, differing in the respects mentioned in the key above. Possibly all these variants are forms of the Black Marlin, but it seems

best, until intermediates are found to link them, to treat them as separate species. One, with rigid pectoral fins, I have named D'Ombrain's marlin, after Mr. Athel D'Ombrain, the accomplished angler and naturalist. The other, with adpressible pectoral fins, is regarded as the short-snouted Spearfish, *Tetrapturus brevirostris*.

D'Ombrain's Marlin is caught off the New South Wales coast (south to Cronulla, but mostly off Port Stephens) and in southern Queensland from November to April. The fish are from six to eight feet long and weigh about 50 to 245 lb.

Type-locality : Off Port Stephens, N. S. Wales.

Indo-Pacific Blue Marlin, Howard's Marlin

Makaira mazara (Jordan & Snyder, 1901)

(Plate III d)

Early reports of very large marlins from Australia may have referred to Blue Marlins, for example a fish stranded over 80 years ago in Tasmania and the large Eden fish which Smith (1956 Ic. Bull. 2, p. 30) named *Makaira* or *Istiompax indica glauca;* or these specimens, which have not been preserved, may have been Black Marlins. It was not until Colonel J. K. Howard captured a 404 lb. female, just over 11 feet long, at Bermagui, N. S. W. in March 1953, which I named *Istiompax howardi* after him, that the suspected existence of a Blue Marlin in Australasia was proved. Howard's Marlin is now regarded as synonymous with, or a southern form of, the Japanese *mazara*, which may range from East Africa to Chile. The most recent description is that of Moreland (1960, Rec. Domin. Mus., 3, p. 247, pl. i).

The Blue Marlin is known from north-western Australia [Royce, 1957, Fishr. Bull. (U.S. Fish & Wildlife 57, 124), p. 499]; New South Wales, New Zealand, down to Dunedin, New Zealand. Examples reached 11 ft. 7 ins. and 522 lb. weight, but an extralimital fish of 1560 lb. has been recorded. The Australian Museum has a cast of the type of *howardi*, and I have seen other specimens of blue marlins in Museums in New Zealand, in Hawaii and in the United States.

From February to April is the season when a few blue marlins are taken by game-fishermen in Australia and New Zealand, but there are reports of other fish having been taken in January (W. Australia), May (New Zealand and Queensland) and August (Queensland). Perhaps the latter records should be accepted with reserve as specimens were not critically examined by specialists.

Type-locality : Misaki, Japan.

Synonym or subspecies: *Istiompax howardi* Whitley, 1954, from Bermagui, N.S. Wales.

Short-snouted Spearfish

Tetrapturus brevirostris (Playfair, 1866)

Early Australasian references to *Tetrapturus brevirostris* seem to refer to the Black Marlin (*Istiompax indicus*) and perhaps other marlins. I have tentatively identified as *T. brevirostris* several specimens of a small marlin which has been caught off Northern Australia and New South Wales which is distinguished from the black marlin by the key characters given above. They have D. xxxv to xl/7; A. xi to xiii/6 or 7; P. i, 18 to 19; V. 2

or 3. Scales circa 130 to more than 140. Median dorsal spines high. Sword 4.6 to 4.9 in length to caudal fork, 9 or 10 times eye. Depth 7 to 8 in total length. Lateral line usually distinct. Pectoral fin adpressible, longer or shorter than ventral.

Greyish-blue above, whitish below. Some with up to about 20 stripes down back, extending about one-third of the depth of the fish, instead of most of the way down as in Striped Marlin. First dorsal fin dark, not spotted, sometimes with light proximal area.

The weight-length ratio is similar to that of D'Ombrain's Marlin, but fish examined by me fall between 5 and 6 feet in length and 45 to 56 lb. weight.

Goode (1883) mapped *Tetrapturus* from the Gulf of Carpentaria. I have ***brevirostris*** from north-western and north Australia and off New South Wales. Northern ones, August to early October. In New South Wales, February, April and December.

Type-locality : Zanzibar.

(C) MACKERELS

Family SCOMBRIDAE

Common or Slimy Mackerel

Pneumatophorus australasicus (Cuv. and Val., 1832)

(Plate IV c after Stead)

All the common mackerels of Australasia are regarded as belonging to one species although authors have suggested that more than one form is represented.

Depth 5.5, head 4-4.25 in total length. Eye 3-4.1 in head, with an adipose lid. Single series of small curved teeth in both jaws and on vomer and palatines. D. X-XII; 1, 11; 5-6 finlets. 1st Spine of 1st D. shorter than 2nd spine. D. fins widely separated. A. i, 11 to 12; 5-6 finlets. P. 18 to 21. A. originates below 3rd ray of 2nd D. Entire body scaled. Scales in P. region somewhat larger. Swim bladder present. L. lat. 160 to 225. Tr. 20+33. G. R. (12–13)+(23–27). Vertebrae 14+17.

Bright green or bluish-grey above with numerous irregular broken wavy blue or dark green markings. Silvery below. Fins blue or pale yellowish green. A black axillary spot, caudal narrowly bordered black.

Length to 20½ inches, wt. 3¼ lb., but usually less than 14 inches.

First reported from Australia by Francois Peron in 1802, were vast schools in south-western Australia which in modern times have been photographed from the air.

Although the mackerel is very plentiful at times off the Australian coastline (generally in May and June in the Sydney district) no adult specimens with roe have been detected. Their occurrence is not regular over the years, probably due to fluctuations in water-conditions. Possibly spawning takes place at the ocean surface many miles from shore, as in related species in other countries. Ogilby (1893, Edible Fishes of N. S. Wales, pp. 94-95) gave an account of the biology.

South Queensland, N. S. W., Vic., Tas., S. A. and W. A., New Zealand and Lord Howe Island. The Australian Museum has juveniles (regd. nos. IB. 309–3100), 36 to 76 mm. in total length, from fish stomachs, off Point Cloates, Western Australia; 2nd to 3rd August 1952.

Type-locality : King George's Sound, Western Australia.

Synonym : *antarcticus* Castelnau, 1872 from Melbourne markets.

Indian or Rake-gilled Mackerel; Wade (Queensland aboriginal).

Rastrelliger canagurta (Cuvier, 1816).

The description below is taken from Munro, 1958.

The Indian Mackerel (*Rastrelliger canagurta*) was not recognized from Australian seas until 1879 when Klunzinger (1879, Sitzungsb. Akad. Wiss. Wien, 80, p. 375) noted it from Queensland, from a 30 cm. specimen sent to him by Baron von Mueller. In 1944, I named a subspecies *serventyi* from Port Hedland, Western Australia, which had been collected in 1914 (Whitley, 1944, Austr. Zool., 10, p. 268). Further Queensland records in the same paper showed that *canagurta* had been caught from February to July in various years down to Yeppoon. Serventy (1952, Emu. 52, p. 49) noted specimens eaten by Boobies (*Sula leucogaster*) at Bedout Island, Western Australia. Then Munro (1958, Hbk. Austr. Fish. 27, p. 112, fig. 747) recorded it from Darwin in the Northern Territory. Whitley (1947, Austr. Zool. 11, p. 138) had found it in the stomach of a trevally off Cape Baskerville, Western Australia. So we have scattered records of this fish (which may be quite common) from north-western Australia, Northern Territory and Queensland. More meristic data are required from series of specimens to determine what races are represented.

RAKE-GILLED MACKEREL, *Rastrelliger canagurta* (Cuvier, 1816). Moderately compressed. Depth 3.7–3.9, head 3.5–3.7 in length without tail. Eye 4–4.6 in head, 1.2–1.3 in snout, with an adipose lid. Teeth in single row in jaws only, sometimes obsolete. Maxilla reaches hind edge of pupil or further in larger examples. D. X-XI; 12; 5 finlets. 1st spine of 1st D. shorter than 2nd spine. D. fins not widely separated but posterior spines of 1st D. minute and hidden in a groove. A. 12; 5 finlets. Entire body scaled. Breast scales larger. L. lat. circa, 120. Tr. 10+30. G. R. (13-16)+(31-36), extremely long and extending into mouth cavity. Blue-green above with 2 rows of black spots along back, upper series along base of D. fins. Larger examples with longitudinal streaks. Fins yellowish. 1st D. fin with black tip. 11 inches or more. Qld., N.T., and W.A.

Type-locality : Vizagapatam, India.

Family GASTEROCHISMATIDAE

Butterfly Mackerel, Blueskin, Butterfly Kingfish.

Gasterochisma melampus Richardson, 1845.

(Plate IV a)

D. xvii–xviii/i, 9 to 10 + 6 to 8; A. i to ii, 9 to 10 + 6 to 8. L. lat. 64 to 70. Tr. 7/19. Teeth conic. No gill rakers. Body compressed, scaly. No caudal keels. Ventral fins large in young and folding into a sheath along the belly, but small in adults.

Dark midnight blue above, lilac blue to gunmetal gray on sides and greyish silvery below. Eye smoky bluish. First dorsal hyaline. Second dorsal dark blue or grey on fin and finlets with white edges; anal similar to second dorsal or pale green, edged white Pectorals grey or bluish. Ventrals blue-black with first spine silvery. Caudal grey or white with sea-green margin.

Said to reach 5½ feet and 200 lb.

Southern Queensland, New South Wales, Victoria, Tasmania and New Zealand ; South America, Falkland Islands and South Africa. Occasionally takes a trolled lure. There have been sporadic appearances of this fish in Australasia over the last 120 years or so, mainly in New Zealand and Tasmania. It is probably a swift migrant, liable to occur in schools at any time. Data are incomplete, but February and May are months in which New Zealand fish have been caught. February to June see them in Tasmania, and they travel up New South Wales to Southern Queensland in July or August.

Type-locality : Port Nicholson, New Zealand.

Synonym : *Lepidothynnus huttoni* Günther, 1889, from Lyttelton, New Zealand.

(D) SEERFISHES

Family ACANTHOCYBIIDAE

Wahoo

Acanthocybium solandri (Cuv. & Val., 1832)

Brief descriptive notes made from Timor Sea, Australian and Papuan specimens examined by me :—

D. xxv/i, 10 to 12+9 to 10 ; A. 10 to 12+7 to 9; P. 24. Teeth about 57/50 each side of jaws. Vertebrae 29 plus 27 to 31 plus 30. Very pointed snout, large head. Close-set triangular teeth in jaws. Villiform teeth on vomer and palatines. Maxillary barely reaching eye. Gills without rakers. Body elongate, cigar-shaped. Long first dorsal base, with many spines. Angular second dorsal and anal followed by 7 or more finlets. Swim-bladder elongate, carrot-shaped with two pointed horns.

Papuan specimen : General colour navy blue above, grey to aluminium on sides, and light grey below. About seventeen dark olive to blue cross-bars on back. Some bright blue marks along temples. Pupil dark glassy grey. Iris pale yellow and grey. First dorsal fin blue, the spines grey. Second dorsal pale grey with smoky margin. Dorsal finlets, pectoral and caudal fins grey. Anal lobe and finlets pale silvery. Ventrals silvery and blue. Palate whitish ; floor of mouth grey.

The type-locality was between Lagoon Island and Thrumb Cap Island in the Paumotus where Cook found it on April 4, 1769. Since reported from a wide tropical range. I obtained one in the Timor Sea at about 10°S lat. by 126°E long. on Sept. 4, 1949, another at Isu Isu, Papua on 8 October 1948, and have seen examples in Brisbane fish markets in March 1943. It is known from Papua down to Port Hacking (Jan. to March). A Wahoo from Lord Howe Island was figured as a record-sized kingfish in "Anglers' Digest", May 1952 ; it was said to have been 6 ft. 7½ in. long and to have weighed 95 lb. Usually Australian specimens are 4 to 5 ft. long and from 20 to 60 lb. weight.

The International Game Fish Association of New York, in its 1957 list of World Record Marine Game Fishes, states that All Tackle Record for the Wahoo was a fish 6 ft. 4½ in. long and weighing 136 lb., taken in Florida in April 1955. A Bahamas fish 6 ft. 11 in. long, caught in 1951, is still the longest, but not the heaviest Wahoo caught.

Zane Grey noted a 67 lb. Tahitian wahoo which was said to have been 8 ft. long, but a mistake must have crept in somewhere, so that his record length is not accepted by the International Association.

(D) SEERFISHES

Family SCOMBEROMORIDAE

There are very dubious records of *Cybium guttatum* from New Zealand and the Chatham Islands and it is doubtful whether there are any seerfishes in New Zealand. In Australia, however, there are four species : *Cybium commerson, C. queenslandicum, Indocybium semifasciatum* and *Sawara niphonia,* the most important of which economically is the first named. The family has been very well revised by Munro (1943, Mem. Qld. Mus., 12, pp. 65–95, pls. vi–viii, text-figs. 1-4). Additional observations over the years have corroborated Munro's findings, so I merely offer a few notes on the species, which are known as Spanish Mackerels in Australia.

Narrow-barred Spanish Mackerel or Queensland Kingfish

Cybium commerson Lacépède, 1800

(Plate IV f)

This is one of the chief marketed fishes in Queensland, over 250,000 lb. being handled yearly there. It is usually eaten in steaks, sometimes smoked. It migrates northward between the Great Barrier Reef and the mainland to spawn in summertime, millions of eggs being laid. The development of the egg and larvae have been described by Munro [1942, Proc. Roy. Soc. Qld., 54 (4), pp. 33–48, pls. ii–iv], who emphasised the ease of artificial fertilization which might later be useful to augment natural stocks in the event of over-fishing. After spawning the fish work south to feed and fatten for the next season. They feed on surface fishes, squid and crustacea and are caught on jigs, spinners and lures trolled from launches.

The usual size is from 9 to 30 lb., but a maximum of 7 ft. 6 in. and 130 lb. has been recorded.

Warm coastal waters of Western Australia, Northern Territory, Queensland and New South Wales; rarely ranging south to Victoria and even Tasmania. I have found the vertebrae to number 21+21, 18+24, and 20+24 in Western Australian specimens. The species has a wide extralimital range, generally between 40°N. & S. of the Equator.

Type-locality : Mauritius.

Queensland School Mackerel or Doggie

Cybium queenslandicum (Munro, 1943)

(Plate IV d)

There is little to be added to the original account of this species (Munro, 1943, Mem. Qld. Mus., 12, p. 82, Pls. vii–viii, text-figs. 1-3). I have found it in tropical Western Australia and at Parry Shoal in the Northern Territory. It may sometimes enter New South Wales. Taken by trolling, netting or handlining with live bait, this fish is usually about 19 inches long and 3 or 4 lb. weight, but reaches 30 inches and 10 lb.

The Western Australian form differs slightly from the Eastern Australian type in having non-serrate teeth, generally more anal and pectoral rays, and fewer dorsal rays. The gill rakers are sometimes fewer and the vertebrae less numerous in the West Australian form. The proportions are similar but the pectoral fin's length goes from 1.2 to 2.0 in the head in small specimens. The differences are so slight that I do not think the

Western Australian form is entitled to subspecific rank, though it would have afforded me much pleasure to name it after Mr. Ian Munro, had such a course been necessary. More than 40 were jagged in Shark's Bay in August and early September 1944 and 18 were obtained between there and the Lacépède Islands in August to November 1945. Sizes ranged from L. C. F. 405 mm. (wt. 1 lb. 3 oz.), immature, to L. C. F. 658 mm. (6 lb.), mature adults; females slightly exceeding males in numbers. Apparently both sexes mature at between L. C. F. 520 and 620 mm. Liver not striated. No air-bladder. Most stomachs empty, but some had fed on clupeoid and other fishes. Vertebrae: 18+27=45, 19+27=46, 19+27=46, 20+27=47, and 19+29=48.

Iridescent blue, green and pink to purple along back, blue and bronze-greenish on top of head. Round, grey lateral blotches in two or three rows. Pupil black, iris pearly-grey, smoky grey above. First dorsal black with cream patch. Second dorsal grey, also pectorals and caudal. Finlets dirty white. Anal and ventral fins white. Caudal keels black.

Type-locality: Cape Cleveland, Queensland.

Broad-barred or Grey Spanish Mackerel, Tiger Mackerel.

Indocybium semifasciatum (Macleay, 1883).

(Plate IV e)

Munro's and my papers have dealt with this species, which may grow to over 4 feet in length and 25 lb. weight. It ranges along eastern Queensland, the Northern Territory and north-western Australia, but a straggler, 18 inches long, was found at Esperance, W. A. in December 1944. A juvenile, 45 mm. in total length (no. IB. 4308) is in the Australian Museum from Fanny Bay, Darwin (Sept. 1958), from which vicinity I have recorded mature males (L. C. F. 584 to 761 mm.) caught at the end of September 1949. Mr. D. G. Stead collected examples of this species, up to 11 inches in length and with 15 dorsal spines, at Singora, Thailand (6 May, 1922); Trengganu, Malaya (1 May 1922) and at Sungei Batu Pahat and Bandar Maharani, Johore.

Type-locality: Lower Burdekin River, Queensland.

Synonym: *Cybium tigris* De vis, 1884, from Cape York, Queensland.

Japanese Kingfish

Sawara niphonia (Cuv. & Val., 1831).

Grows to 40 inches and 25 lb., but the usual size of specimens seen by me in Northern Australia was from 50 to 84 cm. in L.C.F. and 2½ to 7¼ lb. weight: maturing males and females (Sep.–Oct. 1949).

No air-bladder. Vertebrae 46 to 48. First dorsal fin often injured as if posterior part had been bitten out.

This species is found around the top of Australia from the Abrolhos Islands in the west to New South Wales in the east.

Type-locality: Japan.

ADDENDUM.

PAPUAN SCOMBROIDS

Papua-New Guinea Catch statistics from the latest trolling surveys were given by D. J. Dunstan [1961, *Papua & N. Guinea Agricult. Journal*, 13 (4) 1961, p. 151—2] who stated, " Listed in order of importance the species are Narrow-barred Spanish Mackerel, *Cybium commersoni* (Lacépède), 46.4 per cent.; Tuna, mainly dog-tooth, *Gymnosarda nuda* (Günther), but including Yellowfin Tuna, *Neothunnus macropterus* (Schlegel), Mackerel Tuna, *Euthynnus alletteratus* (Rafinesque), Striped Tuna, *Katsuwonus pelamis* (Linnaeus), and Big-eye Tuna, *Parathunnus mebachi* (Kishinouye), 17.4 per cent.; Trevally (*Caranx* sp.), 13.3 per cent.; Paradise Fish, *Aprion virescens* Valenciennes, 12.6 per cent.; Pike, *Sphyraena* sp., 9.9 per cent., Red Bass, *Lutjanus coatesi* Whitley, 0.4 per cent.

Small quantities of the following species were also taken :—

Coral Trout, *Variola louti* (Forskal).

Shark Mackerel, *Grammatorcynus bicarinatus* (Quoy and Gaimard).

Runner, *Elegatis bipinnulatus* (Quoy and Gaimard).

Reef Cod, various species of Epinephelidae, etc.

Wahoo, *Acanthocybium solandri* (Cuvier)

Leather skin, *Chorinemus lysan* (Forskal).

Dolphin, *Coryphaena hippurus* Linnaeus.

Shark, various species.

The majority of the less-abundant species were taken when trolling reef and shoal waters. However, the yellowfin tuna, wahoo and dolphin were also caught some distance from reefs, indicating that they do move out to deeper waters.

The highest percentage (66.4) of Spanish mackerel was taken in May when this species was shoaling in the region of Boirama, Blakeney, Hull and Grace Islands (Appendix V). Trolling from Samarai to Bramble Haven in June yielded the highest percentage of pike (15.9). In November, 17.9 per cent. of the total catch was trevally, the troll catches for this month being the lowest recorded for the year. Dog-toothed tuna accounted for 33.3 per cent. of the total catch in the reef waters east of Samarai in March, with corresponding decrease in the relevant percentage of other species. This high figure was due to the discovery of a tuna spawning ground in March, 1958, when large catches of running ripe dog-toothed tuna were made on successive days. On no occasion were large catches of red bass taken. In July 21.6 per cent of the total troll catch comprised paradise fish taken in Area 2 mainly along the Sunken Barrier.

The above figures indicate where the highest percentage of any one species may be expected in any one month. However, over the full period of investigations, the highest average catch and the highest catch rates for all species were all recorded in Area 2, east of Samarai and the Suau area, the best months being December to March, and August to September.

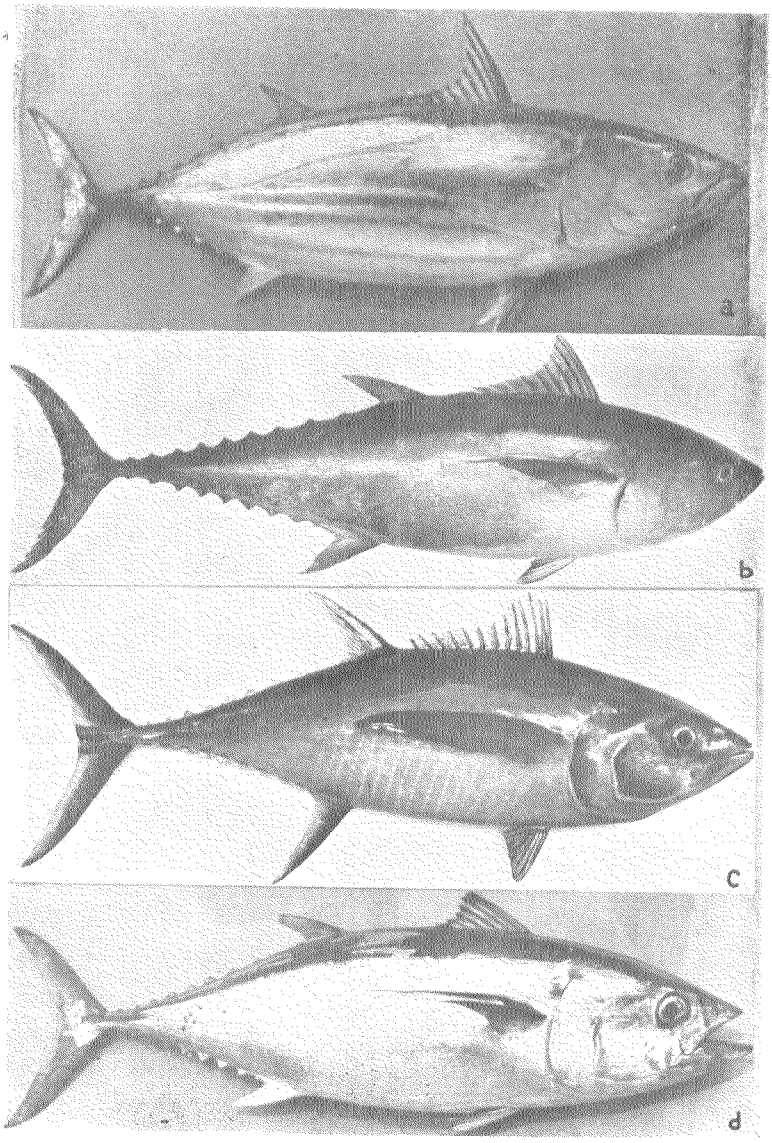


PLATE I. (*a*) *Katsuwonus pelamis* (Linnaeus), (*b*) *Kishinoella tonggol* Bleeker. (*c*) *Neothunnus macropterus* (Temminck and Schlegel). (*d*) *Thunnus thynnus maccoyii* Castelnau. (*a—d* after Serventy, C.S.I.R.O. photos).

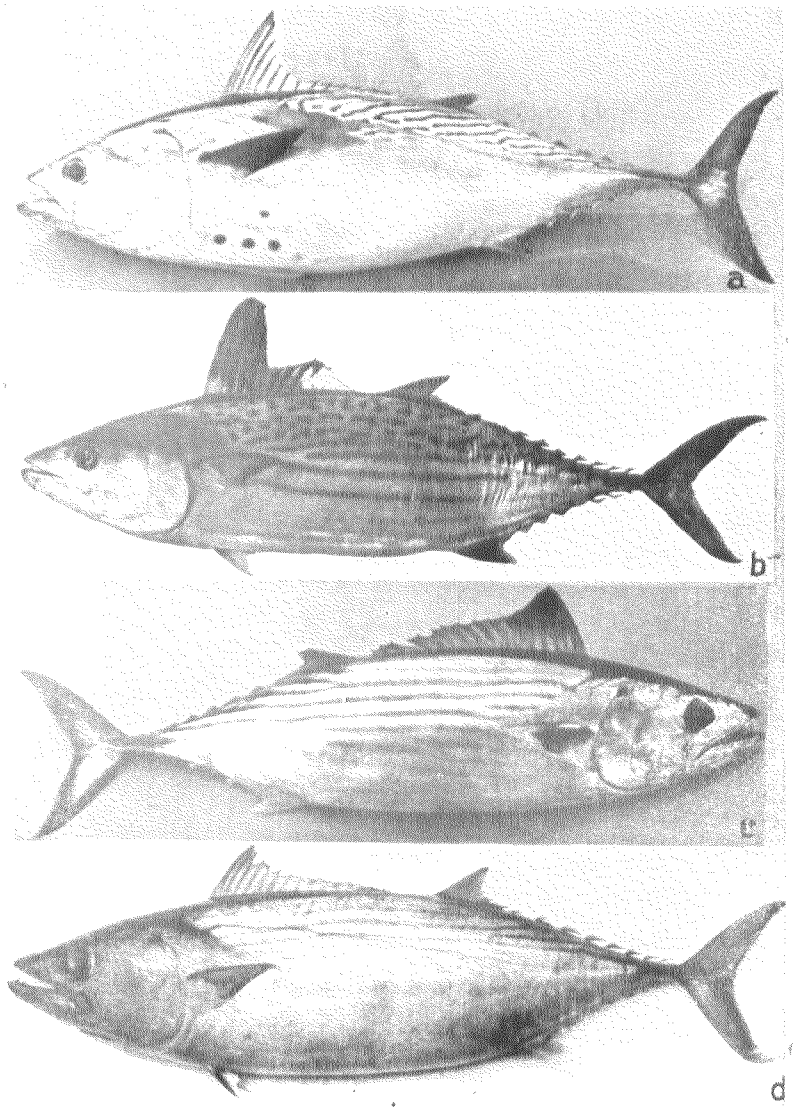


PLATE II. (*a*) *Euthynnus wallisi* Whitley. Holotype of *Wanderer wallisi*, Shellharbour, N. S. Wales. (*b*) *Cybiosarda elegans* Whitley. A Western Australian specimen. (I. S. R. Munro, pinx). (*c*) *Sarda chilensis australis* Macleay. (After Serventy. C. S. I. R. O. photograph), (*d*) *Sarda orientalis* (Temminck and Schlegel) (C.S.I.R.O. photograph).

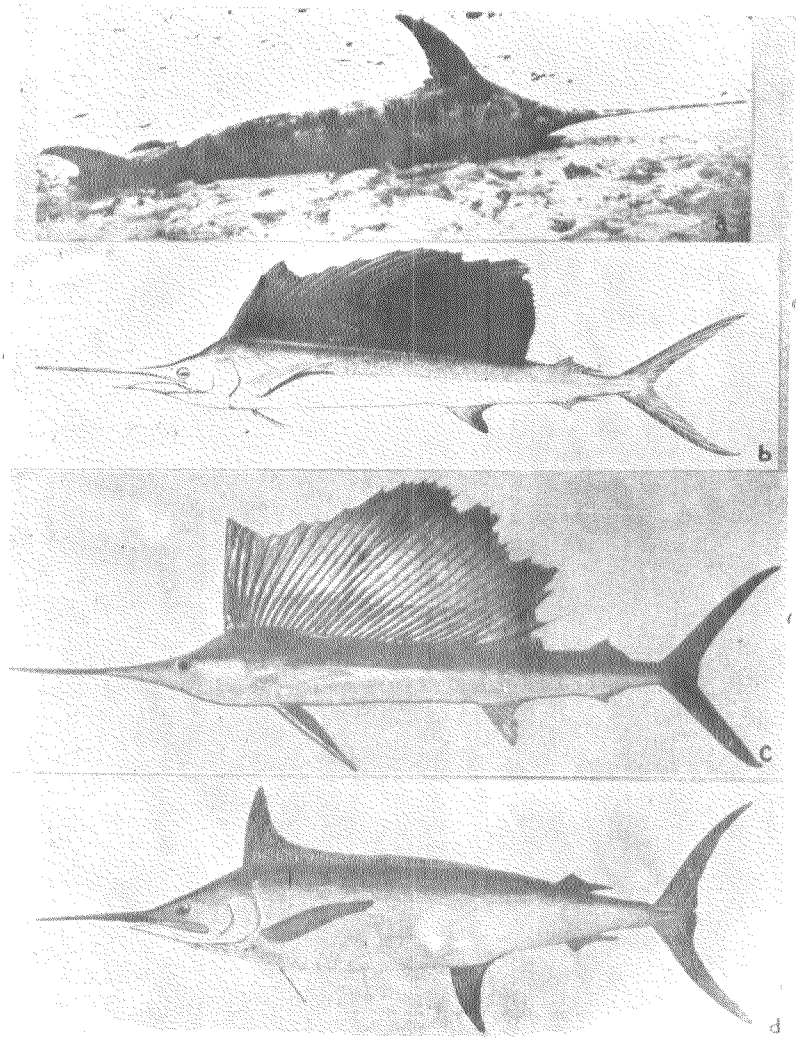


PLATE III. (*a*) *Xiphias gladius estara* Philipps. A 400 lb. specimen at Quindalup, Western Australia : 13 March, 1951 (after Fisheries News Letter, 1951). (*b*) *Istiophorus ludibundus* Whitley. Holotype from Port Stephens, New South Wales : length 6 ft. 8 ins. A. R. McCulloch del. (*c*) *Istiophorus ludibundus* Whitley. Photograph of cast of a fish 7 ft. 11 ins: long, which weighed 48 lb., from 80 miles north of Cairns, Queensland. Photo Howard. (*d*) *Makaira mazara* Jordan and Snyder. Holotype of *Istiompax howardi* from Bermagui, N. S. Wales. John Beeman and G. P. Whitley del.

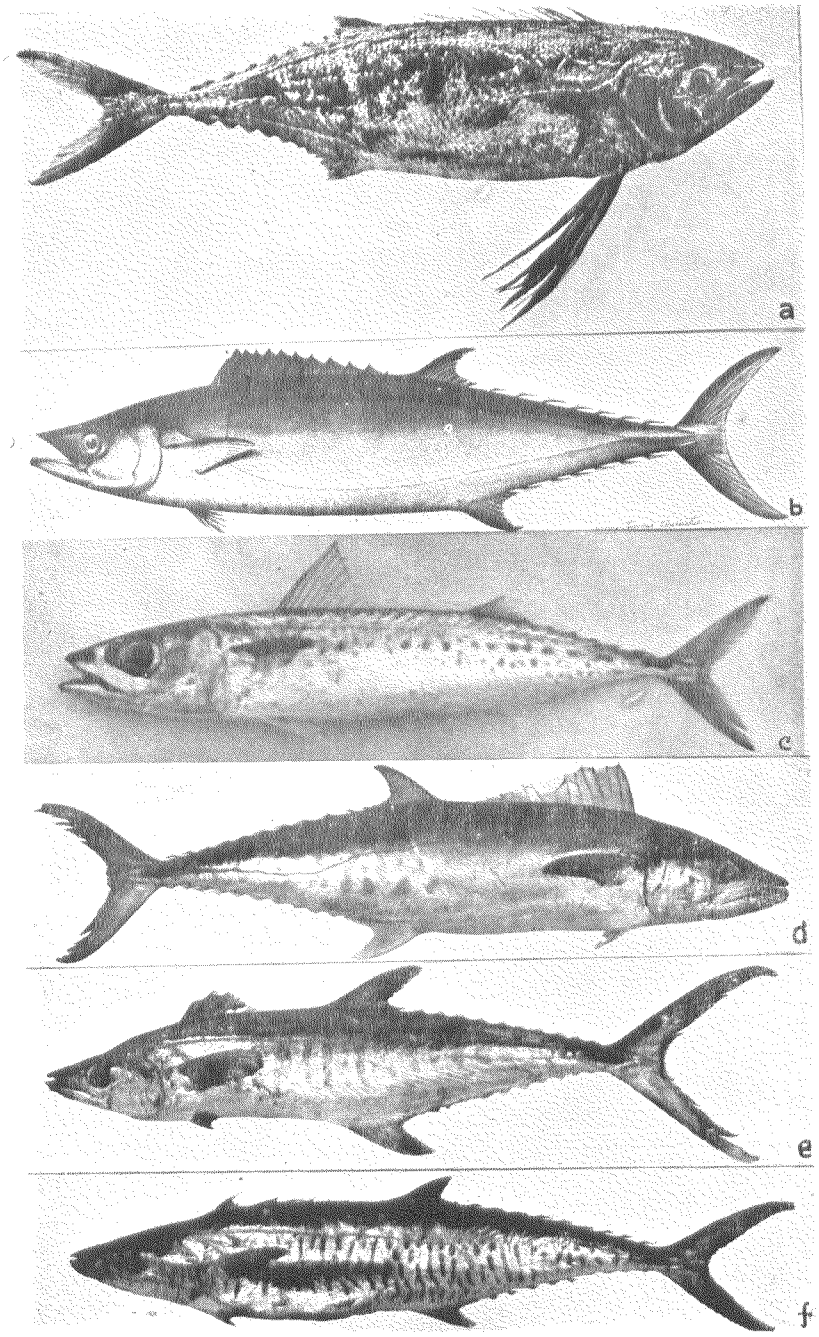


PLATE IV. (*a*) *Gasterochisma melampus* Richardson. A specimen about 15 inches long from Shoalhaven, N. S. Wales ; August 1906, (after Stead). (*b*) *Grammatorcynus bicarinatus* Quoy and Caimard. A specimen 925 mm. in length to caudal fork from Cook Island, N. S. Wales, June, 1914. (*c*) *Pneumatophorus australasicus*.....N. S. Wales, (after Stead). (*d*) *Cybium queenslandicus*. (*e*) *Indocybium semifasciatum*. (*f*) *Cybium commerson*

MACKEREL FROM THE ANDAMAN SEA

BY

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INTRODUCTION

The study of the mackerel (Genus *Rastrelliger* Jordan and Starks) of the Andaman Sea is of special interest in as much as it covers an area adjacent to the Indonesian waters from where as recently as 1951 de Beaufort recognised three species of mackerel, the validity of one of which is open to question. Fishery workers in India have hitherto recognized only a single species of mackerel, *Restrelliger kanagurta* (Cuvier) from Indian coastal waters and in this connection also the Andaman Sea presents an interesting area for study. In the course of a number of collections from there by members of this Institute including the authors in 1960-61, it has been possible to obtain material of two distinct species of mackerel, sufficient to enable drawing up a detailed comparison. It should be mentioned here that sporadic observations on the morphometric and meristic characters of *R. kanagurta* made by different authors from various parts of the Indo-Pacific do not indicate marked deviations of any specific nature in character from place to place. Unfortunately, upto now no attempt has been made to re-describe the typical *R. kanagurta*. *Scomber kanagurta* Cuvier is based on Russell's brief description and drawing of *kanagurta* (vernacular name) a fish from the Vizagapatnam coast north of Madras. However, Cuvier (1831) has also given a description of *R. kanagurta* based on material from Pondicherry about 100 miles south of Madras. As will be discussed later on, our examination of a small sample of *R. kanagurta* from Madras indicates differences between it and the Andaman material of the same species and it is felt that eventual analysis may show that they may belong to different populations. Thus it will be seen that the study of the Andaman mackerel is also closely linked with our having some idea of their congeners from different parts of their distributional ranges. Hence before comparing the two species from Andaman Sea, a resume of previous work on mackerel from this area is given below.

HISTORICAL RESUME

Day (1870) described *Scomber reani* as new from the Andamans and the species was characterised as:

"B.vi; D.6 I 1/12/V. P.19; V.1/5; A. 1/11; C.19; Vert. 9/22.

Length of head 1/4, of caudal 1/5, height of body 1/4 of total length. *Eyes* with wide adipose margins. Diameter 2/7 of length of head, 1 diameter from end of snout, 1½ diameters apart. The maxilla extends to opposite the posterior margin of the orbit, snout pointed; opercles scaly. *Fins*: A groove along the base of the first dorsal fin, extending halfway to the base of the second dorsal. Caudal deeply forked, a keel along either side of its base. Airbladder present. Caeca pylori numerous. *Colours*: Back bluish green, becoming silvery white along the abdomen. A darkish longitudinal band along the lateral line, three above it and two yellow ones below it." *Habitat*: "Andamans, where it is very common upto 12 inches in length. Said to refuse all bait."

The depth of the body in relation to total length, the pointed nature of the snout, and the colouration suggest that the species is conspecific with *R. kanagurta*, a reasoning which Day himself had arrived at, at a later date (1878) when he synonymised *S. reani* with

S. microlepidotus (=*R. kanagurta*). The only other species of mackerel that Day (1870) reported from Andamans was *Scomber kanagurta* Cuvier and Valenciennes, but in the absence of a description it is hardly possible to refer this to anything other than *R. kanagurta* (Cuvier) itself. Day (1878, pl. liv, fig.5) has given the figure of a 12-inch specimen of *Scomber microlepidotus* which has the same body-form as *R. kanagurta*, the body being less deeper in both the forms.

Herre (1941) recorded three species of mackerel from the Andaman waters, namely, *Scomber microlepidotus* Rüppell; *Restrelliger brachysoma* (Bleeker) and *R. kanagurta* (Rüppell). Of these, as mentioned elsewhere (Jones, Silas and Dawson, 1960), *S. microlepidotus* and *R. kanagurta*, are conspecific, leaving two species of mackerel, *R. kanagurta* and *R. brachysoma* as being known from the Andaman Sea.

SCOMBER NEGLECTUS VAN KAMPEN, A SYNONYM OF *SCOMBER BRACHYSOMA* BLEEKER

De Beaufort (1951) recognised *Rastrelliger neglectus* (van Kampen) along with *R. brachysoma* and *R. kanagurta*, distinguishing the three species as follows:

(*a*) Height 2.79. Head as long as high.....*R. brachysoma*

(*b*) Height 3.1—3.4. Head as long as high.....*R. neglectus*

(*c*) Height 3.4—3.8. Head longer than high.....*R. kanagurta*

His description of *R. brachysoma* is made after the "type and single specimen known, long 120 mm without caudal", and he has corrected Bleeker's description by drawing attention to the fact that the type specimen has 6 dorsal and 6 anal finlets instead of 5 each as mentioned by Bleeker. However, we do not agree with de Beaufort in his action of relegating *R. brachysoma* Day (*nec* Bleeker as he calls it) to the synonymy of *R. neglectus*, for the following reasons :

(1) Day gives the depth of body of this species he described from material from Andamans as 3⅓ in length. This falls within the expected range for *R. brachysoma* in our collection.

(2) Day's remark that the posterior margin of the spinous dorsal of this species is black is a very conspicuous feature which cannot be missed when specimens of *R. kanagurta* and *R. brachysoma* are compared. The outer margin of the first dorsal is only lightly dusky in the former.

(3) We feel that the action of van Kampen in naming a second species from the Java Sea as *S. neglectus* was unwarranted as the name *S. brachysoma* was already available for the deep bodied form occurring there. The argument put forward by de Beaufort is that "Van Kampen (l.c.) pointed out, that the two common species of *Restrelliger* in the Java Sea have been confused by Bleeker and others. The species which Bleeker called *loo* C.V, is the same as that of the French authors, but it is a synonym of *kanagurta* C V. This species therefore has to be called *kanagurta*. The other species is mentioned by Bleeker and others as *kanagurta*, and had therefore to be renamed. Van Kampen called it *neglectus*".

(4) *R. neglectus* was also recognised by Delsman and Hardenberg (1934) and as de Beaufort remarks, the basis for this was that "Generally the species called *neglectus* by Van Kampen is mentioned as *brachysoma* Blkr., but last named species is probably different (see above), being still deeper". It should be remembered that *Scomber brachysoma* was described from a single specimen by Bleeker and this and the inadequate description may be responsible for some of the subsequent workers failing to recognise this species from Indonesian waters, although definitely a deep bodied form occurs there.

(5) Another point mentioned by de Beaufort needing comment is that " Many authors record 44–45 gill rakers on the lower branch of the first arch, which fact suggest that there are still other species, or perhaps races of one and the same species, not yet described. The two species differ in that *kanagurta* is more slender than *neglectus*. Delsman and Hardenberg also mention a difference in the gill rakers. They find only 20 rakers on the lower branch of the first arch in *kanagurta*, and about 30 in *neglectus*, which difference they attribute to the different mode of life of the two species; *kanagurta* being a open sea form, feeding on the coarse pelagic plankton, the other a coastal form, feeding on the finer neretic plankton." With the earlier part of the statement regarding the number of gill rakers of the two species, we are not in agreement with Delsman and Hardenberg for the simple reason that we feel that the full complement of gill rakers on the lower limb of the outer arch for both the species has not been counted. The figure given by Delsman and Hardenberg clearly shows that the last raker on the lower limb of both the species is more than half the length of the longest raker. In reality this may not be the case, for the examination of our material shows that the last raker is hardly 1/4 the length of the longest gill raker and certain amount of care has to be used for removing the branchial arch intact or else one is liable to miss the first few rakers of the upper limb (which likewise are also minute) and the last few rakers on the lower limb. This we feel is the main reason for the very low counts of 'about 20' and 'about 30' counts for *kanagurta* and the so-called *neglectus* respectively given by Delsman and Hardenberg.

However, we agree with these authors that the structure of the gill rakers is different in the deep bodied and the narrow bodied species, but in the absence of comparative data on the mode of feeding and the food of the deep bodied species it is not possible to adduce reasons here. To say that *kanagurta* is an open sea form feeding on 'coarse pelagic plankton' and so has lesser number of rakers when compared to the second species will need substantiation with more data on the habits of these species. Although *kanagurta* occurs regularly in the inshore waters along our coast, it could perhaps be considered a more open sea form as it has a wider spatial distribution as compared with the deep bodied form which we consider as *brachysoma*.

It is our contention that only two species of mackerel occur in Indonesian waters as well, one the narrow bodied form, *R. kanagurta* and the second, the deep bodied form, *R. brachysoma*, which name has priority over *S. neglectus* Van Kampen. Manacop (1958) has described *R. brachysoma*, from Philippine waters, and has also given details of morphometric and meristic data for *R. chrysozonus* (=*R. kanagurta*). It is likely that in both these species infra-specific variations depending on the geographical locations of the occurrence of the species may occur. However, work is yet to be carried out in this direction.

MACKEREL–LIKE FISHES OCCURRING IN THE ANDAMAN SEA

Fraser-Brunner (1950) recognises two species of chub mackerels, *Scomber scombrus* Linnaeus and *S. japonicus* Houttuyn relegating *S. australisicus* Cuvier, and *S. janeseba* Bleeker to the synonymy of the latter. We are in full agreement with de Beaufort when he says that " We are greatly in need of a revision of the Indo-Pacific species of *Scomber* and for that of the whole genus too, but this can only be done at the hand of a very large material, and on a statistical basis". Until such time we shall recognise *S. japonicus* as the species occurring in the Indian Ocean. Fraser-Brunner (1950) mentions Seychelles, Gulf of Aden, Red Sea, Muscat and Madras, as localities from the Indian Ocean from where material of this species was available to him for examination. The range of the species clearly indicates the likelihood of its occurrence in the Andaman Sea.

A second mackerel-like fish needing mention is the double-lined mackerel *Grammatorcynus bicarinatus* (Quoy and Gaimard). We have obtained several specimens of this species from Andamans. The genus as pointed out by Kishinouye (1923) is more akin to the true Scombrinae than, to the Thunninae, Gasterochismatinae, and Scomberomorinae, all subfamilies of the family Scombridae (Jones and Silas 1960).

KEY TO THE IDENTIFICATION OF MACKEREL AND MACKEREL-LIKE FISHES FROM THE ANDAMAN SEA

1*a*. Side of body with a second decurved lateral line commencing from a point above mid-length of pectoral and travelling along the lower half of the abdomen to the caudal keel where it becomes confluent with the main lateral line ; gill rakers on lower limb of outer gill arch generally not exceeding 16 ...*Grammatorcynus bicarinatus* (Quoy and Gaimard)

1*b*. Side of body with a single lateral line ; gill rakers on lower limb of outer gill arch exceeding 20.....2

2*a*. Vomer and palatine toothed ; an osseous and moderately stiff anal spine present ...*Scomber japonicus* Houttuyn

2*b*. Vomer and palatine edentulous ; osseous stiff anal spine absent.....3

3*a*. Greatest height of body 23% to 27% of fork length ; length of head distinctly more than greatest depth of body, being 26.1% to 29.1% in fork length ; snout pointed, anterior margin of first dorsal dusky ; scales behind pectoral deciduous, getting easily detached when handled ; dark stripes or rows of dusky spots along upper half of body more distinctly seen in areas where scales have fallen off ...*R. kanagurta* (Cuvier)

3*b*. Greatest height of body 28.6% to 34% of fork length ; length of head distinctly shorter than greatest depth of body, being 25.6% to 28.7% in fork length ; snout short and bluntly rounded ; outer margin of first dorsal conspicuously black, scales on body non-deciduous and not easily detachable when handled, no dark stripes or regular rows of dusky spots along upper half of body. ...*R. brachysoma* (Bleeker).

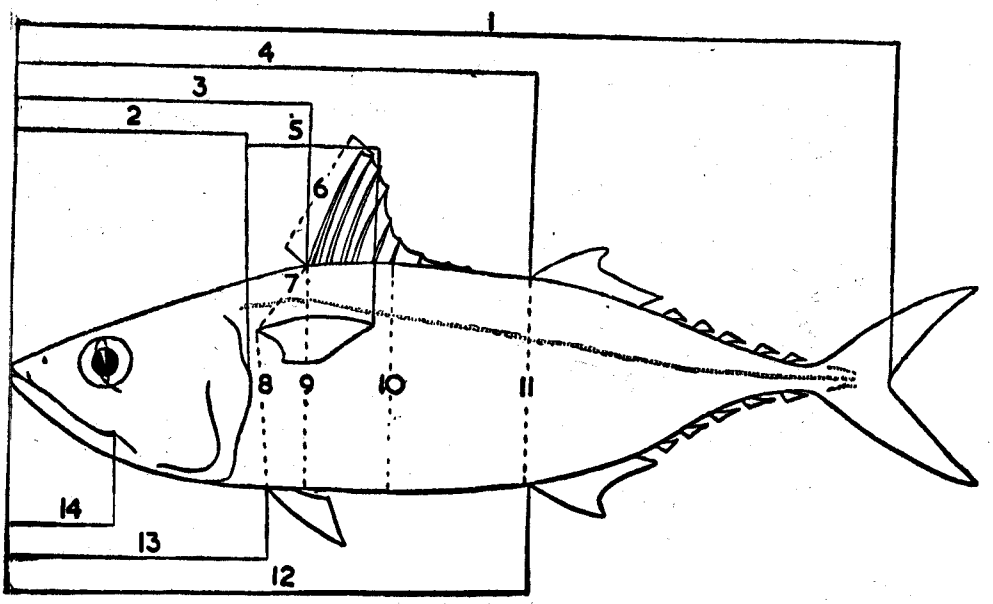
COMPARISON BETWEEN *R. KANAGURTA* AND *R. BRACHYSOMA* FROM THE ANDAMAN SEA

MATERIAL AND METHODS

This preliminary study is based on 31 specimens of *R. kanagurta*, 126 mm. to 278 mm. in fork length, and 36 specimens of *R. brachysoma*, 137 mm. to 221 mm. in fork length, all collected at Port Blair, Andamans.

In text fig. 1, the methods used for taking morphometric measurements are indicated. For additional details for taking morphometric measurements and meristic counts in mackerel and other scombroid fishes, reference is invited to Jones and Silas, (1960).

We have been able to examine one specimen of *R. kanagurta* from South African waters and seven specimens of the same species from East African waters, and relevant observations on these specimens are also included. In general body form, some of the abnormal specimens of *R. kanagurta* collected by us along the Indian Coast show some similarity to *R. brachysoma* from Andaman waters, which could lead to confusion in identity. A few typical conditions observed by us are dealt with here.



Text Fig. 1.—Schematic drawing of mackerel showing methodology used in taking body measurements. (No. 5 should be measured from the upper point of origin of the pectoral as given for Nos. 7 and 8).

Body Shape

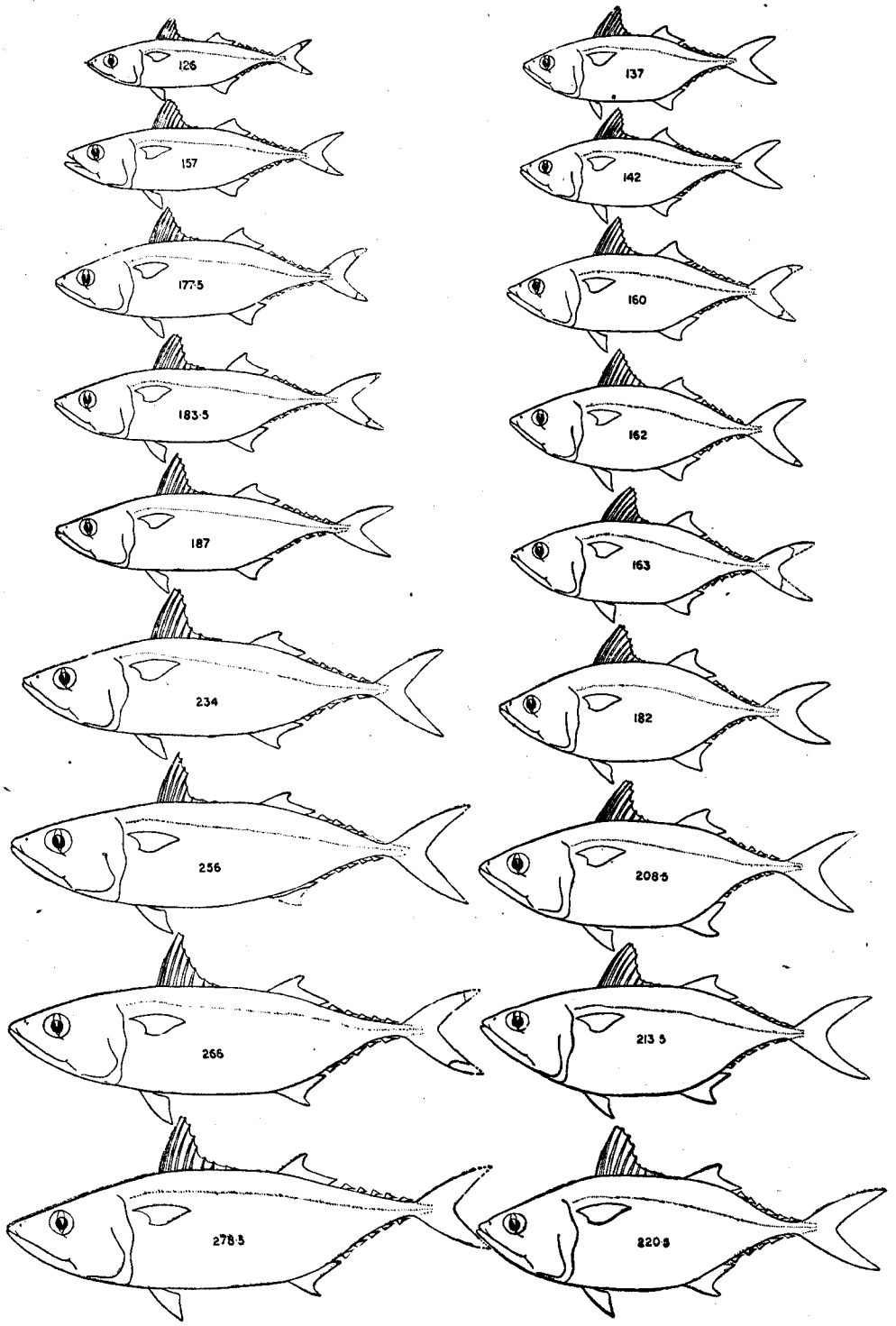
In text fig. 2 outline drawings of graded series of specimens of *R. kanagurta*, 126 mm. to 278.5 mm., and *R. brachysoma* 137 mm. to 220.5 mm. from Andaman waters are given side by side to show the difference in body profile. The deeper body of *R. brachysoma* as a consistent character is seen in all sizes, and is markedly pronounced in the larger specimens. In *R. kanagurta* the depth of the body is shorter, giving the body a spindle-shaped appearance. These may be compared with the outline drawings of some of the abnormal specimens of *R. kanagurta* (text figs. 8 and 9) given later on, as well as with text fig. 10 showing outline drawings of specimens of *R. kanagurta* from East and South African waters.

Manacop's (1958) figures of juvenile *R. brachysoma* and *R. chrysozonus* (=*R. kanagurta*) indicate that some of the adult differences are well established even in early juveniles. Thus his drawings of a 54 mm. and a 48 mm. (fork length) specimen each of *R. brachysoma* and *R. chrysozonus* respectively show that in the former, the greatest depth of the body, the anterior height of the dorsal, and the length of the pectoral are relatively greater than in the latter. The body is more or less cylindrical in the early juveniles of *R. chrysozonus*, while the curved ventral profile is clear in *R. brachysoma*.

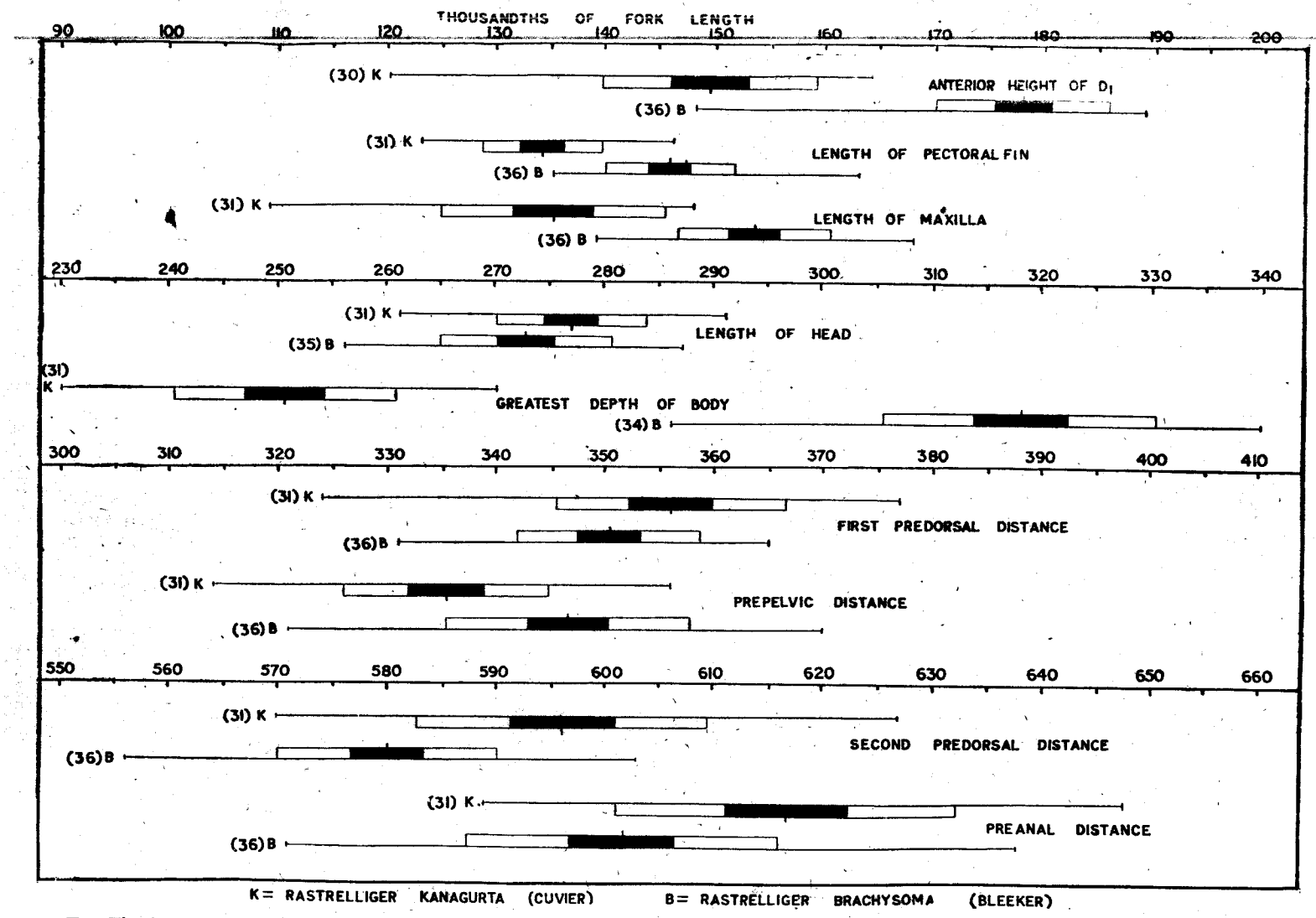
Body Proportions

In specimens of both the species, the percentages of intergradation and divergence have been calculated for nine characters (Table I : A, B and C). It will be seen that in the following characters, namely, second predorsal distance ; length of the pectoral fin ; anterior height of first dorsal fin ; and the length of the maxilla, divergence to the magnitude of 75% or more is seen. In the greatest depth of the body there is no overlap, giving 100% divergence. The data for the nine characters are graphically represented in text figure 4.

As will be seen from Table II, in the nine characters chosen, the difference between *R. brachysoma* and *R. kanagurta* from Andaman waters is statistically significant at the 5% level.



Text Fig. 2.—Outline drawings of graded series of specimens of *Rastrelliger kanagurta* (Cuvier) and *R. brachysoma* (Bleeker) from Andaman Sea showing the characteristic profile and body shape of the two species at different sizes. The numbers given on the body represent fork length of the respective specimens in mm.



Text Fig. 4.—Graph showing variations in 9 characters in two samples of *R. kanagurta* and *R. brachysoma* from Andaman Sea. (The horizontal line represents the total range ; the short vertical line the mean ; the solid rectangle two standard errors on each side of the mean and the hollow rectangle one standard deviation on each side of the mean). The number of specimens in each sample is given in parenthesis.

TABLE I

Divergence and intergradation levels in species of *Rastrelliger* from Andaman Sea

A

Character	Head length/Fork length						1st predorsal distance/F.L.							Prepelvic distance/F.L.							
Class intervals (in thousandths of F.L.)	250–259	260–269	270–279	280–289	290–299	Number of specimens	220–229	230–239	240–249	250–259	260–269	270–279	Number of specimens	310–319	320–329	330–339	340–349	350–359	360–369	370–379	Number of specimens
Frequency :																					
R. kanagurta	4	16	9	2		31	1	1	4	14	8	3	31	2	6	11	9	3	...	...	31
R. brachysoma ...	2	9	17	2	...	35	...	3	16	9	8	...	36	...	1	12	6	14	2	1	36
Divergence–Intergradation levels ...	Intergradation					41%	Intergradation						32%	Intergradation							31%
	Divergence					59%	Divergence						68%	Divergence							69%

B

Character	2nd predorsal distance/F.L.									Preanal distance/F.L.									Length of P_1/F.L.					
Class intervals (in thousandths of F.L.)	550–559	560–569	570–579	580–589	590–599	600–609	610–619	620–629	Number of specimens	570–579	580–589	590–599	600–609	610–619	620–629	630–639	640–649	Number of specimens	120–129	130–139	140–149	150–159	160–169	Number of specimens
Frequency :																								
R. kanagurta			3	8	5	10	4	1	31	...	1	3	6	8	6	5	2	31	8	17	6	...	...	31
R. brachysoma ...	1	5	11	14	3	2	...	...	36	1	8	5	9	10	2	1	...	36	...	7	21	7	...	36
Divergence—Intergradation levels ...	Intergradation								25%	Intergradation								33%	Intergradation					19%
	Divergence								75%	Divergence								57%	Divergence					81%

TABLE I—(*contd.*)

C

Character	Greatest depth of body/F.L.												Anterior height of first dorsal/F.L.								Length of maxilla/F.L.							
Class intervals (in thousandths of F.L.)	230–239	240–249	250–259	260–269	270–279	280–289	290–299	300–309	310–319	320–329	330–339	340–349	No. of specimens	120–129	130–139	140–149	150–159	160–169	170–179	180–189	No. of specimens	100–109	110–119	120–129	130–139	140–149	150–159	160–169	No. of specimens
Frequency :																													
R. kanagurta	3	14	8	5	1	...	...	..	..	...	...	...	31	2	2	8	15	3	...	...	30	1	1	6	11	12	...	...	31
R. brachysoma	...	...	...	...	...	2	1	5	11	8	6	1	34	...	...	1	...	4	13	18	36	...	...	...	1	10	19	6	36
Divergence—Intergradation levels	Intergradation 0% Divergence 100%													Intergradation 6% Divergence 94%								Intergradation 15% Divergence 85%							

TABLE II

Biometric data based on thousandths of fork length of selected morphological characters in species of *Rastrelliger* from Andaman Sea

Characters (proportions expressed in thousandths of fork length for selected characters)	*Rastrelliger kanagurta* Range 126–278 mm. in fork length					*Rastrelliger brachysoma* Range 137–221 mm. in fork length					Differences between Means	t	P
	No.	Range	Mean	σ	σM_1	No.	Range	Mean	σ	σM_2			
1 Head length/F.L. ...	31	261-291	276.81	6.8506	1.2304	35	256-287	272.60	7.9076	1.3366	4.21	2.3171	P at 5% level is 1.960
2 First predorsal distance/F.L. ...	31	324-377	356.06	10.5920	1.9024	36	331-3653	350.42	84.800	1.4133	5.64	2.379	
3 Prepelvic distance/F.L. ...	31	314-354	335.45	9.4393	1.6953	36	321-390	346.78	11.225	1.8708	11.33	4.4880	
4 Second predorsal distance/F.L. ...	31	570-627	596.225	13.274	2.3841	36	556-603	580.36	10.010	1.6683	15.86	5.4516	
5 Preanal distance/F.L. ...	31	589-648	616.90	15.107	2.7133	36	571-638	601.92	14.367	2.3944	14.98	4.1388	
6 Greatest depth of body/F.L. ...	31	230-270	250.45	10.198	1.8316	34	286-340	318.00	12.498	2.1434	67.55	23.9726	
7 Anterior height of first dorsal/F.L. ...	30	120-164	149.20	9.8285	1.7944	36	148-189	177.694	7.8236	1.3039	28.49	12.8463	
8 Length of maxilla/F.L. ...	31	109-148	135.064	10.344	1.8578	36	139-168	153.42	7.0143	1.1691	18.36	8.3685	
9 Length of pectoral fin/F.L. ...	31	123-146	134.00	5.4535	0.9735	36	135-163	145.67	5.9161	0.9860	11.67	8.3963	

The greatest depth of body measured for both species is generally almost midway between the origins of first and second dorsal fins. Measurements of the body at the origins of the first and second dorsals respectively, did not show any overlap in the samples of the two species examined (text-figure 5). Further, an interesting feature that may be noticed from the above figure (text-fig. 5) is that in *R. brachysoma* a distinct increase in depth of body is seen with growth, while in *R. kanagurta* the increase in the depth of the body in relation to the fork length in specimens over 150 mm. is not so apparent.

Body proportions for seven additional characters for the two species from Andaman waters are given below in Table III.

TABLE III

Character	*R. kanagurta*			*R. brachysoma*		
	No. of specimens	Range %	Mean %	No. of specimens	Range %	Mean %
Depth at D_1/F.L. ...	31	22.7—26.3	24.49	36	27.6—32.3	30.27
Depth at D_2/F.L.	30	22.2—26.1	23.92	35	28.0—31.7	30.36
Distance from P_1 to D_1 origin/F.L. ...	31	11.1—14.7	13.17	35	12.0—15.1	15.39
Distance from P_1 to D_2 origin/F.L. ...	31	15.1—17.8	16.94	36	18.2—21.9	20.56
Width of body at P_1/F.L. ...	31	10.3—15.7	14.29	36	13.0—15.9	14.06
Length of longest gill raker/F.L. ...	15	8.2—10.4	9.41	36	9.5—12.5	11.05
Length of longest gill filament/F.L. ...	15	6.2— 7.3	6.67	36	5.4— 7.5	6.31

COLOURATION

The major differences in adult body colour between *R. kanagurta* and *R. brachysoma* are :

1. The upper half of the body has a series of linear blotches which are very clear in specimens of *R. kanagurta* in portions where the scales have been lost. In *R. brachysoma* such longitudinal bands are absent although stray spots may be present in the dorsal half of the body.

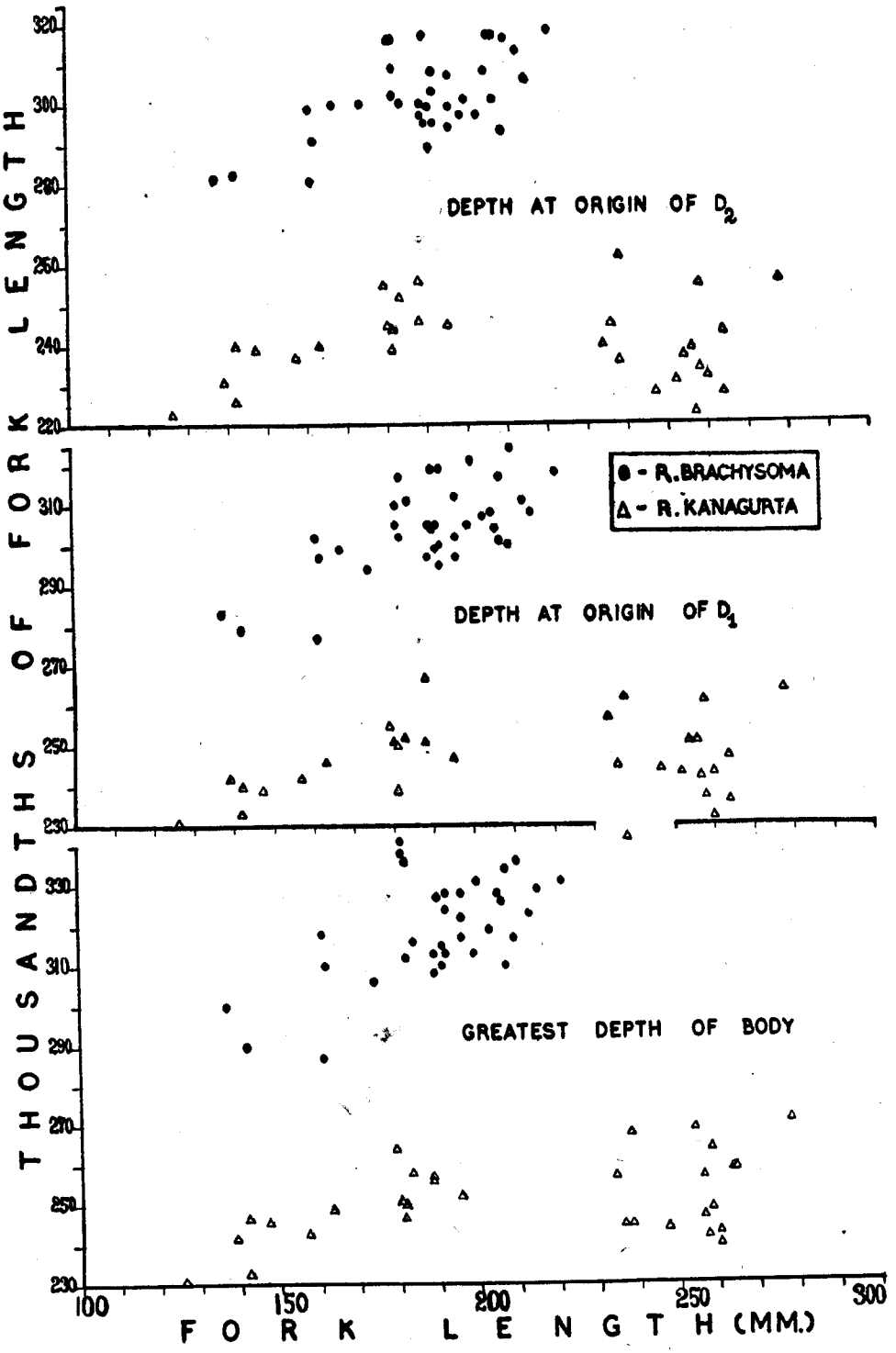
2. The tip and outer margin of the spinous dorsal fin are tinged light grey in *R. kanagurta*, but in *R. brachysoma* the tip and outer margin of the spinous dorsal fin are blackish.

3. The conspicuous dark spot seen below the pectoral in fresh specimens of *R. kanagurta* is very indistinct in *R. brachysoma*.

4. Sides of the body are more silvery in *R. brachysoma* than in *R. kanagurta*.

DORSAL AND ANAL FINLETS

The frequency of occurrence of the number of dorsal and anal finlets in *R. kanagurta* and *R. brachysoma* from Andaman Sea is given in Table IV. In both species, 5 dorsal and 5 anal finlets are more typical, the other combinations of 6/5 and 6/6 being exceptions.



Text Fig. 5.—Scatter diagram showing the depth of body at three points, plotted against the fork length of specimens of the species *R. kanagurta* and *R. brachysoma* from Andaman Sea.

TABLE IV

Frequency of number of dorsal and anal finlets in species of *Rastrelliger* from Andaman Sea

Number of dorsal/anal finlets	*Rastrelliger kanagurta*		*Rastrelliger brachysoma*	
	No. of specimens	Per cent	No. of specimens	Per cent
5/5 ...	30	96.77	33	91.66
6/5 ...	1	3.23	2	5.55
6/6 ...	...	...	1	2.77

For Philippine waters, Manacop (1958) gives the following data (Table V).

TABLE V

No. of finlets	*R. brachysoma*		*R. chrysozonus* (*R. kanagurta*)	
	No. of specimens	Per cent	No. of specimens	Per cent
5/5 ...	839	92.40	72	93.50
5/6 ...	50	5.60	3	3.90
6/5 ...	6	0.67	...	...
6/6 ...	2	0.23	2	2.60
5/4 ...	1	0.11	...	...
4/5 ...	9	0.99	...	...

SEX AND MATURITY

R. kanagurta : Of 20 specimens sexed, 10 were immature, while 3 were mature males and 8 maturing females. A 23.8 cm. female was found to have small translucent ova 0.21 to 0.34 mm. in diameter, while the largest specimen in the sample, a female 27.8 cm. had opaque ripening ova 0.51 to 0.57 mm. in diameter. According to Holt (1959) these specimens fall under stage II "Mature virgins....." and stage III "Ripening" respectively.

R. brachysoma : Of 30 specimens sexed, 6 were immature, 12 were males and 12 females, the last said ranging in size from 18.4 to 22.1 cm. The 18.4 cm. specimen showed developing ova, the largest of which were 0.19 to 0.22 mm. in diameter, while the 22.1 cm. specimen had ova 0.4 to 0.51 mm. in diameter. The maturity of these two specimens corresponds to stages II and III as given by Holt (1959).

Although our observations are inadequate, a matter which needs further attention would be to check whether in Andaman waters *R. brachysoma* matures at a smaller size than *R. kanagurta*, for, from the above it would appear that the 18 to 22 cm. specimens of the former show corresponding stages of maturity as the 23 to 27.8 cm. specimens of the latter, all taken at Port Blair, Andamans, during the month of December 1961.

That *R. brachysoma* could be a distinctly smaller species is also evident from the observations of Manacop (1958). He remarks that in Philippine waters *R. brachysoma* "reaches a maximum length of 220 mm. and a weight of about 200 grams. The average size taken is about 180 mm. and the average weight 100 grams." As for *R. chrysozonus* (*R. kanagurta*),

the average size of the commercial catch is about 250 mm. (not cm.) (230 gm.) with a maximum of about 300 mm. (not cm.) (380 gm.).

GILL RAKERS

Contrary to the opinions expressed by Delsman and Hardenberg (1934), and de Beaufort (1951), we find that the gill raker counts in *R. kanagurta* and *R. brachysoma* from Andaman waters show considerable overlap. Hence, unless large series are examined, gill raker counts alone as a single character may not suffice to separate the two species. The gill raker counts on the upper and lower limbs of the outermost gill arch on the left and right sides of the specimens of each species show variations as will be seen in Tables VI A-F, VII and VIII. Maximum divergence of

Tables showing frequency distribution of the counts of gill rakers in the outer gill arch in species of *Rastrelliger* from Andaman Sea

TABLE VI-A

Species	No. of specimens	No. of gill rakers on upper limb of left side				
		17	18	19	20	21
R. kanagurta ...	31	2	9	14	4	2
R. brachysoma ...	36	1	14	16	4	1

Intergradation 45% Divergence 55%

TABLE VI-B

Species	No. of specimens	No. of gill rakers on upper limb of right side					
		17	18	19	20	21	22
R. kanagurta ...	31	3	11	9	6	2	...
R. brachysoma ...	35	1	7	16	6	4	1

Intergradation 38% Divergence 62%

TABLE VI-C

Species	No. of specimens	No. of gill rakers on lower limb of left side									
		33	34	35	36	37	38	39	40	41	42
R. kanagurta ...	31	...	...	1	4	4	9	8	3	...	2
R. brachysoma ..	36	...	...	1	...	6	8	10	8	2	1

Intergradation 38% Divergence 62%

TABLE VI-D

Species	No. of specimens	No. of gill rakers on lower limb of right side									
		33	34	35	36	37	38	39	40	41	42
R. kanagurta ..	30	1	...	...	6	5	8	7	2	1	..
R. brachysoma ..	36	...	...	...	2	4	11	8	9	1	1

Intergradation 37% Divergence 63%

TABLE VI-E

Species	No. of specimens	Total number of gill rakers on the left arch (upper and lower combined)										
		51	52	53	54	55	56	57	58	59	60	61
R. kanagurta ...	31	...	...	...	4	4	6	4	6	3	1	3
R. brachysoma ...	35	...	...	1	...	5	5	6	9	6	2	1

Intergradation 38% Divergence 62%

TABLE VI-F

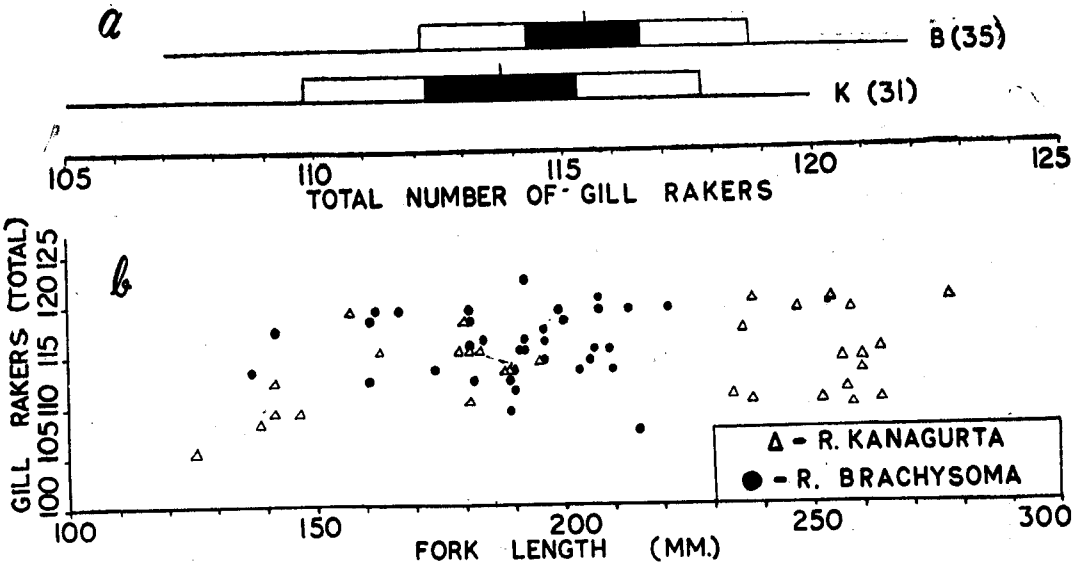
Species	No. of specimens	Total number of gill rakers on the right arch (upper and lower combined)										
		51	52	53	54	55	56	57	58	59	60	61
R. kanagurta ...	31	1	...	2	4	3	5	5	8	...	1	2
R. brachysoma ...	36	...	...	...	2	...	6	7	6	5	7	3

Intergradation 32% Divergence 68%

73% was seen when the grand total number of gill rakers (left and right combined) were counted for specimens of both the species falling within the size group 126 mm to 195 mm. (Table VIII). These data may be compared with the graphical representation of the grand total of gill rakers given in text-fig. 3*a* and also with the frequency distribution of the total counts in relation to fork length of the fish given in text-fig. 3*b*. No definiteness in the number of gill rakers is noticeable in the specimens over 140 mm. in fork length. The range of gill rakers for the two species from Andaman waters was found to be as follows:

R. kanagurta: 17-21 + 33-42.

R. brachysoma: 17-22 + 35-42.



Text Fig. 3-*a*.— Graph showing the variation in the total number (left and right combined) of gill rakers in *R. brachysoma* (B) and *R. kanagurta* (K) from Andaman Sea. (The horizontal line represents the total range ; the short vertical line the mean ; the solid rectangle two standard errors on each side of the mean and the hollow rectangle one standard deviation on either side of the mean).

3-*b*. Scatter diagram of the total number of gill rakers in the two species plotted against the fork length.

The shape and size of the gill raker differ in both the species. In *R. kanagurta* the raker is relatively shorter being 8.2 to 10.4% of the fork length, while in *R. brachysoma* it is longer, being 9.5 to 12.5%. This difference is best seen when the mouth of both the species is kept open. (Plate II, figs. A and B.) The gill rakers are seen feather-like projecting out to a greater extent in *R. brachysoma* than in *R. kanagurta*. Another difference is that the raker in the latter is more densely pigmented, and the number of simple branches on the raker is more and they are relatively shorter. (Plate II, figs. C and D). The length of the longest gill filament in *R. kanagurta* ranges from 6.3% to 7.5% of the fork length, while in *R. brachysoma* it is 5.3% to 7.5%, but mostly 5.3% to 6.6% in fork length, indicating that unlike the gill rakers, the gill filaments are relatively longer in *R. kanagurta* than in *R. brachysoma*. It is difficult at this stage to presume whether this is on account of the more oceanic habit of the former.

TABLE VII

Species	No. of specimens	Total number of gill rakers on both (right and left combined) outer branchial arches																	Mean
		105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	
R. kanagurta ...	31	1	...	...	2	3	3	1	2	3	3	5	...	1	1	3	3	...	113.58
R. brachysoma	35	...	...	1	...	1	...	1	3	5	2	5	3	2	3	7	...	1	115.4

Intergradation 29% Divergence 71%

TABLE VIII

Frequency of occurrence of total number of gill rakers on both the right and left outer gill arches (combined) in *Rastrelliger kanagurta* and *R. brachysoma* for the size group between 126–195 mm.

Species	No. of specimens	Total gill rakers																		Mean
		105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	
R. kanagurta	15	1	...	...	1	2	1	...	1	2	1	4	...	...	1	1	...	...	...	112.66
R. brachysoma	20	...	...	...	...	1	...	1	3	3	...	3	2	1	2	3	...	...	1	115.20

Intergradation 27% Divergence 73%

Since we find considerable overlap in the number of gill rakers in both species, it is felt that variations on account of differences in the feeding habits of these two species may be more easily seen from the structure and relative length of the rakers than from their numbers. A study of the food of both the species from Andaman waters will certainly throw light on the real significance of these differences.

In Philippine waters also the same trend of differences in the gill rakers between *R. brachysoma* and *R. kanagurta* is seen. Manacop (1958) gives the following data (Table IX) for adult and juvenile specimens from Philippines.

TABLE IX

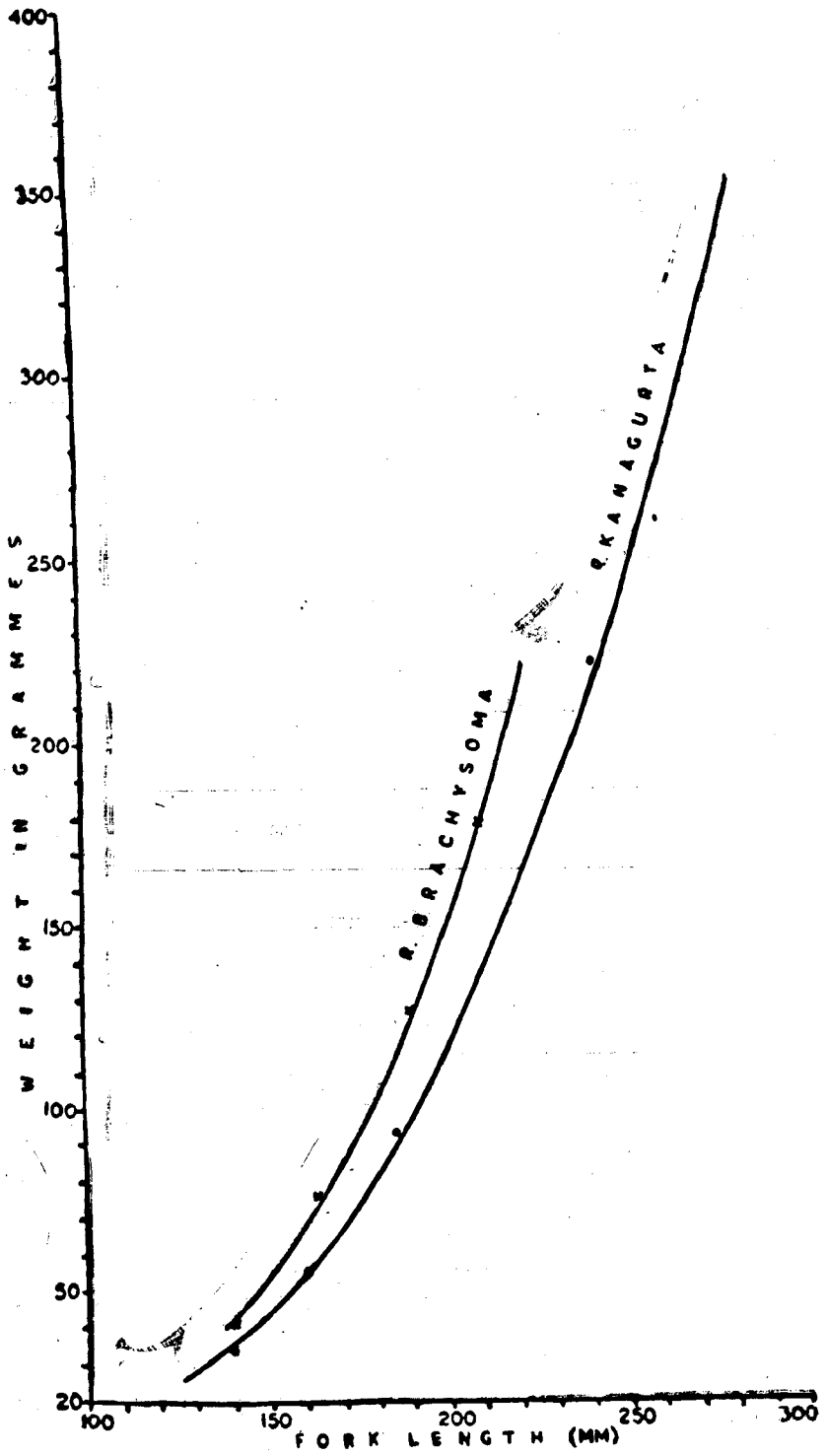
Character		*R. brachysoma*	*R. chrysozonus* (*R. kanagurta*)
Upper gill rakers	...	16–24 (mostly 20)	19–23 (mostly 23)
Lower gill rakers	...	34–45 (mostly 39)	34–39 (mostly 37)
No. of gill raker pores (simple branches)		180–200	130–152

The ranges and modes indicated for upper and lower gill raker counts in the above table differ slightly from that we have observed for specimens from Andaman waters. The significance of these differences will be more clear when data on good series of specimens from the Indonesian waters are examined.

LENGTH-WEIGHT RELATIONSHIP

The specimens could not be measured and weighed in the fresh state. On collection they were preserved in 10% formalin. The fork length of the fish to the nearest millimeter and the weight to the nearest milligram were taken, the latter after removing surface moisture. The material does not cover the various size groups, but consists of half grown and maturing adults. Since no visible external characteristics were noticeable to separate the sexes, data for both sexes have been combined in the present study.

The relationship of the average weight to the length in *R. kanagurta* and *R. brachysoma* is shown in text-figure 6, and the average observed and calculated weights for the samples



Text. Fig 6.—Length-weight parabola in *R. kanagurta* and *R. brachysoma* from Andaman Sea.

are given in Tab'e X. These indicate that length for length *R. brachysoma* is heavier than *R. kanagurta*. The logarithmic relationship of the weight and length of the two species is shown in text-figure 7. The regression coefficient was tested and found to be linear. The regression equations obtained are given below :

R. kanagurta : Log W = 5.5390 + 3.3087 Log. L.

R. brachysoma : Log W = — 6.0421 + 3.5779 Log. L.

TABLE X

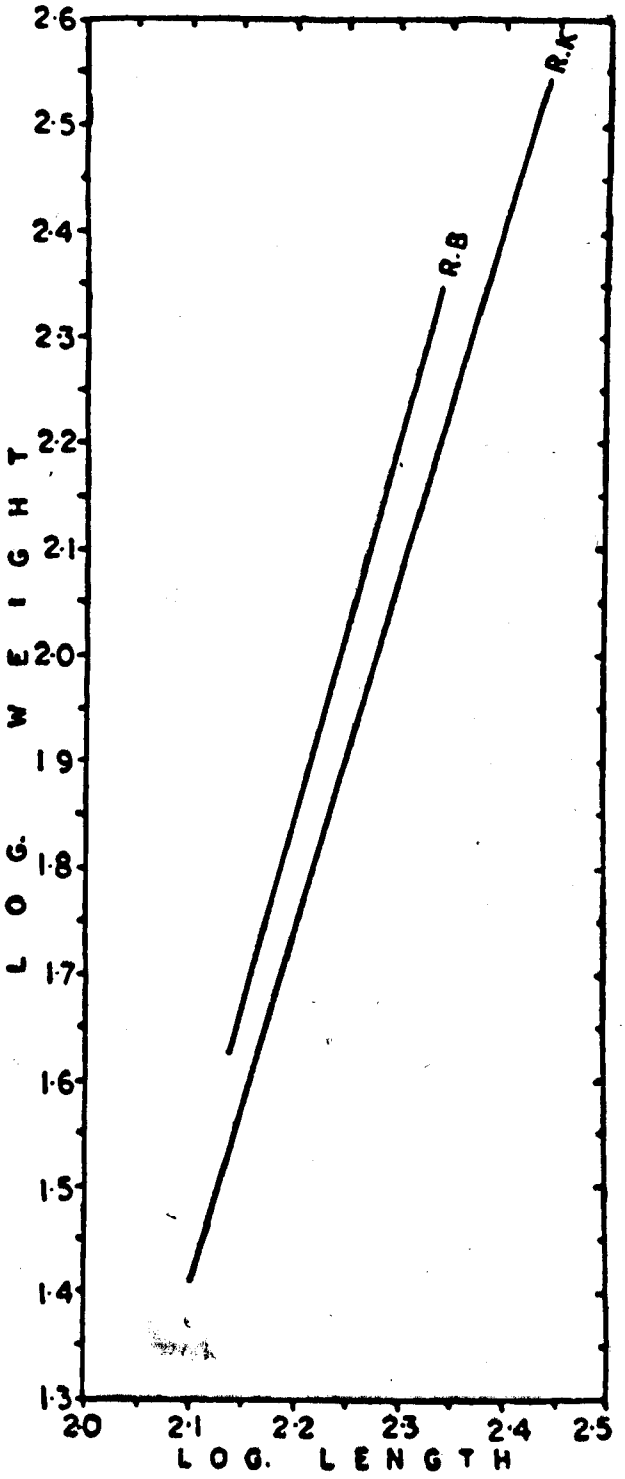
Average observed and calculated weights for samples of *R. kanagurta* and *R. brachysoma* from the Andaman Sea

Size groups (mm)	*R. kanagurta*				*R. brachysoma*			
	No. of obser-vations	Length (Average)	Weight in gm. (average)	Calculated weight in gms.	No. of obser-vations	Length (average)	Weight in gms. (average)	Calculated weight in gms.
125–149 ...	5	139.2	34.8	36.2	2	140.00	40.5	43.00
150–174 ...	2	160.00	55.5	56.5	4	162.5	76.00	73.25
175–199 ...	8	184.37	93.62	91.0	19	188.42	127.15	126.68
200–224 ...	...	...	...	...	11	208.45	178.48	180.63
225–249 ...	5	238.6	221.6	213.2	...	...	...	...
250–274 ...	10	258.3	260.0	276.9	...	...	...	...
275–300 ...	1	278.00	387.0	353.0	...	...	...	...

SCALES

Scales from the side of the body just below the tip of the pectoral fins in *R. kanagurta* (Pl. III, figures A, B and C) were examined in a number of specimens from the Andaman Sea. Data on scales of *R. kanagurta* both from East African and South African waters are included and they are figured on Pl. IV, figures A and B. Scales from identical positions from two of the abnormal specimens of *R. kanagurta* (specimens Nos. 1 and 6 in text-figure 8) are also shown in plate III, figures D and E, which indicate no deviation from the typical condition though the abnormal specimens are characterised by relatively deeper bodies as seen in *R. brachysoma*. The salient differences between *R. kanagurta* and *R. brachysoma* seen from the data given in Table XI and the figures on plates III and IV are :

(1) The scales are distinctly broader than long in *R. kanagurta* and in larger examples they are almost rectangular in shape. In *R. brachysoma* the scales are almost as broad as long or only slightly broader than long, appearing more or less squarish in shape.



Text Fig. 7.—Logarithmic relation of length and weight in *R. kanagurta* (R.K.) and *R. brachysoma* (R.B.) from Andaman Sea.

(2) An important difference is the size of the nucleus. In *R. kanagurta* from Andaman waters as well as elsewhere, and in the abnormal specimens of the same species examined the nucleus appears as a wide band along the middle of the scale, its width being contained 1.75 to 2.5 times in the greatest width of the scale. In *R. brachysoma* the nucleus is small, narrow and less wide, its width being contained 3.5 to 5.5 times in the greatest width of the scale.

(3) The number of ctenoid projections appears to be quite variable, but generally they are of slightly lesser number in *R. brachysoma*.

(4) The number of apical and basal circuli in the scales is seen to be more in *R. brachysoma* than in *R. kanagurta* when scales from similar sized specimens of both the species are examined.

(5) On account of the small and centrally placed nucleus, incomplete lateral circuli were not seen in the scales of *R. brachysoma* which were examined. Incomplete lateral circuli are present in almost all scales of *R. kanagurta* examined from identical position behind the pectorals.

TABLE XI

Particulars of scales of *R. kanagurta* and *R. brachysoma*

Species and locality	Length of specimens (mm)	L. of* scale	W. of* scale	No. of ctenoid projections	No. of apical circuli	No. of basal circuli	Incomplete lateral circuli	
							Left	Right
R. kanagurta (E. Africa) ..	198	47	66	22	46	33	1	4
R. kanagurta (S. Africa) ...	222	59	77	27	48	48	1	Nil
R. kanagurta (Andamans) ...	245	69	100	37	45	53	6	6
„ ...	160.	43	55	Damaged	38	18	6	8
„ ...	„	38	49	„	34	18	6	9
„ ...	„	38	52	„	32	19	9	7
„ ...	255	60	96	37	40	46	7	4
„ ...	„	60	97	34	37	53	5	2
„ ...	„	58	95	31	37	48	1	7
„ ...	„	60	97	33	40	50	3	7
„ ...	„	59	95	35	41	53	3	7
„ ...	„	60	92	33	45	47	6	5
„ ...	„	58	90	32	47	42	7	8
R. brachysoma (Andamans) ...	162	51	58	17	55	40	Nil	Nil
„ —	195	57	72	22	47	48	Nil	Nil
„ ...	221	68	82	31	47	62	Nil	Nil
„ ...	„	66	78	Damaged	52	60	Nil	Nil

*Length and width of scales are given in microdivisions. 17.5 m.d. = 1 mm.

ABNORMAL SPECIMENS OF *R. kanagurta* FROM INDIAN COASTAL WATERS

We have found that along the Indian Coast, occasionally among catches of *R. kanagurta* a few abnormal specimens may be encountered, some of which may even be mistaken for

R. brachysoma by those not familiar with the latter species. The frequent abnormalities seen are listed below :

(1) Short stumpy forms in which depth of the body is equal or greater than the length of the head.

(2) The shortening of the portion of the body behind the second dorsal.

(3) "Twisting" or curvature of the vertebral column in the caudal peduncular region.

(4) Loss of one or more dorsal finlets due to injury.

(5) Increase in the number of dorsal and anal finlets due to "twisting" of the caudal peduncular region.

(6) Increase in number of first dorsal spines.

(7) Short first dorsal fin.

The above are easily noticeable even in the field. We have not examined the osteological features of these specimens some of which are illustrated here in text-figs. 8 and 9. Morphometric and meristic data for these specimens are given in Table XII.

TABLE XII

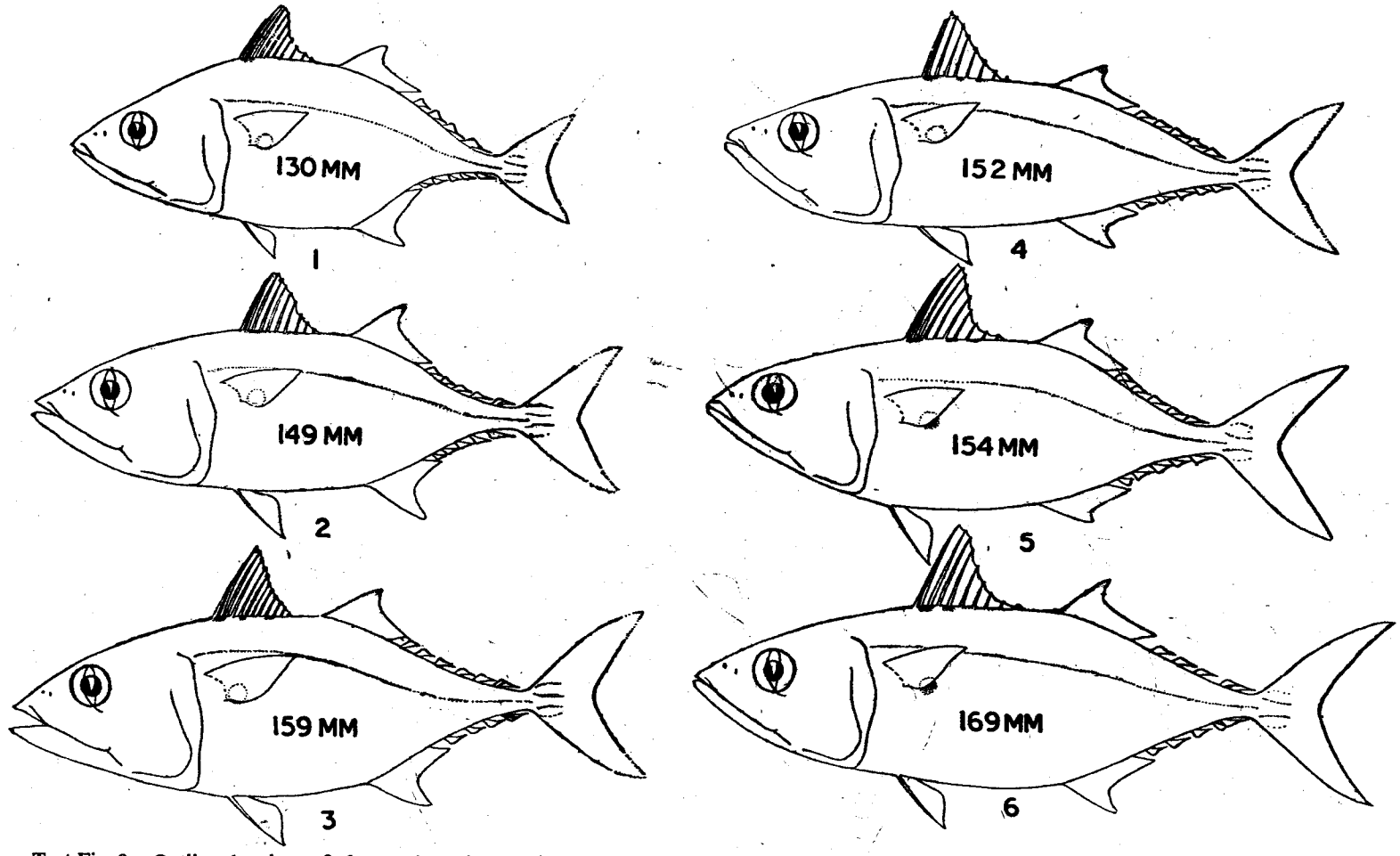
Morphometric and meristic data on abnormal specimens of *R. kanagurta* from Indian waters*

Characters	Localities								
	No. 1 Calicut ?	No. 2 Narakal 20-1-58	No. 3 Narakal Jan. 58	No. 4 Narakal 20-1-58	No. 5 Calicut 30-11-55	No. 6 Calicut 30-11-55	No. 7 Calicut 4-11-56	No. 8 Calicut 30-11-55	No. 9 Calicut 19-12-55
Fork length ...	130	149	159	152	154	169	150	175	193
Head length ...	43	50	52	47	47	50	45	53	57
Greatest depth of body ...	47	44	49	41	47	49.5	42	48	48
Length of pectoral ...	21	24	26	22	24	26	22.5	25	27
Length of maxilla ...	324	26.5	29	25	26	29	25	28	31
First predorsal distance ...	51.5	59	60	55	57	61	55	65	69
Second predorsal distance...	76	88	88	90	92	100	95	101	112
Prepelvic distance ...	52	59	64	56	56	61	56	63	70
Preanal distance ...	82	91	101	92	94	104	9 7	106	120
D_1 ...	XI	XI	XII	IX	X	X	IX	VIII	IX
D_2 ÷ finlets ...	11 ÷ 4	11 ÷ 5	12 ÷ 6†	12 ÷ 5	12 ÷ 5‡	12 ÷ 4†	11 ÷ 6	12÷5†	12 ÷ 5
P_1 ...	19	19	20	20	19	20	19	19	20
A ÷ finlets ...	12 ÷ 5	11 ÷ 5	12 ÷ 4†	12 ÷ 5	12 ÷ 5	12 ÷ 4†	1 ÷ 6	13 ÷ 5†	12 ÷ 2
Gill rakers ... *Right*	18÷35	19÷37	194÷0‡	20÷39	19÷37	19÷35	18÷41	20÷40	
Left	19+36	*Removed*‡	*Removed*	19+39	18+36	19+35	19+41	19+40	

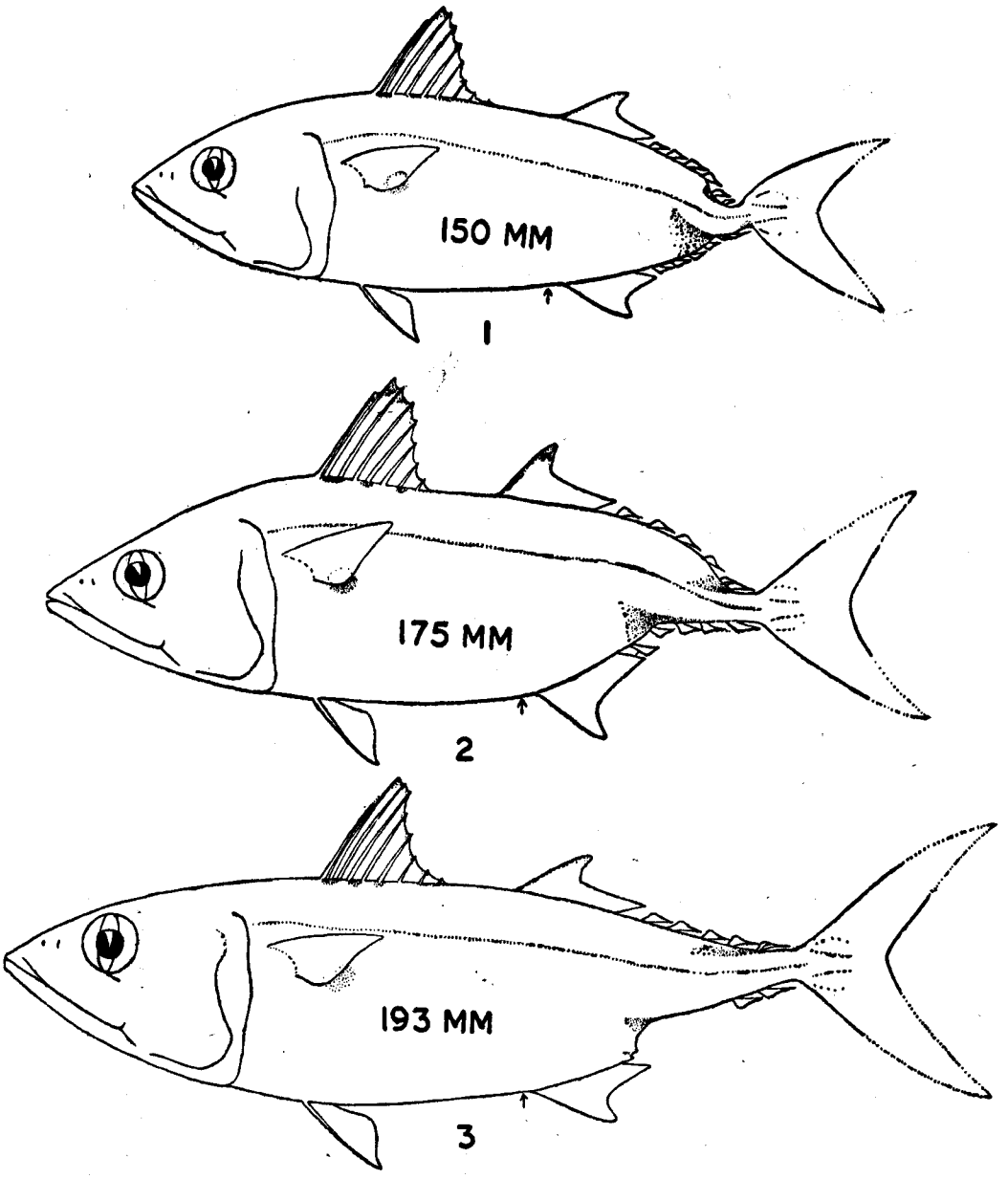
*All measurements are in millimetres. Specimen numbers 1–6 are figured in text fig. 8 and 7–9 in text. fig. 9

†Finlet nearest caudal base divided to base and appearing as two is counted as 1.

‡ Outer left gill arch appears to have been completely removed.



Text Fig .8.—Outline drawings of abnormal specimens of *R. kanagurta* collected from the south-west coast of India. The number given on the body of each specimen represents fork length in mm. See also Table XII.



Text Fig. 9.—Outline drawings of abnormal specimens of *R. kanagurta* collected from the south-west coast of India. The number given on the body of each specimen represents fork length in mm. See also Table XII.

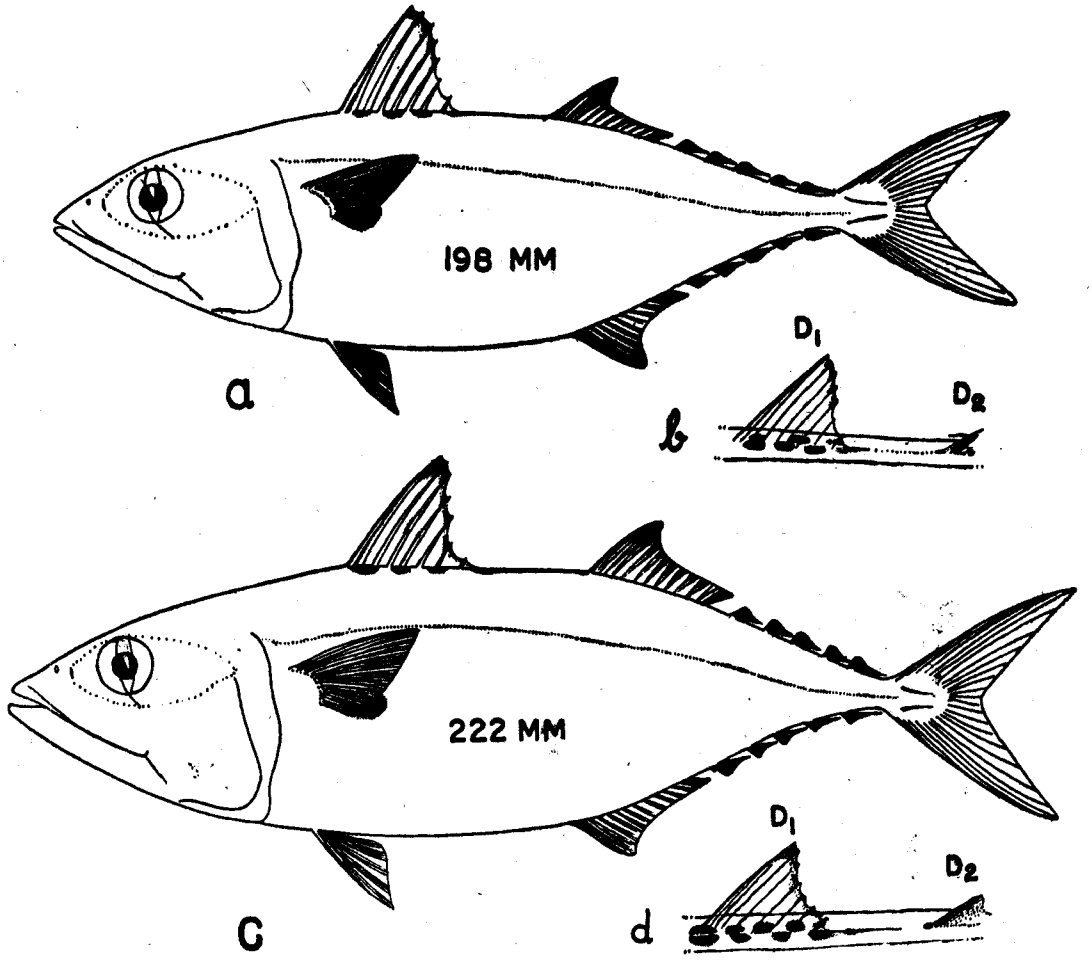
R. KANAGURTA FROM EAST AFRICAN WATERS

We have been able to examine seven specimens of *R. kanagurta* 145 mm. to 198 mm. in fork length (Text-figure 10a, b) from the British East African Waters kindly sent to us by Mr. F. Williams who had collected them off S. W. Zanzibar. The specimens do not show any marked difference from *R. kanagurta* occurring along Indian coastal waters and have the following meristic characters :

D_1 VIII— IX ; D_2 + finlets 11—12 + 5 ;

P_1 19—20 ; A + finlets 10—12 + 5 ;

scales along lateral line about 118—122.



Text Fig. 10.—Outline drawing of *R. kanagurta* (Cuvier) (A) specimen 198 mm. in fork length from south-west Zanzibar, British East Africa; (B) part of mid-dorsal profile at base of spinous dorsal showing faint black blotches ; (C) specimen 222 mm. in fork length from the Natal coast, South Africa and (D) part of mid-dorsal profile at base of spinous dorsal of same showing distinct and conspicuous black blotches.

The gill raker counts for the seven specimens are as follows :

Outer gill arch on	Upper limb					Lower limb			
	15	16	17	18	19	34	35	36	37
Right side ...	...	1	4	...	2	3	1	...	3
Left side ...	1	...	3	2	1	2	2	1	2

The various body proportions expressed in thousandths of fork length are as follows : Head 265 to 289 ; first predorsal distance 333 to 366 ; second predorsal distance 544 to 609 ; prepelvic distance 320 to 363 ; preanal distance 592 to 621 ; distance from origin or P to D_1 origin 112 to 131 ; distance from P_1 to P_2 origin 160 to 188 ; depth of body at origin of D_1 224 to 260 ; greatest depth of body 224 to 278 ; depth of body at origin of D_2 214 to 258 ; anterior height of D_1 157 to 167 ; length of P_1 126 to 143 ; length of maxilla 136 to 166 ; width of body at P_1 98 to 136 ; length of longest gill raker 75 to 114; and length of longest gill filament 51 to 64.

The occurrence of *R. brachysoma* or a similar deep bodied form has never been reported from these waters, although it is listed in the ichthyofauna of South African waters.

R. KANAGURTA FROM SOUTH AFRICAN WATERS, S. W. INDIAN OCEAN

We have been able to examine a single specimen of *R. kanagurta* kindly loaned to us by Prof. J. L. B. Smith, (text-figure 10 c and d). The specimen shows the following characteristics :

D_1 IX ; D_2 + finlets 12 + 5 ; P_1 19 ; A + finlets 11 + 5 ; scales along lateral line about 128. Gill rakers $\begin{matrix} R \\ L \end{matrix} \frac{18 + 37}{20 + 35}$ (total—110)

The various body proportions expressed in thousandths of fork length are as follows : Head 293 ; first predorsal distance 360 ; second predorsal distance 599 ; prepelvic distance 347 ; preanal distance 617 ; distance from origin of P_1 to D_1 origin 191 ; depth at D_1 275 ; depth at D_2 261 ; greatest depth 286 ; anterior height of D_1 150 ; length of P_1 137 ; length of maxilla 158 ; width of body at P_1 140 ; length of longest gill raker 115, and length of longest gill filament 68.

Gilchrist and Thompson (1907) ; Barnard (1927) ; Fowler (1935) and Smith (1949 ; 1961) record *Rastrelliger microlepidotus* (*R. kanagurta*) from South African waters.

Gilchrist and Thompson (1917) referred to *R. brachysoma* from South African waters and Barnard (1927) though he did not examine any specimens, gave the following brief description of this species : " Depth 3 1/7—3 2/3, length of head 3 3/4 in length of body. Eye 3 4/5—4 1/3 in length of head, 1 1/3 in snout, 1 1/4 in inter-orbital width. D X + 12+5. A I, 11+5. Maxilla reaching to level of posterior third of eye. Gill rakers 44 on lower part of anterior arch. " The description fits in well with the known characteristics for *R. kanagurta*. Smith (1949, 1961) also records *R. brachysoma* from South African waters.

However, he gives the depth of body of this species to be about 3 3/4 in the length while for *R. kanagurta* the depth of body is mentioned to be about 3 1/2, which means his *R. brachysoma* has a less deeper body than that of *R. kanagurta*. Other distinguishing characteristics mentioned for these two species from South African waters are :

Characters	*R. kanagurta*	*R. brachysoma*
D_1 ...	IX—X + 11—12 + 5	IX—X + 12—13 + 5
A ...	I—II, 11—12 + 5	I, 11 + 5
Gill rakers (on lower limb of outer gill arch)	25-35	I, 11 + 5 about 45

It may be mentioned here that the possibility of the occurrence in South African waters of *R. brachysoma* or a form closely allied to it cannot be ruled out. However, confirmation of its occurrence should await examination of good series of specimens.

The specimen of *R. kanagurta* we have examined from South Africa is characterised by more distinct black blotches middorsally on either side of the spinous dorsal, though in East African, Indian and Andaman specimens they are not so conspicuous. Smith (1961) has shown the upper third of the spinous dorsal fin as being coloured black in *R. kanagurta* (Pl. 68, figure 837), but in the specimen we have examined (Text-figure 10c and d) this is not the case. Proper gill raker counts and morphometric data are wanting for South African specimens of *R. kanagurta*.

ACKNOWLEDGEMENT

We are very thankful to Mr. S. K. Dharmaraja of this Institute for the help rendered in the statistical calculations.

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THE PAPER WAS READ BY DR. E. G. SILAS

DISCUSSION

MR. S. K. BANERJI : You say that you have studied over 15 characters. Out of these how many show overlap and to what degree ?

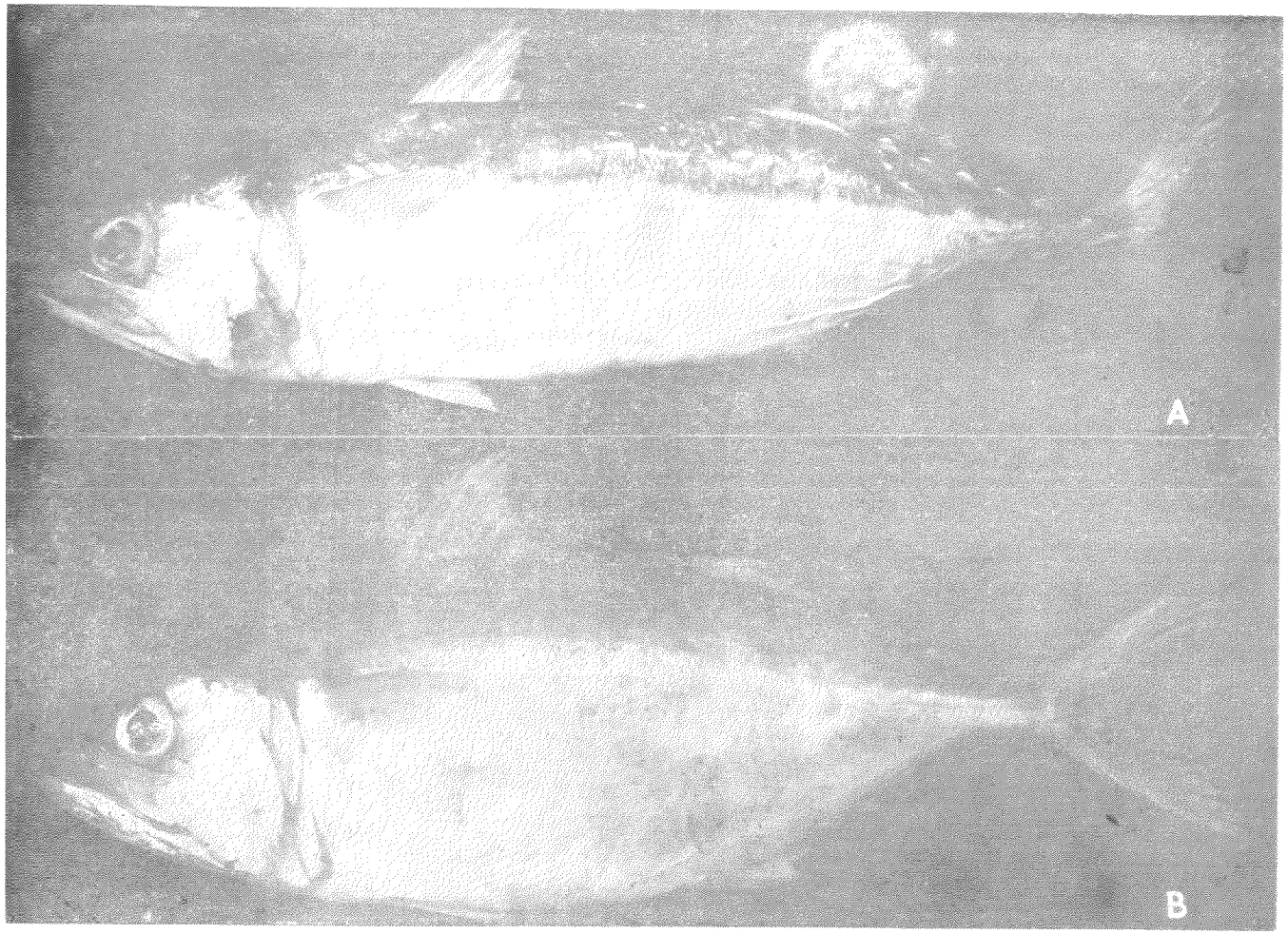
DR. E. G. SILAS : Initially over 35 characters, both morphometric and meristic, were analysed to select some dependable characters which would help in studying variations of interspecific nature. In about fifteen such characters partial overlap is seen to varying degrees. In characters such as depth of body at different points along the length of the body there appears to be no overlap, the degree of divergence in the samples of the two species examined being 100 per cent. Contrary to earlier belief we find that gill raker counts in both species show considerable overlap and may not prove to be of primary importance in species differentiation in this genus.

MR. RODNEY JONKLAAS : What was the method of collection employed there ?

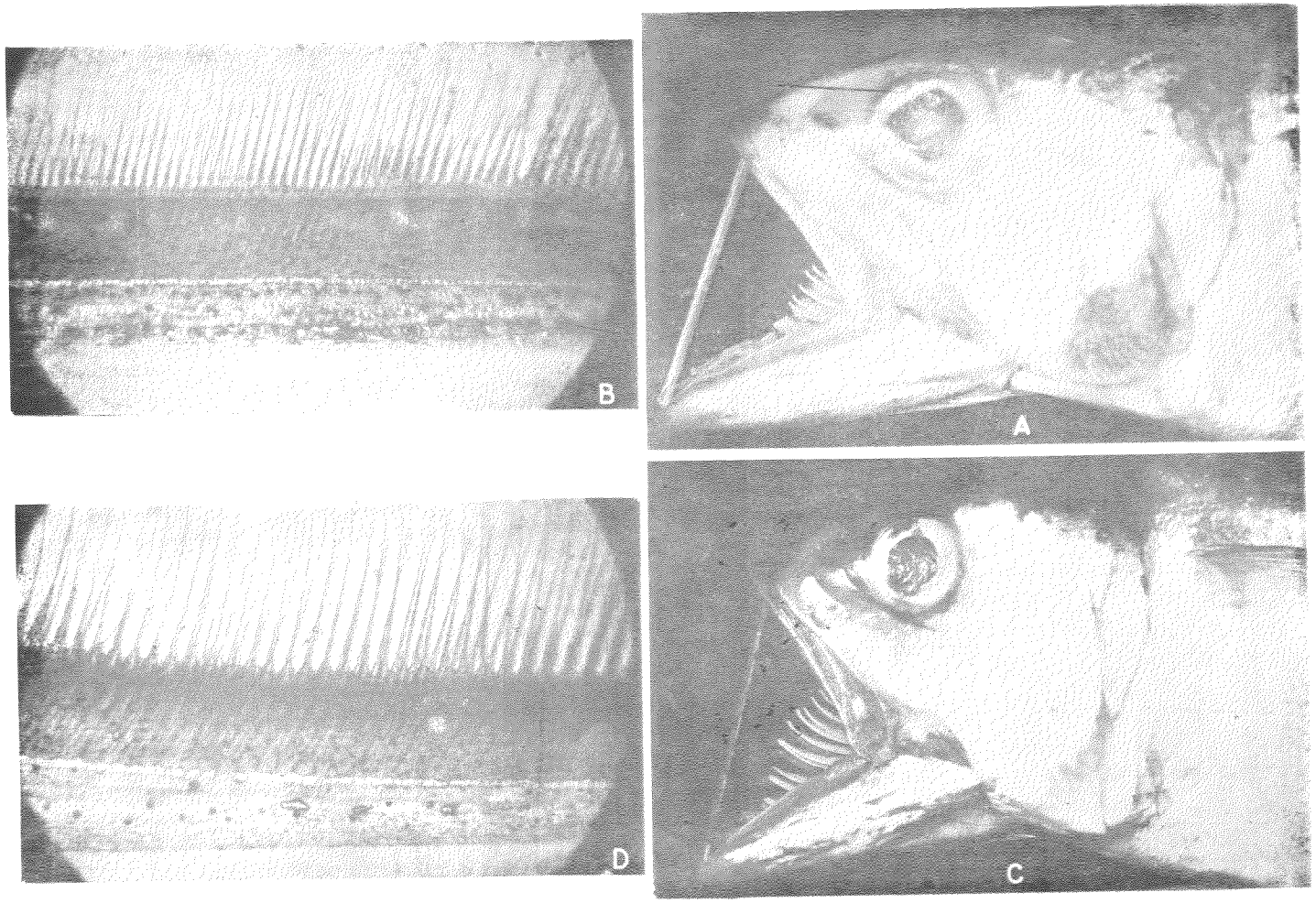
DR. E. G. SILAS : The specimens we examined were obtained in shore seines operated in bays close to Port Blair, Andamans.

MR. K. V. SHEKARAN : The specific name of the Indian mackerel has been spelt with '*c*' as *R. canagurta* by workers from the Central Marine Fisheries Research Institute. You have used '*k*' as *R. kanagurta* and I would like to know what spelling should be followed for this species.

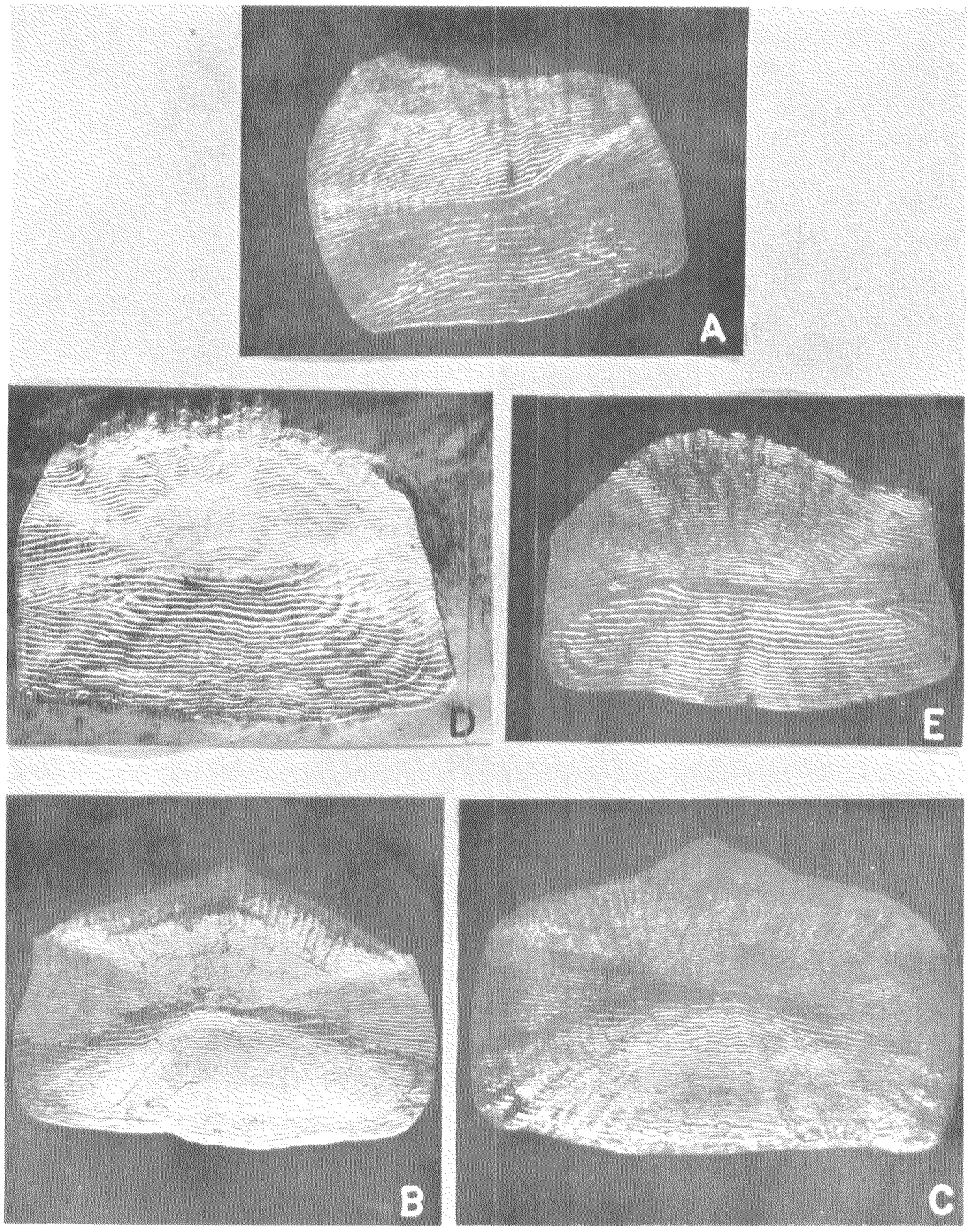
DR. E. G. SILAS : The specific name *R. kanagurta* is based on Russell's (1803) designation of the Indian mackerel by one of the local vernacular name used to denote it along the Coromandel Coast (Vizagapatam), namely *Kanagurta* (Telugu dialect: Also *Kanagadathalu* is used for the same species in the same dialect). Unfortunately the species described by Russell are not recognised on account of the non-usage of binomial nomenclature. However, it has been the custom to attribute the authorship of these species to the first subsequent worker dealing with the species and in this case Cuvier appears to be the first to mention Russell's species *Scomber kanagurta* in a footnote in 1817 (*Regne Animal*, 2 : 313). In the second edition of the same work appearing in 1829 (*Regne Animal*, 2 : 197) he uses the spelling *S. canagurta* for the species, although two years later in the 8th volume of Histoire Naturelle de Poissons (p. 49, 1831) again the species name is given as *Scomber kanagurta*. Another point to be mentioned is that according to the law of priority it is not proper to attribute the authorship of *Scomber kanagurta* to Rüppell (1828 : Atlas Reise Nordl Afrika, Fische Rothen Meeres, p. 93 : from Gomfuda, Red Sea) as some workers have done, especially as there is no ambiguity about Russell's *Kanagurta* both as evident from the description as well as his drawing of the species. In fact, unlike many earlier post-Linnean works, there is no ambiguity about most of the 200 species described by Russell, and if his work is recognised, the authorship of the Indian mackerel *Scomber kanagurta* (= *Rastrelliger kanagurta*) would rightly go to him. In addition, the spelling of the species as *R. kanagurta* is so widely current in literature that it will be most undesirable and unnecessary to change it at this stage.



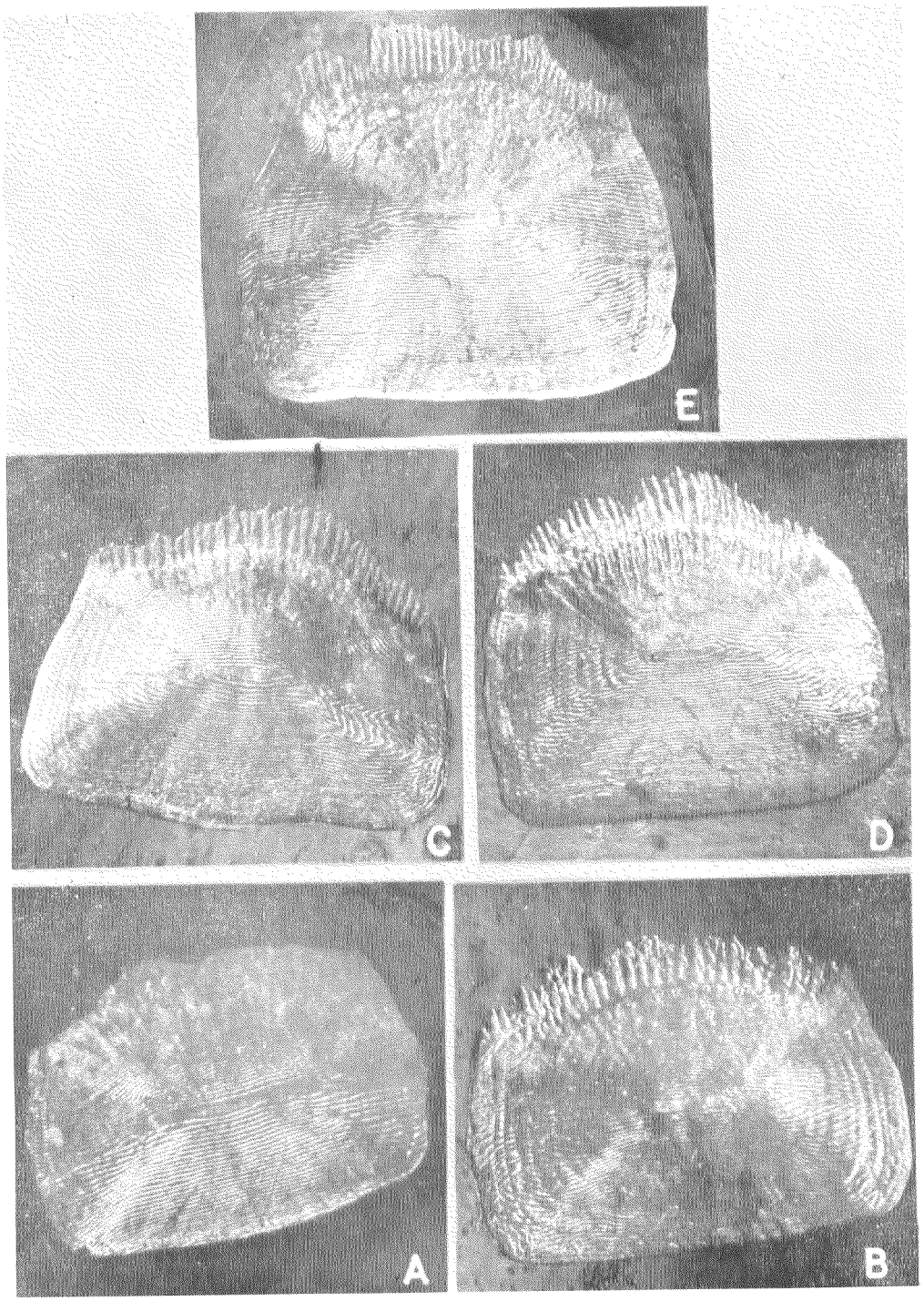
A. Rastrelliger kanagurta (Cuvier), 268 mm. in fork length. *B. Rastrelliger brachysoma* (Bleeker), 213 mm. in fork length. Both the specimens are from Port Blair, Andamans.



Rastrelliger kanagurta (Cuvier) : (A) Mouth of 268 mm. specimen kept open to show the relatively less exposed gill rakers. (B) Part of longest gill raker on the lower limb of the outer gill arch of the same showing the dense pigmentation and the relatively shorter simple branches. *Rastrelliger brachysoma* (Bleeker) : (C) Mouth of 213 mm. specimen kept open to show the long feather-like exposed gill rakers. (D) Part of the longest gill raker of the same species showing the sparse pigmentation and the relatively longer simple branches.



Rastrelliger kanagurta (Cuvier) : Scales from behind tip of pectoral fin of (A) specimen 160 mm. (2.45 × 3.1 mm.) ; (B) Specimen 245 mm. (3.9 × 517 mm.) and (C) specimen 255 mm. (3.4 × 5.5 mm.) all from Andamans. Scales from identical position of (D) abnormal specimen 169 mm. (2.45 × 3.5 mm.) and (E) abnormal specimen 130 mm. (2.1 × 3.0 mm.) both from Calicut, West Coast of India (Measurements of scales are given in parenthesis after the length of the specimen).



Rastrelliger kanagurta (Cuvier) : Scales from behind tip of pectoral in (A) 198 mm. (2.7 × 3.7 mm)., specimen from Zanzibar, E. Africa ; and (B) 222 mm. (3.3 × 4.4 mm.) specimen from South African waters. *Rastrelliger brachysoma* (Bleeker) : Scales from identifical position in (C) specimen 195 mm. (3.2 × 4.1 mm.); (D) and (E) specimen 221 mm. (3.7 × 4.4 and 3.9 × 4.7 mm.) from Port Blair, Andamans. (Measurements of scales are given in parenthesis after the length of the specimen).

ASPECTS OF THE TAXONOMY AND BIOLOGY OF THE ORIENTAL BONITO *SARDA ORIENTALIS* (TEMMINCK AND SCHLEGEL)*

BY

E. G. SILAS

Central Marine Fisheries Research Intitute, Mandapam Camp

INTRODUCTION

Three species of *Sarda* Cuvier (1829), namely *S. sarda* (Bloch), *S. chilensis* Cuvier, and *S. orientalis* (Temminck and Schlegel) are at present recognised from the tropical and temperate waters of the world. However, as the position of the genus itself in the system is not yet well defined and as various views have been held by authors regarding the higher categories under which the genus has to be placed among the scombroids, a brief résumè is called for.

HISTORICAL RESUME

Günther (1860) did not recognise the genus *Sarda* Cuvier, but included certain species referable to it under the composite genus *Pelamys* Cuvier, which in turn was placed under Group Scombrina of family Scombridae. Jordan and Evermann (1896), Fowler (1936) and others recognised *Sarda* as a distinct genus under the family Scombridae, and Fraser-Brunner (1950) placed it under the subfamily Scombrinae of family Scombridae. Kishinouye's (1923) treatment of *Sarda* as a distinct genus under the family Cybiidae along with the genera *Acanthocybium*, *Grammatorcynus*, *Cybium*, and *Gymnosarda* has not found acceptance amongst other workers. Godsil's excellent anatomical studies of the species of *Sarda* (Godsil, 1954, 1955) shows the closer affinities of the genus to *Thunnus* than to *Katsuwonus*, but his scheme of classification placing the latter two genera under the families Thunnidae and Katsuwonidae respectively does not provide for the accommodation of *Sarda* under either. The question remains whether *Sarda* should be given a separate family status (Sardidae) as given by Munro (1958) or should it be placed under a subfamily Sardinae, of the family Thunnidae (Fowler, 1949) or merely as a genus of the family Thunnidae ? According to de Sylva (1955) "In view of the compact group represented by the genus *Thunnus* in relation to its closest relatives.....*Euthynnus*, *Katsuwonus*, and *Sarda* the designation of the genus *Thunnus* as a separate family by certain authors seem to be osteologically untenable. The members of the family Scombridae are more closely related to each other than to any other group. *Euthynnus* and *Katsuwonus* form a natural group on one side of and close to *Thunnus* while *Sarda* forms a natural group on the other side. Examination of the skeletons of the aforementioned genera (Godsil and Byers, 1944; Kishinouye, 1923; Starks, 1910; Clothier, 1950) shows that while *Auxis*, *Euthynnus* and *Katsuwonus* stand as a compact group, above generic rank, they are closely related osteologically to *Thunnus* and to a lesser extent to *Sarda*." This would imply that it may be desirable to consider these groups of genera under the family Scombridae perhaps under different subfamilies. Excessive splitting and upgrading of different groups of scombroids to ordinal or subordinal ranks (Kishinouye, 1923; Berg, 1947) is not a desirable course and unnecessary.

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SPECIES OF *SARDA* CUVIER

The species of *Sarda* are distributed as follows: *S. sarda* in the Atlantic, Mediterranean, and Black Sea; *S. chilensis* in the Pacific (*S. c. chilensis* in E. Pacific and *S. c. australis* in east Australasian waters); and *S. orientalis* in the Indo-Pacific. While, *S. sarda* has been well studied resulting in the recognition of a single species with not much variations and the suppression of the following names to its synonymy (*Scomber pelamys* Brunnich, 1786; *Pelamis Belonii* Willugby, 1789; *Scomber sarda* Bloch, 1793; *S. mediterraneus* Bloch and Schneider, 1801; *S. pelamis* Asso, 1810; *S.ponticus* Pallas, 1811; *Thynnus sardus* Risso, 1826; *Pelamys sarda* Cuvier, 1831; *Sarda pelamys* Gill, 1862; *S.mediterranea* Jordan and Gilbert, 1883; *Pelamis sarda* Graells, 1885 ; *Sarda sarda* Dresslar and Fesler, 1889 and *Sarda pelamis* Lozano, 1919), the works of Kishinouye (1923), Godsil (1954, 1955), and others, clearly draw attention to the need for more detailed investigations on the species problem concerning the Indo-Pacific species. Briefly stated, Godsil (1954, 1955) has shown that *Sarda lineolata* (Girard, 1858) is conspecific with *S. chilensis*, and the latter along with *S.sarda* forms a group or complex—the *sarda-chilensis* complex. He has also discussed the conspecificity of *S. velox* Meek and Hildebrand (1923) to *S. orientalis*, denoting them as the *orientalis-velox* complex. The record of *S.velox* by Breder (1932) from Block Island, R. I., U.S.A., and of *S. orientalis* based on a single specimen from the Gold Coast, Africa, by Fraser-Brunner (1950) extends the distribution of the *orientalis-velox* complex to the Atlantic. However, the last said two records are subject to confirmation by the collection of fresh material from the Atlantic.

Godsil (1955) differentiated the *orientalis-velox* complex from the *sarda-chilensis* complex by four diagnostic characters, namely, the non-development of gill teeth or posterior rakers on the first arch (*versus* developed) ; the posterior U-shaped portion of the maxillary plus the auxiliary maxillary about half as wide as long (*versus* as wide as long); 2-4 gill rakers on upper limb of first arch excluding raker at angle and 8-13 total rakers (*versus* 7-10 and 20-27 respectively); and the lower jaw with about 10-15 teeth on each side (*versus* 20-25).

Six additional superficial corroboratory characters given separating the two species complexes are:

sarda-chilensis	*orientalis-velox*
Head length/maxillary length =1.86—1.93	Head length / maxillary length =2.05—2.18
Glossohyal has a short longitudinal depression on ventral face of proximal portion.	Glossohyal lacks this groove and face of bone is convex outwards.
Greatest length of auxiliary maxillary / greatest width = 3.00—3.83	Same = 4.01—4.50
Clavicle: posteriorly projecting plate expanded near midlength, and tapered distally.	*Clavicle*: posteriorly projecting plate of approximately uniform width.
Hyomandibular: spine projecting posteriorly from centre condyle slopes upwards.	*Hyomandibular*: spine projecting posteriorly from centre condyle slopes down, or at most is perpendicular to shaft of bone.
"*Vertebral column*: can be positively identified by direct comparison of ventral processes ".	"*Vertebral column*: can be positively identified by direct comparison of ventral processes, but probably not without other type of comparison "

The last said character needs further elaboration which would be clear from Godsil's earlier work (Godsil, 1954) wherein he remarks about *S. lineolata* (= *S. chilensis*), and *S. velox* (= *S. orientalis*) as follows: "A subtle though constant and diagnostically valuable difference distinguishes the vertebral column of *velox* from that of *lineolata*. It concerns the minor ventral processes of the central vertebrae. In *lineolata* the inferior zygopophyses projecting ventrally at the posterior end of each vertebra are broad and blunt and point ventrally. Between them and the small spur that projects from the contiguous proximal portion of the next haemapophysis there is rarely any connection and the two are separated by an appreciable space. In *velox* these inferior zygopophyses are fine, distally pointed and they arch posteriorly so that they approximate or abut against the adjacent spur on the haemapophysis, which incidentally is more developed. While there is considerable variation in individual vertebrae, the aggregate appearance is sufficiently great to identify any and every specimen. Hence this can be considered a positive diagnostic character and a specific difference."

Undue emphasis has been given by previous workers on characters such as colour markings, and varying proportional measurements and meristic counts in describing new species of *Sarda*. Godsil (I955) has rightly drawn attention to the considerable variation in the colour pattern in the different species and its non-utility as a specific character. This we are in full agreement with, since we find variations in the colour pattern with age as well in specimens of about the same size in *S. orientalis* from Indian seas. Likewise, proportions also change with body length and can be used only when treated as regressions on body length, otherwise the proportions being valid indices only for fish of the same size. Concluding his observations on species of *Sarda*, Godsil (1955) remarks that " Superficially it appears that *chilensis* is nothing more than a geographic variation of *sarda* while *australis* (to judge by a photograph) belongs to the *orientalis-velox* complex." Available information indicates that there is no overlap in the number of spines in the first dorsal fin in *S. sarda* and *S. chilensis*, the counts being 20–24 and 18–19 respectively. If future investigations are to show overlap in this character, then as suggested by Godsil, it will be desirable to consider *chilensis* as a geographical subspecies of *S. sarda*, but at present it is best to consider both as specifically distinct. Regarding Godsil's observation on *australis*, the gill raker counts of it given by Munro (1958), namely 6–8 + 12–14, clearly indicates that its affinities are more towards *chilensis* (gill rakers 7–10 + 1 + 11–18 = 20–27) than to the typical *orientalis* (gill rakers 2–3 + 1 + 8–10 = 11–14), and we agree with Munro in designating it as *S. chilensis australis* (Macleay).

Whitley (1945) described a subspecies, *Sarda orientalis serventyi* from S. W. Australia (type locality:Albany, Western Australia), on the grounds that *S. orientalis* has a restricted distribution along that coast and is separated from its congeners by a wide distance. In the absence of sufficient morphometric or meristic detail to support this separation, *S. o. serventyi* is considered here as an absolute synonymy of *S. orientalis*. No doubt, a disjunct pattern of distribution is seen for *S. orientalis* in the Indian Ocean (Silas, 1962) (Fig. 5) but whether this represents the real state of affairs or what amount of it is due to our inadequate knowledge of the fauna in the areas inbetween, such as British East African Coast, North East Coast of India, Laccadive-Maldive Archipelagos; Andaman Sea and Sunda Sea south of Java is to be seen. In the event that *S. orientalis* is found to exhibit slight morphometric and meristic differences, the question is whether these should be recognised as different subspecies or considered as clinal differences from area to area as would appear to be the case for some of the tunas.

On the basis of the above discussion, the following synonymies of *Sarda orientalis* (Temminck and Schlegel), 1842 are recognised. Pertinent references are also mentioned alongside.

Sarda orientalis (Temminck and Schlegel), 1842

Pelamis orientalis Temminck and Schlegel, 1842.

Pelamis orientalis Günther, 1860.

Scarda chiliensis* var. *orientalis* Steindachner and Döderlein, 1885 (**Scarda* typographic error for *Sarda*)

Pelamys chiliensis (*nec* Cuvier) Day, 1878 ; 1889.

Sarda chilensis (*partim*) Meek and Hildebrand, 1923 ;

Barnard, 1925.

Sarda velox Meek and Hildebrand, 1923 ;
Breder, 1929 ; 1932 ;
Jordan, Evermann and Clark, 1930 ;
Walford, 1937 ;
LaMonte, 1945, 1950 ;
Hildebrand, 1946 ;
Linder, 1947 ;
Schweigger, 1947 ;
Godsil, 1954, 1955 ;
Pinkas, 1961.

Sarda chiliensis (*partim*) Chabanaud, 1944.

Sarda orientalis serventyi Whitley, 1945 ; 1947.

Sarda chilensis (*nec* Cuvier) Smith, 1949.

Sarda orientalis Kishinouye, 1915 ; 1919 ; 1923 ;
Soldatov and Lindberg, 1930 ;
Fraser-Brunner, 1950 ;
Rosa, 1950 ;
Mac Innes, 1950 ;
Warfel, 1950 ;
Wheeler and Ommanney, 1953 ;
Herre, 1953 ;
Yabe *et al.*, 1953 ;
Godsil, 1954, 1955 ;
Berdegue, 1956 ;
Munro, 1958 ;
Jones, 1960 ;
Jones and Silas, 1960 ; 1962 ;
Klawe, 1961 ;
Smith, 1961 ;
Yokota *et al.*, 1961.
Silas, 1962.

TABLE I

Common and Vernacular names of *Sarda orientalis*

Country	Standard common name(s)	Vernacular name(s)
Australia (Western) ...	Oriental bonito	
India ...	Oriental bonito	Vari choora (Malayalam)
Japan ...	Hagatsu	Hagatsuwo
	Sujigatuwo	Hohzan
		Kitsunegatsuwo
		Sabagatsuwo
		Shimagatsuwo
		Sujigatsuwo
		Tohzan
Mauritius–Seychelles		Brasse-a-dents (Creole name)
Philippines	Bonito	Oriental bonito
		Skipjack (also for *Katsuwonus pelamis*)
		Gantaan
Somalia		Sinufa
Union of South Africa	Bonito	
United States of America	Bonito	

Rosa (1950) lists the following names for *S. orientalis* from Japan, these being variations of the spelling of those given in the above table : Kitsunekatsuo, Shimakatsuo, Hosan, Sabakatsuo and Sujikatsuo.

DESCRIPTION OF *S. ORIENTALIS* (TEMMINCK AND SCHLEGEL) FROM INDIAN SEAS

Body proportions :

Body proportions expressed as thousandths of total length (measured as suggested by Marr and Schaefer, 1949) for 45 specimens, 80 mm. to 497 mm. collected from Vizhingam from the Kerala Coast are given in Table II.

Fin ray counts :

Table III gives details of fin ray counts in specimens collected at Cape Comorin, Vizhingam and Calicut.

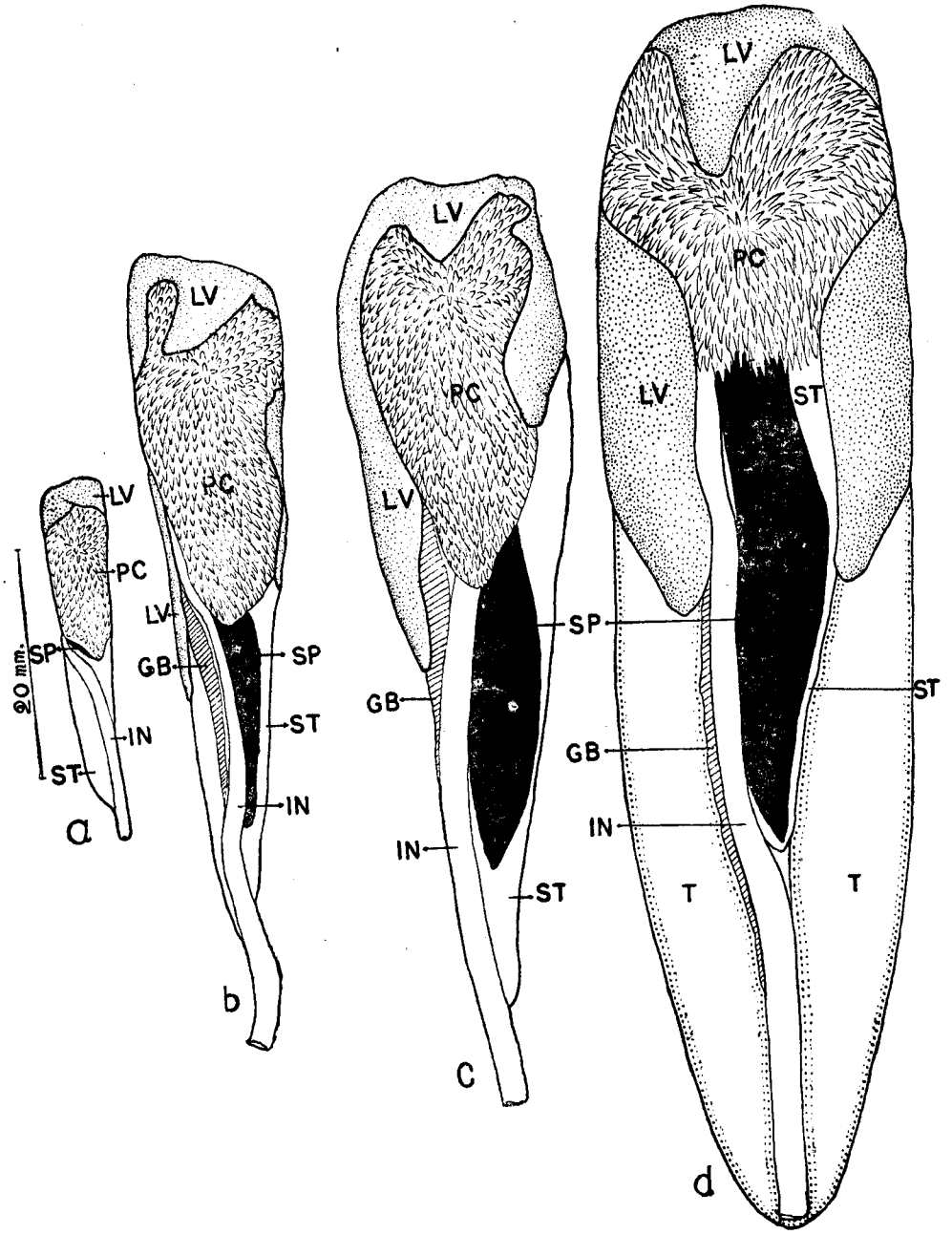
Gill raker counts :

Variations in gill raker counts are indicated in Tables IV, V and VI, for specimens from Cape Comorin, Vizhingam and Calicut.

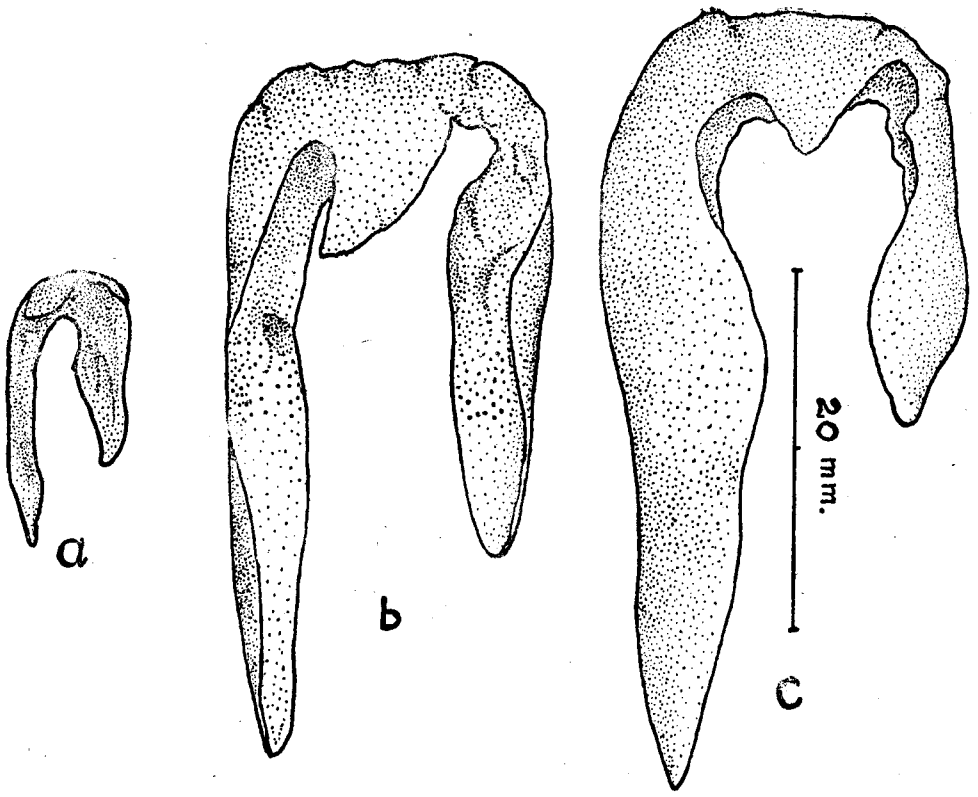
Visceral organs :

Various authors (Kishinouye, 1923 ; Godsil and Byers, 1944 ; Godsil, 1954, 1955 ; Serventy, 1941) have drawn attention to the nature and disposition of visceral organs as useful tools in taxonomic differentiation of species of scombroid fishes. In *S. orientalis*, slight differences with size may be seen as shown in the ventral views of the viscera of three specimens (Fig. 1). In an adult male 497 mm. long, but for the gall-bladder which could be clearly seen lying alongside the intestine, there is hardly any difference in the disposition of the other organs than what has been shown for an adult specimen of the typical *S. orientalis* from Japanese waters by Godsil (1955). As could be seen from figure 2, the right lobe of the liver is slightly longer than the left. In the larger specimens, with the development of the gonads, the stomach is hidden from the ventral view of the viscera *in situ*. The stomach is elongate, reaching backwards to about three-fourths the length of the straight part of the intestine, when partly filled. The wall of the stomach is thick and

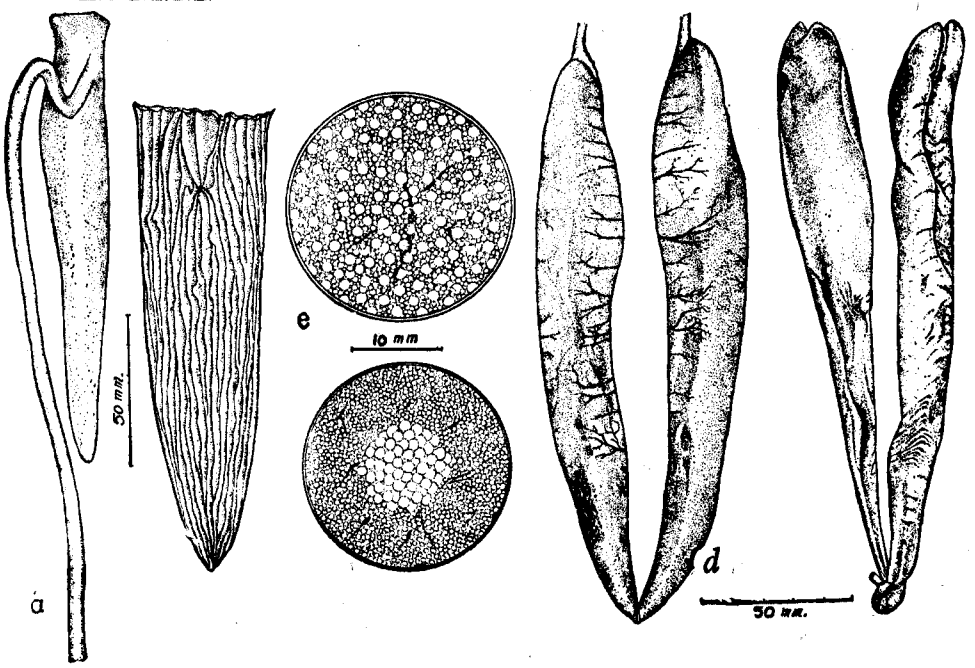
sufficiently distensible and internally shows about ten to twelve longitudinal ridges which converge posteriorly at the sac-portion (Fig. 3b). The intestine is long, with a single upward loop soon after descending from the stomach (Fig. 3a), the condition being totally different from that seen in the yellowfin tuna, the bluefin tuna, etc., where the intestine is more or less N-shaped.



Text Fig. 1. *Sarda orientalis* (T. & S.). Ventral view of viscera in specimens—(*a*) 80 mm.; (*b*) 176 mm.; (*c*) 202 mm. and (*d*) 368 mm. respectively, collected at Vizhingam. (GB—gall bladder ; IN—intestine ; LV—liver ; PC—caecal mass ; SP—spleen ; ST—stomach ; T—testes).



Text Fig. 2. *Sarda orientalis* (T. & S.). Ventral view of liver in specimens : (*a*) 80 mm.; (*b*) 202 mm. and (*c*) 368 mm. respectively, showing nature of the three lobes.



Text Fig. 3. *Sarda orientalis* (T. & S.). (*a*) stomach and intestine ; (*b*) inner surface of stomach showing nature of mucous folds ; (*c*) fully mature testis of a specimen 497 mm. from Vizhingam (the left testis is slightly turned over to show ventral groove accommodating blood vessel) ; (*d*) ripe ovary from specimen 490 mm.; (*e*) cross section of same (schematic) at middle to show distribution of transparent large ova among undeveloped ova from centre to periphery ; (*f*) cross section of ovary (schematic) in ripe running condition in specimen 605 mm. (spawning—see table XII) showing accumulation of ripe transparent ova in central lumen of ovary.

Dentition :

The posterior teeth on each side of the lower jaw are more prominent than those towards the symphysis as well as those on each side of the upper jaw. However, more teeth are present in the upper jaw (10—14 on each side) than in the lower jaw (7—12 on each side), a specimen 386 mm. showing 13 + 14 (= 27) in the upper jaw and 10 + 12 (= 22) in the lower jaw.

TABLE II

Body measurements expressed in thousandths of total length in different size groups of *Sarda orientalis* (Temminck and Schlegel)

Characters	Size groups					
	50-100 mm.	150-200 mm.	201–250 mm.	251–300 mm.	351–400 mm.	451–500 mm.
Head length ...	1 : 319	24 : 275–319 (299)	3 : 291–307 (299)	13 : 288–306 (302)	2 : 295–312 (303)	2 : 294–299 (296)
Snout to origin of D_1 ...	1 : 310	23 : 271–315 (297)	3 : 291–311 (300)	13 : 300–311 (306)	2 : 298–312 (305)	2 : 294–310 (302)
Snout to origin of D_2 ...	1 : 610	24 : 532–619 (586)	3 : 569–599 (587)	13 : 593–626 (604)	2 : 588–604 (596)	2 : 590–608 (599)
Snout to origin of A ...	1 : 709	24 : 623–721 (684)	3 : 688–698 (692)	13 : 686–710 (699)	2 : 688–710 (699)	2 : 688–694 (691)
Snout to origin of P_2 ...	1 : 341	23 : 302–350 (330)	3 : 318–354 (334)	13 : 311–339 (328)	2 : 311–337 (324)	2 : 322–336 (329)
Greatest depth of body ...	1 : 225	24 : 204–233 (218)	3 : 213–240 (226)	13 : 214–234 (224)	1 : 215 ...	2 : 204–209 (206.5)
Length of P_1 ...	1 : 101	24 : 67–121 (107)	3 : 103–124 (112)	13 : 115–126 (129)	2 : 127–131 (129)	2 : 124–137 (130.5)
Height of D_2 ...	1 : 73	24 : 51–80 (64)	3 : 64–80 (73)	13 : 54–86 (70)	2 : 82–84 (83)	2 : 86–87 (86.5)
Height of A ...	1 : 78	23 : 58–81 (64)	3 : 60–71 (66)	13 : 64–79 (71)	2 : 80–87 (83.5)	2 : 86–91 (88.5)
Diameter of iris ...	1 : 56	24 : 39–56 (43)	3 : 43–50 (46)	13 : 43–49 (46)	2 : 49–51 (50)	2 : 41–42 (41.5)

In each column the number of specimens is given followed by range and the mean is indicated in parenthesis.

TABLE III

Meristic counts for specimens from Indian seas*

Characters	Dorsal spines	Second dorsal rays	Dorsal finlets	Pectoral rays	Anal rays	Anal finlets
Range ...	17 18 19	14 15 16	7 7 + 1 8 8 8 + 1	23 24 25	13 14 15 16	5 5 + 1 6 6 + 7
Number of specimens ...	2 37 7	20 7 3	7 5 31 1	3 28 13	4 18 6 1	2 3 36 2 1
	N = 46 M = 18.1	N = 30 M = 14.43	N = 44 M = 7.86	N = 44 M = 24.2	N = 29 M = 14.13	N = 44 M = 6.02

*For calculating mean, when dorsal and anal finlet counts are given as 5 + 1, 6 + 1, 7 + 1 and 8 + 1, these are treated as 6, 7, 8 and 9 respectively.

TABLE IV

Gill raker count for *S. orientalis* from three centres along the South West Coast of India

Locality	Gill rakers on upper and lower limbs of outer gill arch												No. of specimens
	1+8	2+8	3+8	4+8	1+9	2+9	3+9	4+9	1+10	2+10	3+10	4+10	
Cape Comorin ...	...	...	...	...	...	...	2	1	...	...	...	...	3
Vizhingam ...	1	2	3	...	3	6	14	2	...	1	4	1	37
Calicut ...	...	...	...	...	...	...	2	...	...	...	...	...	2
No. of specimens	1	2	3	..	3	6	18	3	...	1	4	1	42

TABLE V

Locality	Gill rakers						
	Upper limb				Lower limb		
	1	2	3	4	8	9	10
Cape Comorin	...	...	2	1	...	3	...
Vizhingam	4	9	21	3	6	25	6
Calicut	...	...	2	...	...	2	...
No. of specimens	4	9	25	4	6	30	6
	N = 42		M = 2.7		N = 42		M = 9

TABLE VI

Locality	Total No. of gill rakers					
	9	10	11	12	13	14
Cape Comorin ...	...	...	...	2	...	...
Vizhingam ...	1	5	9	15	6	1
Calicut ...	...	...	...	2	1	..
No. of specimens ..	1	5	9	19	7	1
	N = 42		M = 11.7			

Scales :

Scales are minute. The corselet is not conspicuous as in *Auxis* or *Euthynnus*, but is well formed, its posterior extension reaching to below tip of pectorals. The lateral line takes an upward loop above level of mid-pectoral from whence it gently slopes to the caudal keel, slightly undulating.

Osteology :

No work has been carried out on *S. orientalis* from Indian seas. However, the works of Kishinouye (1923), and Godsil (1954, 1955) give ample information about the skeletal features of this species from Japanese Sea as well as Eastern Pacific.

Colouration

There are marked differences between juvenile and adult body colourations. According to Jones (1960) in a small juvenile 80 mm. long " The body bears twelve transverse bands which are broad at the dorsal aspect and taper laterally to become imperceptible on reaching the sides of the abdomen and above the anal." In " One of the larger juvenile specimens measuring 158 mm. in standard length and 174 mm. in total length collected from Vizhingam... the transverse bands referred to the previous stage have subdivided into more or less horizontal streaks, which ultimately unite to give rise to the lines so characteristic in the adult. In a specimen 262 mm. in total length all the lines immediately above the pectoral fins have already been formed as in the adult." (Jones, 1960). In specimens between 250 mm. and 300 mm. examined by me from Vizhingam the sides of the body are characterised with 5 to 7 longitudinal stripes along the upper half running horizontally. Below the stripes in the lower half of the body the interrupted bars are still evident. The tips of the second dorsal, dorsal finlets, anal and anal finlets are whitish. The interspinous membrane of D_1 is blackish throughout except for the narrow basal area between the first eight spines which is light dusky. The outer margin of the pectoral is also whitish while the pelvics are colourless. In formalin preserved specimens, dorsally the body is blackish while laterally it is dusky and ventrally yellowish brown, the last appearing in life more or less silvery. In adults according to Day (1878) " The upper half of the body with about eight broad, straight, blue lines passing backwards and a little upwards, silvery below the lateral line where, however, there are similar lines but very faint."

GENERAL VARIABILITY

The meristic counts for *S. orientalis* as recorded by various authors from different parts of the Indo-Pacific are given in Table VII. This shows the following meristic formula for the species :

D_1 XVII—XIX ; D_2 12—16 ; D_2 finlets 6—9 ; P_1 22—27 ; A. 12—16 ; A. finlets 5—9 ; gill-rakers 1 - 4+5—10.

The data are not comprehensive enough to draw attention to differences from area to area, except for material from Japan and Indian seas which shall be dealt with presently. Other differences of interest noticeable from the data given in the table are :

(1) Yabe *et al.* have given the second dorsal fin ray counts as 12—14 for juvenile specimens from Japan. The count of 12 is definitely on the lower side, and 14—16 appears to be the more frequent counts for this character for the species. However, 15—16 spines have also been recorded for adult specimens of *S.orientalis* from Japanese Sea.

(2) South African specimens of *S. orientalis* have been reported as having 6-9 dorsal finlets, the count of 6 being low when compared to the range of 7-9 for this character for the species.

(3) Likewise, in the case of the anal finlet counts, it is 5-7 for all areas except South Africa where a range of 6-9 has been reported. More data regarding the number of dorsal and anal finlets and their frequency of occurrence in samples from South African waters will be desirable.

(4) A range of 8—14 may be expected for the total gill raker counts. For the Indian specimens the counts include only those structures that can be elevated from the arch and not mere basal plates and protruberances which cannot be elevated from the arch. Differences in the methods of counting may account for some of the differences seen in the counts from the different areas. As seen for samples from Japanese and Indian seas, slight

differences in modal values may be expected. The counts given by Yabe *et al.* indicate the modal formula for juvenile specimens from Japan to be 4+8, as compared to specimens I have examined from Indian waters, the latter being 3+9. However, data for adult specimens from Japanese Sea given by Kishinouye (1923), namely 4+9, and by Godsil (1955), namely 2—3+1+8—9 show considerable overlapping in this character. For the Indian specimens examined, no difficulty was experienced in making separate counts of the upper and lower limbs of the outer gill arch, while some authors have used +1+ for a raker at the angle of the arch. Lack of uniformity in recording gill raker counts precludes any detailed comparisons at this stage.

TABLE VII

Meristic counts in *Sarda orientalis* from various parts of the Indo-Pacific

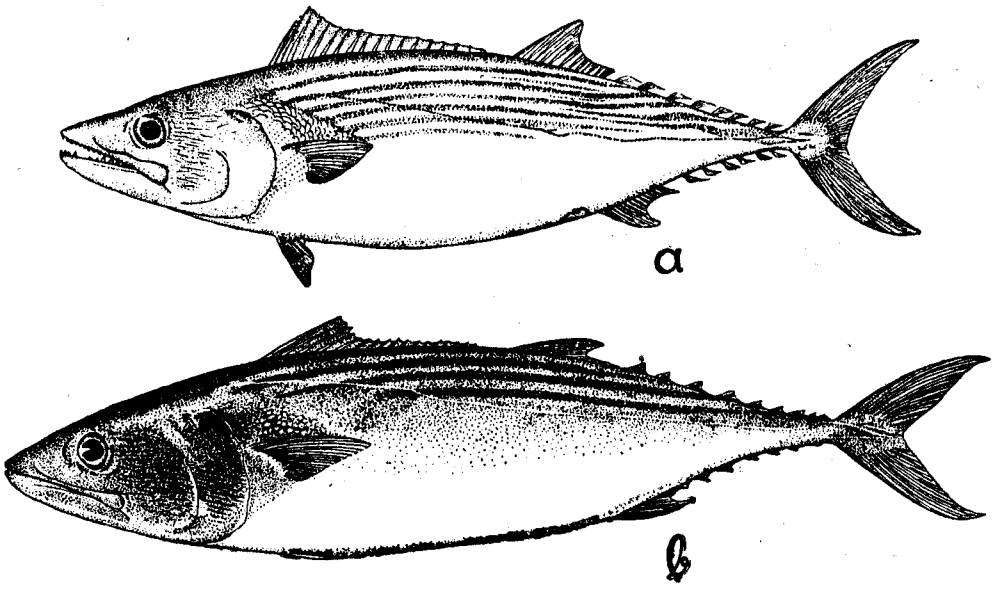
Author and area	D_1	D_2	D_2 finlets	P_1	A	A finlets	Gill rakers
A—Western Indian Ocean							
East coast of S. Africa :							
Barnard (1927) (*S. chilensis*) ...	XVIII	14–16	(6) 7–9	...	2, 10–12	6–9	...
Smith (1949 ; 1961) ...	XVII–XIX	14–16	6–9	...	2–3, 10–12	6–9	— + 8
Seychelles Plateau :							
Wheeler and Ommanney (1953) ...	...	...	8	...	...	7	...
B—Northern Indian Ocean							
Coast of India :							
Day (1878) ...	XVIII	3, 13	8	24	3, 12	6	...
S. W. coast of India :							
Silas (in this paper) ...	XVII–XIX	14–16	7–8 (exceptionally 9)	23–25	13–16	5–7	1—4+8—10 (= 9—14)
C—Eastern Indian Ocean							
W. Australia :							
Munro (1958) ...	XVII–XIX	15	7–8	22–27	15	5–6	2—4+7—9
D—Western Pacific							
Philippines :							
Warfel (1950) ...	XVIII–XIX	14–15	7–9	...	14–15	5–6	3+1+7—10 (= 11—14) Mode 4+9
E—North Western Pacific							
Japan :							
Kishinouye (1923) ...	XIX	15	7–8	...	15	5–6	4+9 (=13)
Yabe *et al.* (1953) ...	XVII–XIX	12–14	7–8	...	12–15	...	2—4+7—9 (=10—12)
Godsil (1955) ...	XVIII	15–16	8	...	15	6–7	2—3+1+8—9 (=11—13)
F—Eastern Pacific							
Meek and Hildebrand (1923) (*S. velox*) ...	XVIII	16	8	...	2, 12	7	— + 9
Godsil (1954) (*S. velox*) ...	XVII–XIX	15–16	7–9	...	14–16	6	2—3+1+5—8 (=8—11)
G—General							
Fraser-Brunner (1950) ...	XVIII (fig.)	...	7–8	...	...	5–6	3—4+7—9
Klawe (1961) ...	...	...	...	...	...	...	2—3+6—10

TABLE VIII

Range in gill raker counts in *S. orientalis* from Japanese and Indian seas

Area and author	Gill rakers													
	Upper limb				Lower limb				Total gill rakers					
	1	2	3	4	7	8	9	10	9	10	11	12	13	14
Japan :														
Yabe *et al.* (1953)	...	1	7	10	6	11	1	...	...	4	6	8	...	...
Godsil (1955) (+ 1 + raker at angle added to lower limb) ...	...	1	4	...	...	...	3	2	...	...	1	2	2	...
Total for Japanese Seas	...	2	11	10	6	11	4	2	...	4	7	10	2	...
India :														
Silas (in this paper)	4	9	25	4	...	6	30	6	1	5	9	19	7	1

(5) As in the case of *S. velox* (Figure 4b), available information on *S. o. serventyi* (Figure 4a) shows the very close relationship of the latter with the typical *S. orientalis.* Since our views regarding subspecies, races, populations, etc., of tunas and tuna-like fishes are still



Text Fig. 4. (*a*) *Sarda orientalis serventyi* Whitley (after Whitley 1947) ; (*b*) *Sarda velox* Meek and Hildebrand (after Meek and Hildebrand, 1923)

in a nebulous state, it may be desirable to refrain from recognising subspecies of *S. orientalis* at this stage. As could be seen from figure 6 showing the distribution of the genus *Sarda*, the known occurrences of *S. orientalis* does not show a continuous pattern. Observations on spawning areas as well as corroborative evidence based on the occurrence of larvae

and juveniles from three areas (S. W. coast of India; Japanese Sea ; and Eastern Pacific) tend to indicate the likelihood of independent populations occurring in the different areas. More information is needed about the occurrence of *S. orientalis* in the Atlantic as its records from the east coast of United States, (Block Is. Rhode Is. : Breder; 1932) and the West Coast of Africa (Gold Coast: Fraser-Brunner, 1950) are based on single specimens.

VARIATIONS IN GILL RAKER COUNTS WITH SIZE

Since gill raker counts in the genus *Sarda* appear to be a dependable character for use in species identification, it will be interesting to establish at what length they develop and at what length the final complement is attained. Out of 41 early and late juveniles from S. W. coast of India, the size and gill rakers of 18 are given along with data for 18 specimens from Japanese Sea given by Yabe *et al.* (1953). To indicate specific importance of this character as well as the fact that the final complement of the gill rakers is attained even at an early stage, comparable data for 14 specimens of *S. chilensis* given by Klawe (1961) are also included in Table IX.

ABNORMALITIES

Only two types of abnormalities, namely, the occasional absence of a finlet indicated by a wide gap between two successive finlets and the marked shortening of the pectoral fin were noticeable in over 45 specimens of *S. orientalis* examined from the S. W. coast of India.

TABLE IX

Size of specimens and No. of gill rakers in *S. orientalis* and *S. chilensis*

S. orientalis -				*S. chilensis*	
S.W. coast, India		Japan (after Yabe *et. al.*, 1953)		Peru, Chile (after Klawe, 1961)	
Size mm.	No. of gill rakers	Size mm.	No. of gill rakers	Size mm.	No. of gill rakers
80	3 + 9	76	4 + 8	34	7 + 1 + 15
156	3 + 9	144	4 + 7	36	7 + 1 + 15
165	4 + 9	147	3 + 9	37	4 + 1 + 16
175	3 + 9	147	3 + 8	39	5 + 1 + 14
178	3 + 9	156	4 + 7	41	7 + 1 + 15
183	3 + 10	185	4 + 7	44	7 + 1 + 16
184	3 + 9	200	3 + 8	70	7 + 1 + 18
188	3 + 9	215	4 + 8	89	7 + 1 + 17
194	2 + 9	216	4 + 8	94	9 + 1 + 16
198	1 + 9	219	4 + 8	106	7 + 1 + 15
199	2 + 9	220	4 + 8	111	8 + 1 + 17
212	3 + 9	235	3 + 7	128	9 + 1 + 17
242	3 + 9	240	2 + 8	129	7 + 1 + 15
257	3 + 9	243	3 + 8	135	7 + 1 + 15
266	2 + 8	245	3 + 7		
276	2 + 10	252	4 + 8		
285	2 + 9	252	3 + 7		
293	2 + 9	260	4 + 8		

KEY FOR THE IDENTIFICATION OF THE SPECIES OF THE GENUS *SARDA*

1*a*. XX-XXIV spines in the first dorsal; vertebrae 26-28+26-27 (=ca 53-54) (Atlantic).
... *Sarda sarda* (Bloch)

1*b*. XII-XIX spines in the first dorsal; vertebrae 22-25+20-22 (=ca 44-46).....2

2*a*. 12 or more gill rakers on lower limb of outer gill arch, gill raker formula being 6-10+12-19; length of maxillary less than 50% of head length.....3

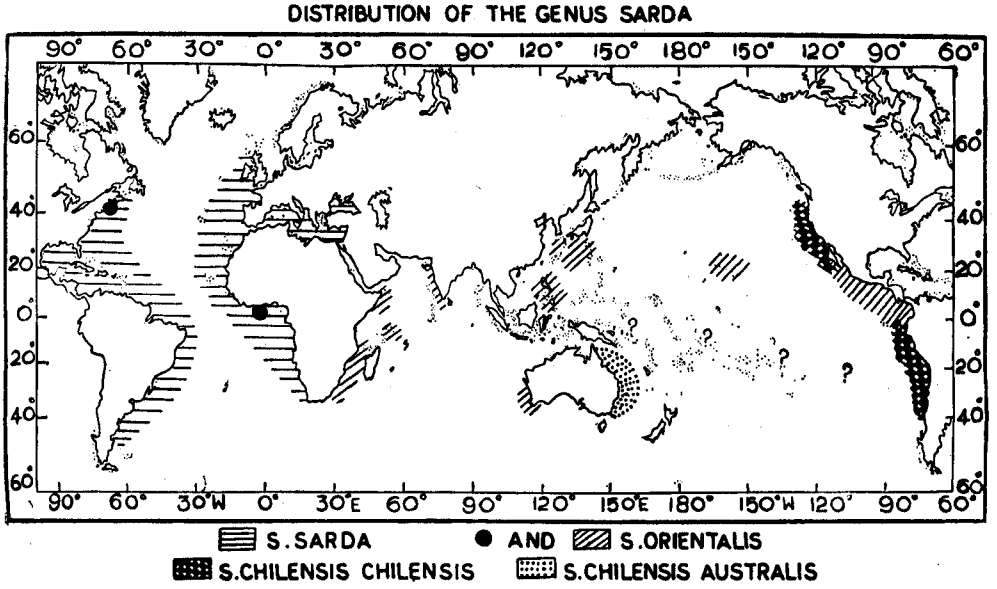
2*b*. Less than 12 gill rakers on lower limb of outer gill arch, gill raker formula being 1-4+5-10; length of maxillary distinctly more than 50% of head length (Indo-Pacific; Atlantic?).
... *Sarda orientalis*
(Temminck and Schlegel)

3*a*. Gill rakers in adults 7-10+15-19 (Eastern Pacific: California, Baja California, Peru, Chile).
... *Sarda chilensis chilensis*
(Cuvier)

3*b*. Gill rakers in adults 6-8+12-14 (Eastern Australia : Queensland, New South Wales, and Victoria).
... *Sarda chilensis australis*
(Macleay)

DISTRIBUTION OF *S.ORIENTALIS* IN RELATION TO ERVIRONMENT

As shown in figure 5, the spatial distribution of *S. orientalis* covers : the east coast of South Africa; Seychelles; Somalia and Gulf of Aden; West Coast of India; South West coast



Text Fig. 5. Map showing the geographical distribution of *Sarda orientalis* and related species and sub-species of the genus *Sarda* Cuvier.

of Australia; Philippines; Japan; Hawaii; Pacific coast of Central America and Galapagos Islands, besides two records from the Atlantic. It is interesting that in the Indian Ocean itself the species has not been reported from the British East African Coast, the Laccadive Sea, the Andaman Sea, Sunda Sea south of Java, etc. Eggs of *S. orientalis* have not been identified from the plankton from any area, neither is information available about the distribution of larvae from the Indian Ocean. Larvae suspected to be those of either *S.orientalis* or *S.chilensis* have been obtained from Baja California coast (Klawe, 1961). The collections of juveniles are also from areas of known distribution of adults of the species.

In this connection it may be mentioned that the temperature spectra for bonitos are given by Rosa and Leavastu (1961) as ranging between 12°C and 25°C, and by Kishinouye (1923) for *S. orientalis* as being between 13.5°C and 23°C. Available information also indicates that in the Indian Ocean the species is found in the northern hemisphere between 0°N and ca 20°N and in the southern hemisphere between 10°S and ca 37°S which indicates its presence in more temperate waters in the southern hemisphere in the Indian Ocean. In the Pacific, the pattern of distribution of the species is different in that it is conspicuously absent in the southern hemisphere east of the Philippine Archipelago, while in Japanese waters it may be found as far north as ca 40°N- lat. Interestingly enough in the Eastern Pacific it appears to have a restricted distribution along the coasts of Central America and Galapagos Islands, while its congener *S. chilensis chilensis* occurs along the California coast and further southwards from Galapagos to Chile.

No information is available about the vertical distribution of *S. orientalis*, nor is it known whether like some of the tunas (yellowfin, bigeye, etc.) it exhibits daily vertical migrations. In several areas its occurrence in coastal waters is sporadic and along the south west coast of India where there is a minor seasonal fishery for this species, nothing is known about its whereabouts in the offseason. In this area, fully mature adults appear from about May to September followed by the appearance of juveniles in the months of October-November. Slight fluctuations from year to year as to the months of occurrence may be seen. Similar conditions obtain for other areas also.

The temperature range for fishery of bonitos is given as 15°C to 22°C by Rosa and Leavastu (1961), but no optimum temperature range for fishery is known.

FOOD AND FEEDING HABITS

Only very scanty information is avilable about the food and feeding habits of *S. orientalis*. Jones (1960) remarks that the food of juvenile *S. orientalis* from Indian waters consists of larval and juvenile fish and crustaceans. Yabe *et al.* (1953) found the stomachs of 15 of the 18 juvenile specimens (83.3%) caught along the Southern Kyushyu coast (Aburatsu) to be empty. Two specimens were found to contain remains of *Engraulis japonicus*, while one was found to have unidentifiable fish remains.

For 24 specimens caught in set nets, pole and line fishing and trolling from three areas along the Southern Kyushyu coast Yokota *et al.* (1961) have calculated the "stomach contents weight index" (= SCW/BW x 100) as shown in Table X. (SCW=stomach contents weight; BW=body weight). Munro (1958) mentions "Feeds on pilchards, mackerel and mackerel scad."

TABLE X

"Stomach Contents Weight Index" for *S. orientalis* (after Yokota *et al.* 1961)

SCW Index	*Tanegashima* Set nets				*Tosa-Shimizu* Pole and line		*Kushimoto* Trolling		
	Date (Year–Month)								
	59–1	59–4	59–5	59–6	60–1	60–2	60–11	60–11	60–12
0.0	...	2	1	...	0	0	2	4	0
—0.5	2	...	...	1	3	1	3	1	1
1.0	...	...	...	...	...	...	...	...	1
1.5	1	...	...	...	...	...	...	...	...
2.0	...	...	...	...	...	...	...	...	...
2.5	...	...	...	...	...	...	...	...	...
3.0	...	...	...	...	..	...	...	...	...
3.5	...	...	...	...	...	...	...	...	...
4.0	...	...	...	...	...	...	...	...	...
4.5	...	1	...	...	...	...	...	...	...
5.0	...	...	...	...	...	...	...	...	...

The above meagre data would suggest that except in two specimens taken in set nets, the food present in the stomach (when present: by weight) was more or less the same for specimens taken in set nets, by pole and line and trolling.

Yokota *et al.* (1961) give the stomach contents of *S. orientalis* caught in pole and line fishing as shown in the following Table XI.

TABLE XI

Stomach Contents of *S. orientalis* caught in Pole and Line Fishing

Date	Fishing grounds	Nos.	Saury	*Sphyraena* sp.	Squid	Carangoid
1959–2	Satsunan ...	6	5	...	...	...
1960–10	Ashizuri ...	5	...	1	...	1
1960–11	Ashizuri ...	5	...	...	1	...

MATURITY AND SIZE

Along the South West Coast of India, between Trivandrum and Cape Comorin, juvenile and immature specimens are known to occur during the months of October-November. Maturing ovaries containing transparent ova were seen in specimens above 386 mm. at Vizhingam. Specimens collected during the months of August-September, 1960 and 1961 at Vizhingam measuring between 480 mm. and 605 mm. were in ripe running condition or had already spawned, some showing signs of recovering. However, the age of the investigated mature specimens is not known.

As regards size, large specimens caught in shore seines, drift nets, and hook and line off South West Coast of India are generally less than 700 mm. in length. However, the fish is said to attain a larger size as Smith (1949, 1961) mentions (under *S. chilensis* = *S.orientalis*) "Attains atleast 40 inches." According to Kishinouye (1923) *S. orientalis* "Grows to a length of about 80 cm. and to a weight of 1.5-3.0 kg." Munro (1958) mentions a weight of 8½ lb. for Western Australian specimens. Two mature specimens 490 mm. (male) and 497 mm. (female) in length caught at Vizhingam weighed 1.446 kg. and 1.716 kg. respectively. It may be exceptional to find specimens weighing over 5 kg. although Migdalski (1958) mentions "Supposedly, they run in weight up to 25 pounds."

FECUNDITY

Preliminary data on fecundity are summarised in Table XII. The fish is said to attain about a metre in length and the estimates given here are only for smaller sizes ranging from 386 mm. to 605 mm. A larger number of eggs may be expected in still larger specimens. The number of ova shed per spawning in two specimens in running ripe stage is estimated to be 0.08 and 0.15 million. The total number of ova produced during a spawning season is estimated to vary from 0.24 to 0.64 millions. Since the specimens were collected more towards the end of the spawning season it is felt that slightly higher estimates of ovarian eggs could be expected if estimates from running ripe ovaries at the beginning of the spawning season could be carried out.

The number of ovarian eggs per 1000 gm. of body weight was not found to differ much in two specimens measuring 386 mm. and 490 mm.

Plate II A—E, and text-figure 3d—f illustrate mature and ripe ovaries of *S. orientalis* collected at Vizhingam. The legend given under the figures are self-explanatory.

EGG STRUCTURE

Ripe ovarian egg is large, spherical and transparent, becoming slightly opaque when preserved in formalin. The ripe ova which had burst from the follicles and were lying loose in the lumen of the ovary were found to have a mean diameter of 1.3 mm. Most of the ripe ova taken as such were found to have a cluster of small oil globules at one of the poles, their numbers varying between 3 and 14 with an average of about 8 and ranging in diameter from 0.06 mm. to 0.23 mm. Several eggs had oil globules of same size as shown in Plate II, figs. G& H. Such large numbers of oil globules are indeed a very peculiar feature and quite contrary to the single oil globule present in the known eggs of other scombroids, except perhaps *Sarda sarda* where the fertilized eggs have been reported as having varying number of oil globules of different sizes (Sanzio, 1932 ; Vodianitski, 1936; Vodianitski and Kazanova, 1954 ; Padoa, 1956 ; and Demir and Demir, 1960). In the present case, however, as the eggs showing multiple oil globules are unfertilized, it is suspected that they may even represent a batch of unshed eggs retained over a longer period and probably in the earliest stage of degeneration. If so, the retention and eventual resorption of a large batch of eggs towards the end of the spawning season is interesting. This is all the more so, as only very few degenerate eggs were seen in recovering ovaries, and these eggs also show scattered oil globules of different sizes. An early ripe ovum in which the oil globules are not discernible (diameter 0,9 mm.) is shown in Plate II, fig. F.

TABLE XII

Counts of Ovarian Eggs in five mature specimens of *S. orientalis* from Vizhingam, S.W. Coast, India

Date of collection	13-9-1961	20-8-1960	8-9-1960	1-8-1960	25-8-1960
Total length (mm.) ...	386	490	...	545	605
Body weight (grams) ...	899	1446	...	...	...
Weight of ovaries (grams) ...	53.650	85.720	89.140	72.750	84.400
No. of countable ovarian eggs in gram of roe ...	4533	4525	5750	8900	4890
No. of eggs in ovaries (in thousands) (to be spawned in a season) ...	2432	3879	5126	6475	3980
No. of eggs per 1000 gms of body weight (in thousands)	2705	2682	..	..	...
No. of eggs of the most advanced mode in grams of roe	...	...	990	2131	160
No. of eggs of the most advanced mode in ovaries ...	...	...	88248	155030	13024
Remarks	Spent-recovering?	Maturing	Ripe running?	Ripe running?	Spawning (partially spent?)

SPAWNING SEASON AND SPAWNING FREQUENCY

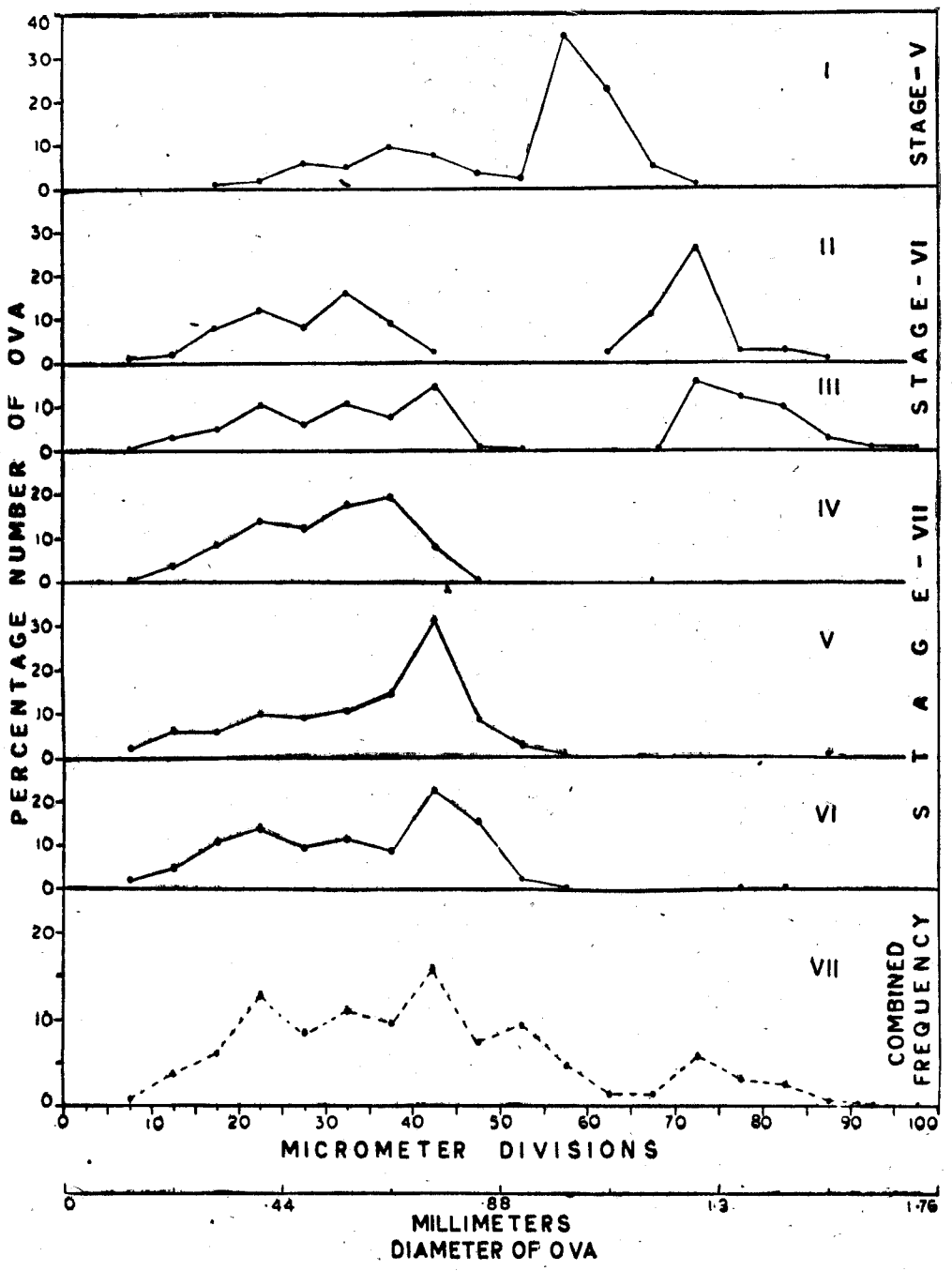
The definite duration of the spawning season is not yet fully known. Specimens in stages V and VI (mature and ripe running) conditions have been collected at Vizhingam during the months of July, August and September 1960 and 1961, suggesting that the spawning season could commence even earlier and last till about September. Practically nothing is known about the spawning season of this species in other areas.

The study of the ova diameter frequency polygons of ripe, spawning (or ripe running) and recovering ovaries indicates that in the most advanced stage (ripe—stage V) (figure 6, I) the most advanced mode containing ripe ova is the most prominent, while more than one mode is seen for the maturing ova. In the ripe running condition (Spawning—stage VI) (figure 6, II and III) the most advanced mode is seen to be completely separated from the maturing eggs which in turn show two or more modes. Three recovering ovaries (stage VII) (figure 6, IV, V and VI) in which there were indications of previous spawning by the presence of degenerate large eggs also show the most advanced mode as the most prominent one as seen in stage V (figure 6, I). The combined frequency (figure 6, VII) shows the most advanced mode containing the ripe ova to be well demarcated from the maturing batches, which in turn show several modes. If it were to be presumed that during a spawning season the ova over 5 microdivisions or about 0.11 mm. are to mature and spawn, it is clear that in *S. orientalis* all the ova do not ripen at one time, but as seen by the number of modes, mature in batches. Spawning season may be an extended one and the preliminary data suggest fractional spawning during a season.

The smallest specimen in the sample examined which had in the ovary a few large eggs, probably remnants of an earlier batch of eggs spawned was 386 mm. If subsequent observations were to corroborate this, then it is evident that the species in these waters becomes mature and is ready for spawning even before attaining 386 mm. The ripe running specimens examined were 49 cm. to 60,5 cm.

SPAWNING GROUNDS

The capture of females with ripe, ripe running and recovering ovaries along the South West Coast of India (Trivandrum to Cape Comorin) indicates that the sea off this coast is one



Text Fig. 6. Ova diameter frequency polygons of ripe, ripe running, and recovering ovaries (Stages V, VI and VII respectively) of *S. orientalis* from south west coast of India.

of the spawning grounds of this species. Larval collections are wanting, but the occurrence of early and late juveniles in this area during October-November months is interesting. No information is available for other areas in the Indian Ocean. In the Pacific, juveniles have been collected along the coasts of S. Japan, and larvae suspected to be that of *S. orientalis* have been collected off the Baja California Coast, suggesting the coastal waters of these areas to be likely spawning grounds.

BEHAVIOUR

Schools of adults and juveniles appear along the South West Coast of India from about June to December, the large schools of juveniles appearing especially in October-November when they enter bays and inshore areas and are caught in shore seines.

Kishinouye (1923) mentions that it " lives rather near the surface of the coastal waters, and sometimes makes large shoals." Tominaga's (1945) observations are in general agreement with that of Kishinouye's statement, but he mentions that in southern Japanese waters large and dense schools of *S. orientalis* are not met with and the fish is rarely seen at the surface. " They always swim around the reef or the seas near the cape where the current is strong, and never go out to the high seas ".

Both Kishinouye, as well as Tominaga mention that the fish bites eagerly on dead bait or artificial bait and hence is easily caught with trolling lines as well as occasionally in longlines.

The following observations by Migdalski (1958) may be of interest. He observes that " As in the Atlantic, these fishes make excellent strip bait....., and they also afford great sport to anglers working light tackle. They strike a lure or bait in full stride with such force that it surprises the angler. Often the bonitos will be attracted by a disturbance in the water. When a fish or two are hooked, you can bet that there is a school in the vicinity, and chumming in the area will provide more fish. Continuous chumming may hold the school for quite a while. Then the school may leave and flash back at varying intervals."

Localized south to northward movement in Japanese coastal waters is suspected (Tominaga, 1943). Yabe *et al.* (1953) report the capture of small numbers of juveniles around Aburatsu in the month of March while appreciable numbers of adults are caught in set nets from November onwards.

PARASITES

Juvenile and adult specimens caught at Vizhingam were invariably found to have a species of monogenetic trematode (*Capsala* sp.) on the gills, palate or inner wall of the operculum. Silas and Ummerkutty (1962) have recorded the parasitic copepods *Caligus bonito* Wilson (adults and chalimus stages), and *Parapetalus* sp. from the gills, buccal cavity and branchial arches of juvenile and adult specimens of *S. orientalis* collected at Vizhingam.

Shiino (1955) described a new genus and species of Caligoid copepod, *Alicaligus tripartitus* from *Sarda orientalis*.

Winter (1955) described a new species of monogenetic trematode, *Capsala caballerio* from *S. orientalis* from the pacific coast of Mexico.

RELATION OF POPULATION TO COMMUNITY AND ECOSYSTEM

The term 'neritic pelagic' may be applied to the habitat of *S. orientalis*. Within this relam, it may be said to belong to the surface and midwater community as most other scombroids. The area of occurrence of *S. orientalis* off South West Coast of India is an area of high biological productivity. In this area, the fishery for this species also coincides that for the little tunny *Euthynnus affinis affinis* (Cantor), the northern bluefin tuna or Indian longtailed tunny *Kishinoella tonggol*, and few other scombroids, especially *Auxis* spp., *Scomberomorus commerson* (Lacépède) *S. guttatus guttatus* (Bloch and Schneider) and *S. lineolatus* (Cuvier). Most of these species prey on smaller fishes and as such it is likely that a certain amount of competition for food may exist between these species in this area.

In Japanese waters *S.orientalis* is usually also caught in pole and line fishing while fishing for the skipjack *Katsuwonus pelamis* in coastal waters. Some competition for food between these two species may exist in this area.

Nothing is known as to whether inter-specific or intra-specific competition of any sort exists in the genus *Sarda*. In this context, the distribution of *S. orientalis* and *S.c.chilensis* in the Eastern Pacific along the Coast of America is interesting. It is highly doubtful whether the distributions of these two forms could be considered allopatric as a certain amount of mixing between *S.c.chilensis* from the California and Mexican coasts and peru, and Galapagos Is., could be expected although at present the patterns of distribution of these as well as *S. orientalis* appears exclusive in this area (Fig. 5). No such condition obtains for *S. orientalis* in the rest of the Indo-Pacific. Records of *S. orientalis* from the Atlantic are from areas from where *S. sarda* is also known (Fig. 5), but the data being meagre, no comments are permissible.

FISHERY

Fishing gear

Along the South West Coast of India, adult *S. orientalis* are usually caught in drift nets (gill nets) and rarely in shore seines. Juveniles are generally caught in shore seines and gill nets. The species has also been taken by trolling in Seychelles waters (Wheeler and Ommanney, 1953).

In Japanese waters adults and juveniles are caught in set nets and adults are also caught by trolling, in longlines and also by pole and line.

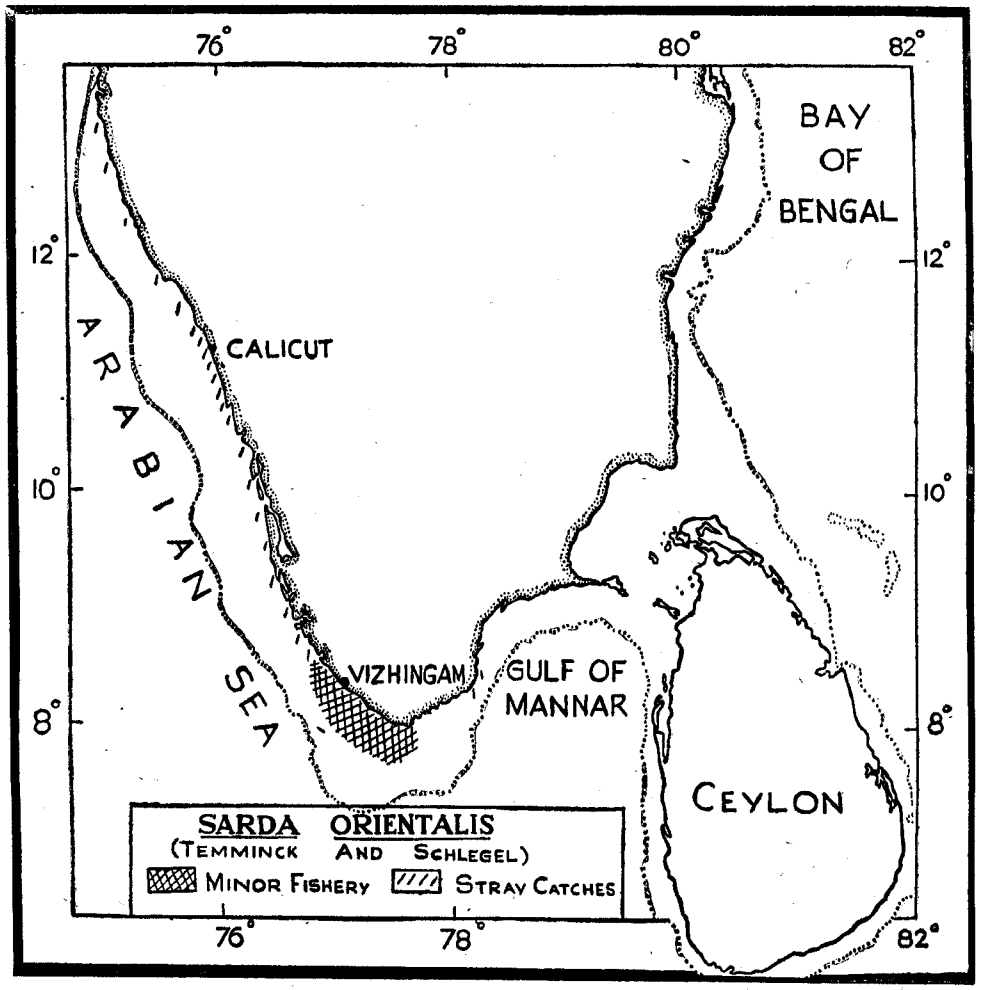
Warfel's work (1950) on the development of tuna industry in the Philippines indicates that most of the catch of *S. orientalis* at Batangas, Iloilo, and Zamboanga were taken in traps during 1948–'49. Two types of traps used for tuna capture one a

shallow trap set in not more than five fathoms and made almost entirely of bamboo and rattan and the second, a deeper trap set in about twenty fathoms and made of pilings of palm trees with bamboo matting are mentioned.

No special boats appear to be in use for fishing for the oriental bonito.

Fishing areas :

Fishing areas for the oriental bonito along the South West Coast of India is shown in figure 7. Rosa and Laevastu (1961) also indicate the regular occurrence of *S. orientalis* along the Somalia coast.



Text Fig. 7. Map showing the occurrence and fishing areas of *Sarda orientalis* along the south west and south east coasts of India.

It forms a minor fishery in certain areas in the Philppines as the data given by Warfel (1950) reproduced here in Table XIII would indicate.

TABLE XIII

Tunas landed at Three Philippine Markets 1948–49

(after Warfel, 1950)

(Most of these were taken by traps)

Scientific name	Number landed at		
	Batangas	Iloilo	Zamboanga
Neothunnus macropterus	3,617	14,056	975
Euthynnus yaito	9,462	48,768	7,490
Kishinoella tonggol	1,570	3,422	231
Katsuwonus pelamis	2,139	2,208	47
Sarda orientalis	269	2,308	6,762
Gymnosarda nuda	27	47	3
Parathunnus mebachi	None	None	18

In Japan also it forms a minor fishery along certain parts of the Kyushu coast where as already mentioned various types of gear are used for its capture.

Fishing seasons :

Along the South West Coast of India the available information points to the fishing season for adult *S. orientalis* to commence from about June and last till about September, although stray specimens may be caught during other months, especially March to June. Juveniles are caught mostly in October–November. It is likely that there may be changes in the duration of the fishing season from year to year. Often during a whole year, good fishing may be restricted to the duration of a fortnight only.

Information is not available about other areas except Japan where the fishing for the oriental bonito may be sporadic or regular throughout the year. When normal, usually more catches result along the West Coast of Southern Kyushu during spring and early summer and along the east coast during summer and autumn months.

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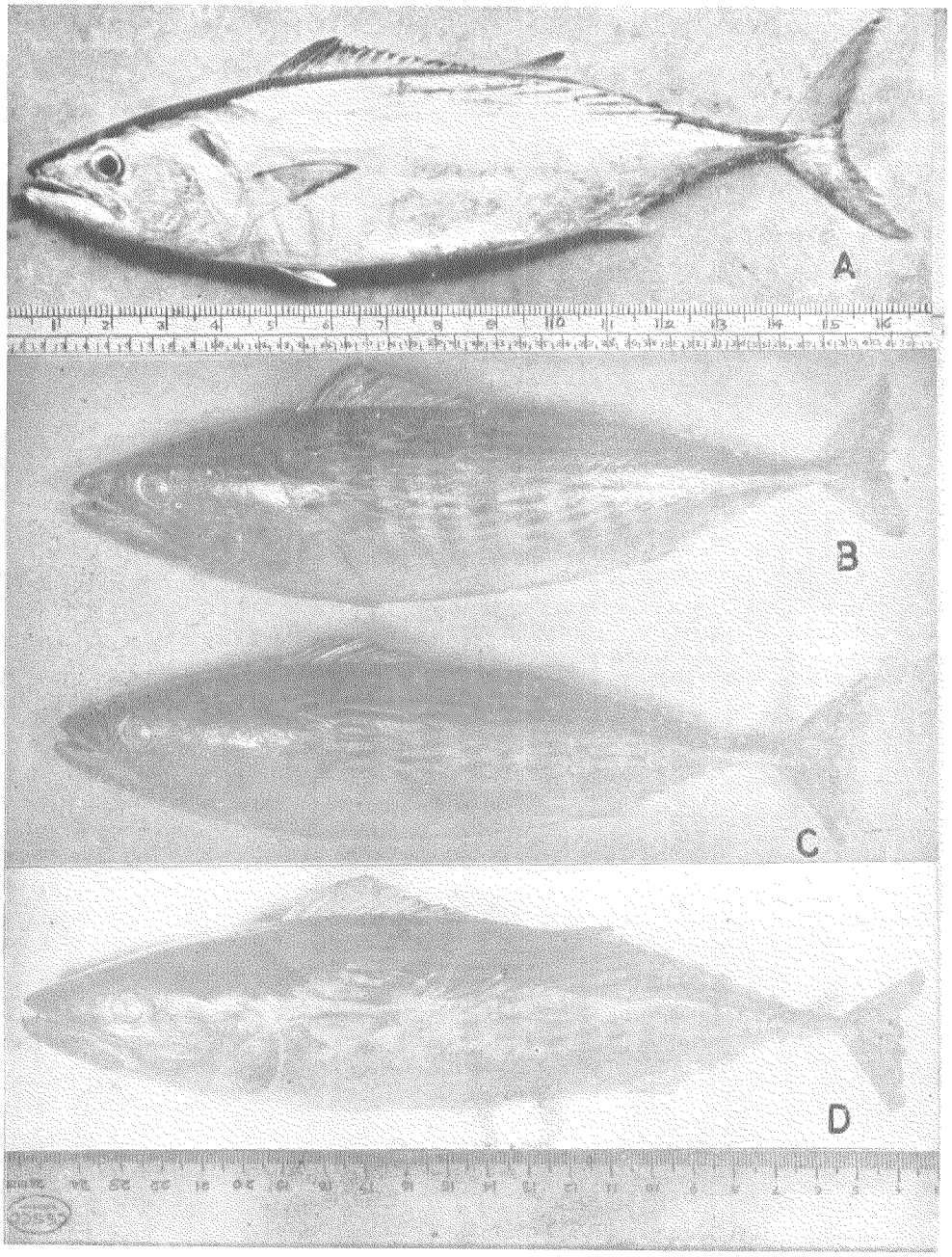
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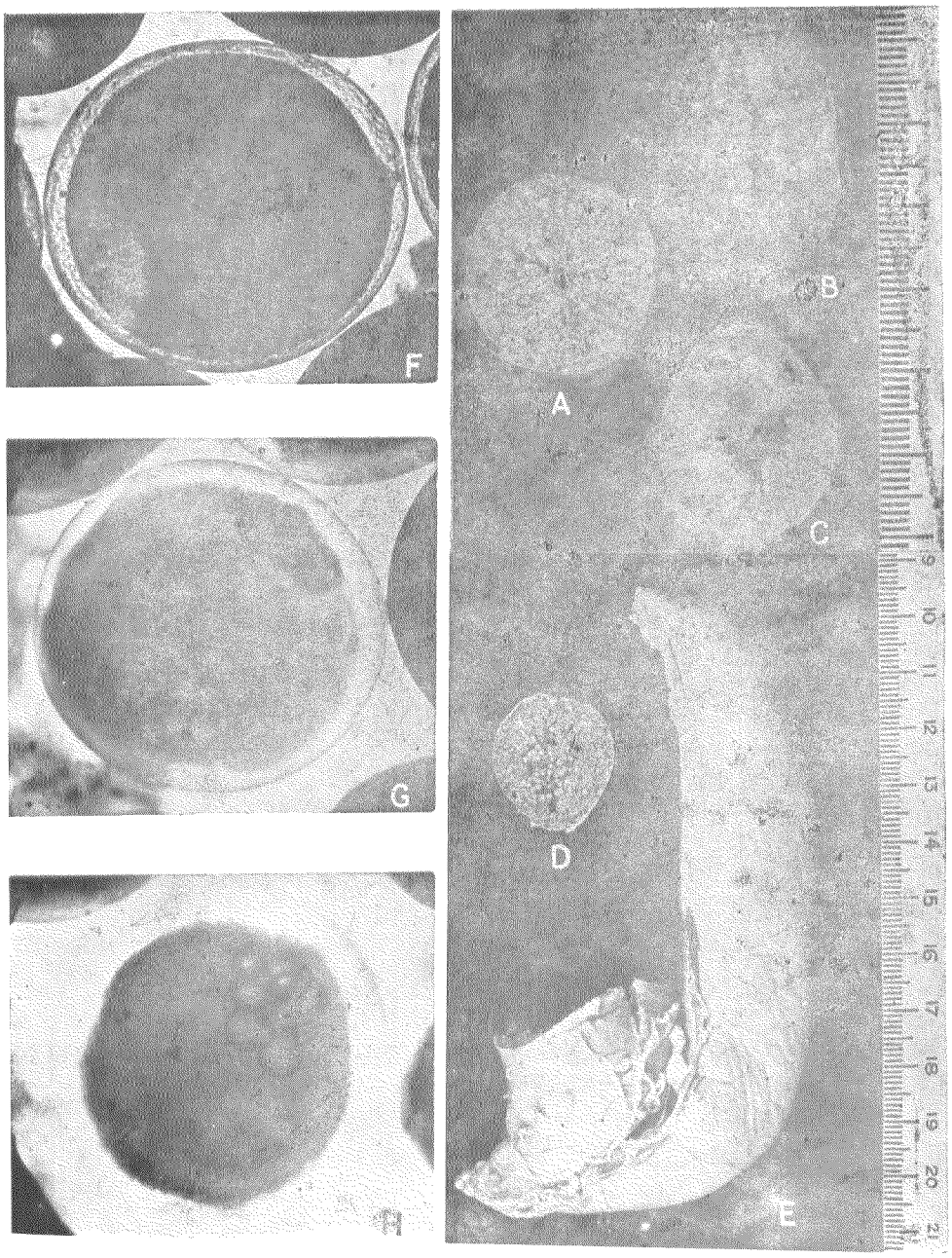
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Sarda orientalis (T. & S.) A. Lateral view of specimen 386 mm. from Vizhingam ; B–D. Lateral views of juveniles 195, 198 and 212 mm. respectively showing variations in colour pattern of body.



Sarda orientalis (T. & S.). A and B. Cross sections of ovaries of specimens 386 mm. and 490 mm., respectively showing distribution of larger transparent ova throughout ovary and also the formation of the central lumen into which the ripe eggs migrate (Stage VI). C. Cross section of ovary of specimen 605 mm. showing central lumen from which ripe transparent ova have been removed. D. same—prior to removal of ripe ova. E. ovary of same specimen—part of right ovary removed for showing cross sections C and D. F. ovum with diameter of 0.9 mm. (stage V). G and H. ripe ova, diameter 1.3 mm. lying loose in the lumen of the ovary showing cluster of oil globules (each about 0.15 mm. in diameter) at one pole.

CYBIUM CROOCKEWITII BLEEKER (1850) AND *C.KOREANUM* KISHINOUYE (1915) CONSIDERED SYNONYMS OF *SCOMBEROMORUS GUTTATUS* (BLOCH AND SCHNEIDER) WITH A REDESCRIPTION AND ANNOTATED BIBLIOGRAPHY OF *S.GUTTATUS**

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INTRODUCTION

In a recent review on fishes of the subfamily Scomberomorinae from Indian seas, Jones and Silas (1961) recorded three species of spanish mackerels or seerfishes, namely, *Scomberomorus commerson* (Lacépède), *S. guttatus* (Bloch and Schneider), and *S. lineolatus* (Cuvier). Two other nominal species, *Cybium kuhlii* Cuvier and *C. interruptum* Cuvier recognised by Day (1878, 1889) and other ichthyologists are now considered synonyms of *S. guttatus* (by de Beaufort, 1951 ; Jones and Silas, 1961), and *S. lineolatus* (by Williams, 1960; Jones and Silas, 1961) respectively.

The examination of several adult and juvenile specimens of *S. guttatus* from various localities along the Indian coast as well as a perusal of the literature dealing with this species has drawn attention to the need for a proper scrutiny of its taxonomy, systematic position, and a redescription. The last said given here based on Indian material may be considered more typical for *S. guttatus* which was first described from Tranquebar on the South East Coast of India, south of Madras. Comparisons of *S. guttatus* with other species of the genus from Indian waters are given along with an annotated bibliography and a subject index at the end.

HISTORICAL RESUME

The original description of *Scomber guttatus* as given by Bloch and Schneider, (1801) is brief and reads as follows :

> "...Sc corpora oblongo, alepidoto, capite acuminato, guttis nigris circa lineam lateralem dorso vicinam, maxilla inferiore longiore, carina caudali, cauda attenuata, pinnulis 8 supra, 7 infra.
>
> B 7, P 18. V 6. A 20. 7. C. 22. D 15/15. 19.8
>
> Habitat ad Tranquebarium pelagicus inter faxa; noctua Januario. Usque ad Martium ad fummum emergeus capitur, 3½ pedes longus; Tamulice *Wantsaran* audit.
>
> Comparatis exemplis donobus ficeis vercor he piscis idem fit cum regali plumeril pictura descripto. In linea laterali in regione pinnae analis deflexa et undulata usque ad candam squamas reliquas vidi parvas; dentes conici maxillam superiorem totam usque ad commissuram ossis labialis occupant."

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The body colouration, the number of dorsal and anal finlets, and the number of dorsal spines (XV) are characteristic.

Russell (1803) defined the *Wingeram* (*Scomber Wingeram*) as:

"Scomber pinnulis octo, seu novum; cauda falcata; corpore lanceolata, alepidoto, maculis ovalibus; eminentia membranacea longitudinalis, as finan lineae lateralis." ('The Scomber with eight or nine pinnulae; the body lanceolate, without scales, and with oval spots; a longitudinal membraneous protuberance at the end of the lateral line.').

Other salient characters given in the description of *Wingeram* are:

"Head small, ovate, sharp, smooth, the front very gently declivous, somewhat flattened.....teeth numerous, close, regular, conical, somewhat larger in the under than in the upper jaw.....lateral line supreme, gently arched to the beginning of the pinnule, then straight to the middle of the caudal fin, carinate to near the end...two dorsal fins.....first spinous consisting of 15 or 16 spines, of which the last six (connected by a very tender membrane lying in a groove) may easily escape notice if not raised.....the pinnae superiae vary from eight to nine..... the anal pinnulae vary from seven to eight.....The *colour*. The upper part of the head a changeable dark green and blue, the ridge of the back of the same colour, but changes to a polish leaden, which, from the lateral line growing gradually lighter, terminates on the belly in a bluish white. Above, but parallel to the line, a row of small round spots, nearly black; and on the sides are several similar spots. The fins are darkish, the ventral and anal excepted which are with the same colour with the belly."

The above description as well as the accompanying figure (Plate I, fig. A) clearly show that Russell's *Wingeram* and *Scomber guttatus* described by Bloch and Schneider, are identical. Shaw's (1803) description of *Scomber leopardus* is based on the *Wingeram* of Russell and consequently becomes a synonym of *S. guttatus*.

De Beaufort (1951) has clearly shown that *Cybium kuhlii* Cuvier is a synonym of *S. guttatus*. Herein it should be mentioned that Munro (1943) proposed a new subgenus *Pseudosawara* with *Cybium kuhlii* as the genotype and characterised the subgenus as :

"A new subgenus is necessary for reception of two species possessing another type of lateral line branching. This is not true ramification but a branching effect produced by the continuation backwards of the area of minutely furrowed skin caused by presence of tracts of cutaneous mucous canals. Such areas are seen on the posterodorsal region of the head of all species of *Scomberomorus*. In the subgenus *Pseudosawara* such canals are branched together along both sides of the lateral line as well as on the head. They all point outwards and backwards and are densest towards the anterior part of the lateral line."

Unfortunately Munro's (1943) selection of the subgenotype (=*C.kuhlii*) for *Pseudosawara* was inopportune as it is a synonym of *S. guttatus* which in turn Munro placed along with *S.lineolatus* (Cuvier) (Syn. *Cybium interruptum* Cuvier) and *S. semifasciatus* (Macleay) (Syn. *Cybium tigris* De Vis) under another new subgenus *Indocybium* (Subgenotype: *Cybium*

semifasciatum Macleay). Consequently, *Pseudosawara* becomes a synonym of *Indocybium*. In case subgenera of *Scomberomorus* are to be recognised, the species thus grouped under *Indocybium* may form a composite lot. Eventually a new name may have to be proposed for species showing the diagnostic characters mentioned for *Pseudosawara*. However, such action should await a detailed revision of the spanish mackerels on a global basis. The nature of the lateral line for *Pseudosawara* given by Munro appears to be a dependable character and among the Indian species of *Scomberomorus*, is seen only in *S. guttatus*. *Cybium koreanum* Kishinouye also shows this type of branching of the lateral line. Interestingly enough the species which possess such pseudobranching of the lateral line also appear to have the following characteristics:

(1) A relatively stumpy head with the dorsal profile slightly decliveous, making the occipital crest appear high.

(2) Relatively deeper body — depth greatest at origin of second dorsal.

(3) Larger second dorsal and anal fins.

(4) Prominently falcate caudal lobes.

(5) Colour pattern on body consisting of ovate or rounded dark spots along sides.

(6) Total number of gill rakers and vertebrae 9–13 and 46–51 respectively.

Regarding variations in vertebral counts in *S. guttatus*, Jones and Silas (1961) remark that: "Munro (1943) gives the vertebral count of this species as 20+26=46, while specimens we have examined from Tuticorin and Vizhingam coasts show a total number of 48 or 49 vertebrae. Kishinouye (1923) mentions 51 as the count for *Cybium guttatum* from Formosan waters. Thus it would appear that of the three Indian species of *Scomberomorus*, the range of variation of vertebral counts is greatest in *S. guttatus*. The significance of this is not apparent as stray observations hitherto made do not lead to any conclusions except draw attention to the likelihood of there being geographical races or distinct populations in different geographical locations along the range of distribution of this species." Available data indicate that *S. guttatus* has a fairly wide spread distribution in the Indo-Pacific, second only to that of *S. commerson*.

It should be mentioned here that de Beaufort's (1951) statement regarding the nature of the lateral line in *S. guttatus* is partly correct. According to him "I do not think that this structure is of any use even to distinguish species" as he found this character to be present "not only in specimens of *kuhli* in the Leiden Museum, but in many specimens of *guttatus* as well, especially in the larger ones and other species." *C. kuhli* is a synonym of *S. guttatus* as already mentioned. The last part of the above statement, namely, "and other species," will certainly not include *S.commerson*, *S. lineolatus* etc. On the other hand, as recognised by Munro (1943) such branching of the lateral line occurs only in *S. koreanus* (Kishinouye), which as shall presently be shown may be considered a subspecies of *S. guttatus*.

CYBIUM CROOCKEWITII BLEEKER, A SYNONYM OF *S.GUTTATUS* (BLOCH AND SCHNEIDER)

The nominal species *Cybium croockewitii* Bleeker (1850) Plate I, fig. D was tentatively recognised by de Beaufort (1951). In doing so, he drew attention to the considerable similarities between *C.croockewitii* [= *Scomberomorus croockewitii* (Bleeker)] and *S. guttatus* with the remarks that "I am therefore not sure that *S. croockewitii* is a good species." Munro (1943) while recognising *S.crookewitii* did not assign it to any one of the nine subgenera of *Scomberomorus* he dealt with. The figure and redescription of *S. croockewitii*

given by de Beaufort (1951) indicate that the species possesses the following salient characters :

(1) The depth of the body is greater than the length of the head, the ratios being 4.7 and 4.3, and 6.1 and 5.6 in length with and without caudal respectively.

(2) Gill rakers 2+8—10.

(3) Origin of second dorsal midway between base of upper caudal rays and of tip of snout.

(4) Second dorsal and anal relatively large and slightly falcate.

(5) Lateral line almost straight to below anterior dorsal finlets, gently bent downwards here and continued along the middle of the caudal peduncle to the peduncular keel.

(6) Pectoral about as long as head without snout.

(7) Fin ray counts: Günther (1860) remarks that " The frequent typographical errors in Dr. Bleeker's papers are sometimes very annoying. In this instance both accounts quoted (Bleeker, *Nat. Tydschr. Ned. Ind.*, 1850, i, p. 161 and *Verh. Bat. Gen.*, 24, Makr. p. 37.) give the formula of the fins that is quiet impossible in a fish of the genus, *viz.*, :— D 15 $\frac{7}{17}$ VII. A. $\frac{6}{28}$ VII., and D. 15 $\frac{7}{17}$ VII. A. $\frac{6}{18}$ VII." de Beaufort (1951) who re-examined the type specimen gives the following fin formulae for *S.croockewitii* : D_1. 15 ; D_2. 7. 17 + 7 ; A. 3. 17 + 7 ; P_1. 2. 18; V. 1. 5.

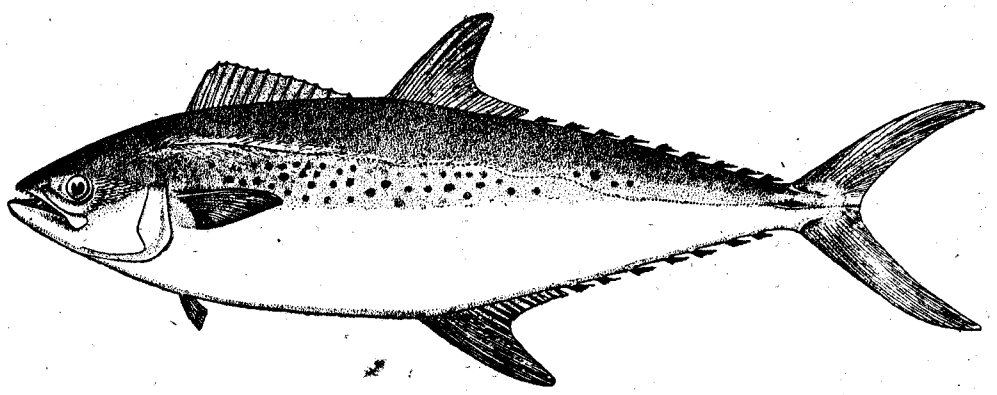
(8) "Colour of the preserved specimen brownish above, silvery below. All fins light or dusky. According to Bleeker a broad black band from dorsal to anal, sides with dark diffuse blotches, first dorsal totally black." (de Beaufort).

No mention is made by Bleeker or subsequent authors regarding the nature of the lateral line and its branching if any. Barring this and the colour characteristics given above under item 8, the characters fully agree with that for *S. guttatus*, as will be seen from the redescription of the latter given latter on. Bleeker's figure of *croockewitii* reproduced by de Beaufort (1951) shows clearly the broad vertical stripe between bases of second dorsal and anal, while de Beaufort found both the preserved specimens "... uniform, without any trace of black vertical band mentioned by Bleeker." I have invariably found all specimens of *Scomberomorus* caught along the Indian coast in drift nets (gill nets) show a distinct vertical broad band as shown in the photograph of *S. guttatus* on plate I, fig. E. caught similarly at Tuticorin, Gulf of Mannar. Such discolouration due to friction of the skin with the strands of the net are very conspicuous in *S. guttatus* below about 500 mm. taken by such gear, and the colour in the form of a broad vertical band generally broader dorsally below or partly in front of second dorsal and narrower towards anal persists even on preservation. Wang's specimen of *S. guttatus* from the China coast, the figure of which is reproduced here (plate I, fig. C.) also shows such a faint vertical marking below second dorsal, and apparently was also captured in a gill net. The vertical dark band of *croockewitii* could have been caused under similar circumstances and I have no hesitation in considering it as an artefact. The dark diffuse blotches on the sides of the body of *croockewitii* mentioned by Bleeker are characteristic of *S. guttatus* though the type specimens at present do not show these, perhaps on account of being in preservative for a long time.

Although information regarding the nature of the lateral line in *croockewitii* is wanting, on account of its similarities in other characters to *S. guttatus* there can be no doubt that it is a synonym of the latter.

CYBIUM KOREANUM KISHINOUYE 1915, A SYNONYM OF *S. GUTTATUS* (BLOCH AND SCHNEIDER)

The comparison of the diagnostic characters of *S. guttatus* and *C. koreanum* (*Scomberomorus koreanus* (Text-fig. 1) shows considerable similarities between the two except in minor details. *S. koreanus* is not so well-known as *S. guttatus* and it may be stated that



Text Fig. 1.—*Cybium koreanum* Kishinouye (after Kishinouye, 1923).

examination of more material of the former for morphometric and meristic characters may show still overlap in characters with the latter. I do not agree with Fraser-Brunner (1950) in considering *C. koreanum* a synonym of *S. semifasciatus*. The unbranched lateral line; the low vertebral count of 44–45 vertebrae; the broad caudal peduncular keels; the dorsal and anal finlets ranging from 8 to 10, with the mode for both being 9; and the colouration, especially the sides of the body having twelve to twenty broad vertical bands of dark grey in *S. semifasciatus* easily separate it from *S. koreanus*, the salient characters of which are discussed below, in comparison with those of *S. guttatus*.

(1) Lateral line: In both *S. guttatus* and *S. koreanus* the lateral line shows the peculiar branching caused by cutaneous mucous canals running backward, being densest towards the anterior part. The lateral line in both is not strongly curved in any part along its course, but may slightly undulate in its posterior one-third.

(2) Vertebrae: *S. koreanus* is said to have 20 + 26 = 46 vertebrae (Kishinouye 1923) while Munro (1943) gives the count for *S. guttatus* as 20 + 26 = 46, and for *S. kuhlii* as 21 + 30 = 51. Kishinouye (1923) gives 21 + 30 = 51 as the count for *S. guttatus* from Japanese waters. As already mentioned, specimens of *S. guttatus* examined by Jones and Silas (1961) show 48 or 49 vertebrae. It is not known as to whether the vertebral count is a constant 46 in *S. koreanus*. Even so, it falls within the known range for *S. guttatus*.

(3) Number of dorsal spines : For the genus *Scomberomorus*, Munro (1943) has shown that the number of dorsal spines may vary from XII to XXII. In *S. koreanus* a count of XIV is recorded, while XV to XVII appears to be the range for *S. guttatus*. Most of the well studied species of *Scomberomorus* from the Indo-Pacific show variations from one to three spines in the dorsal count and consequently it is likely that in *S. koreanus* also variations may be expected in this character. However, if the count of XIV is found to be constant or if the variation is on the lower side, the difference in this character between *S. koreanus* and *S. guttatus* will be of some importance.

(4) Number of dorsal and anal finlets: Kishinouye (1923) gives the dorsal and anal finlet counts for *S. koreanus* as 9 and 7 respectively. However, on plate 21, fig. 35 of *S. koreanus* (= *C. koreanum*) (reproduced here as text-figure 1) and also in the original description (Kishinouye, 1915) 9 dorsal and 8 anal finlets are indicated. Munro (1943) gives the dorsal and anal finlets for *S. guttatus* as 8–9/8–10; *S. kuhlii* as 8–9/7–9; *S. crookewitii* as 7/7; and *S. koreanus* as 9/7. For the Indian specimens of *S. guttatus* I have examined, the number of dorsal and anal finlets are 7–9/7–9 respectively, with the mode at 8/8. The degree of variability of this character in *S. koreanus* is not known, but the recorded counts of 9 dorsal and 7 or 8 anal finlets are well covered by the known range for *S. guttatus* (Tables I-A and I-B).

(5) Number of gill-rakers: The gill raker count for *S. koreanus* is given by Kishinouye (1923) as 3 + 10. Munro (1943) has given the gill raker counts for *S. guttatus* and *S. kuhlii* as 2 + 9, and 2–3 + 8–9 respectively. For adults of the Indian specimens of *S. guttatus* I have examined (Tables II and III) the counts are 1–4 + 7–10, the most frequent counts being 2 + 9 = 11. It is likely that differences in the modal formulae may exist from area to area, but the known counts for *S. koreanus* falls within the known range for *S. guttatus*.

(6) Body proportions: Kishinouye (1915, 1923) has not given any details regarding body proportions in *S. koreanus*, except mention that the length of the head is shorter than the greatest depth of the body. This also appears to be the general rule for all specimens of *S.guttatus* that I have examined from Indian waters. The figures of *C. koreanum* and *C.guttatum* given by Kishinouye (1923: pl. 21, fig. 35, and pl. 34, fig. 61 respectively) indicate that the former has a much more deeper body (about 3.8 in fork length versus about 5.5 in figure of the latter species). In specimens of *S. guttatus* from Indian waters I find the ratio of depth of body in fork length to vary from about 4.2 to 5.

(7) Body colouration: In *S. koreanus* according to Kishinouye (1923) "the back is greyish blue, and the belly silvery. There are three or more longitudinal rows of small greyish spots along the lateral median line..." Kishinouye's figure of *C. koreanum* (pl. 21, fig. 35) shows clearly four rows of spots just behind the pectoral. There is hardly any difference in the colour pattern on the sides of the body of *S. guttatus*, except that exceptionally as many as eight rows of rounded or oval dark spots may be present on either side.

(8) Additional characters : There is no difference in the nature of the dentition in both the species. The air-bladder is also wanting in them.

From what is known it is clear that the similarities between *S. guttatus* and *S. koreanus* are considerable. When a good series of *S. koreanus* is examined it is likely that more overlap in the various characters discussed above may be seen. In view of what has been said, it will be desirable to consider *S. koreanus* as a subspecies of *S. guttatus* namely, *Scomberomorus guttatus koreanus* (Kishinouye), than treat it as its synonym, a course which is adopted here.

SCOMBEROMORUS GUTTATUS FROM WESTERN INDIAN OCEAN

Some confusion exists as to the status of the spotted spanish mackerel from the Western Indian Ocean. Williams (1960) opined that Smith (1949) and Fourmanoir (1957) erroneously used the name *Scomberomorus leopardus* (Shaw) for the species *S. lineolatus* (Cuvier). According to him, *S. guttatus* did not occur along the British East African coast. A careful study of the descriptions of the spanish mackerels from South African waters Western Indian Ocean) and Madagascar indicates that *S. guttatus* or a form closely allied to

TABLE I–A

Number of dorsal and anal finlets in species of *Scomberomorus* (adults) from Indian Seas (all localities combined)

Species	No. of specimens	Finlets											
		Dorsal						Anal					
		7 (= 6 + 1 or 7)	8 (= 7 + 1 or 8)	9 (= 8 + 1 or 9)	10 (= 9 + 1 or 10)	11 (= 10 + 1 or 11)	Mean	7 (= 6 + 1 or 7)	8 (= 7 + 1 or 8)	9 (= 8 + 1 or 9)	10 (= 9 + 1 or 10)	11 (= 10 + 1 or 11)	Mean
S. commerson (Lacépède)	7	– + –	– + –	1 + –	4 + –	2 + –	10.14	– + –	– + –	– + 1	6 + –	– + –	9.85
S. lineolatus (Cuvier)	18	– + –	– + 3	9 + 3	3 + –	– + –	9.00	– + –	– + –	10 + 3	2 + 1	1 + 1	9.38
S. guttatus guttatus (Bloch and Schneider)	40	– + 1	6 + 24	8 + 1	– + –	– + –	8.2	1 + 3	14 + 18	4 + –	– + –	– + –	8.00

The finlets are counted from the base of the caudal forwards. Thus in some specimens the last finlet nearest the second dorsal or anal fin may appear to be united with the fin presenting difficulty in making accurate counts. In order to avoid confusion, during collection of data, such conditions have been recorded as 6 + 1, 7 + 1, etc. and cases where the last finlet was distinct as 6, 7 etc. For the purpose of calculating 'mean' 6 + 1 and 7 have been considered as 7 and so on. However, in the table the frequency is indicated separately for convenience (*e.g.*, in *S. lineolatus* 9 dorsal finlets were seen in 12 specimens as follows : 8 + 1 in 9 specimens and 9 in 3 specimens respectively).

TABLE I–B

Frequency of occurrence of dorsal and anal finlets in species of *Scomberomorus* from Indian seas (all localities combined)

No. of dorsal/anal finlets	*S. commerson*		*S. lineolatus*		*S. guttatus guttatus*	
	No. of specimens	Per cent	No. of specimens	Per cent	No. of specimens	Per cent
7/7	...	...	...	...	1	2.43
8/7	...	...	...	...	3	7.31
8/8	...	...	...	...	24	58.53
8/9	...	...	2	11.11	3	7.31
8/10	...	...	1	5.55	...	...
9/8	...	...	...	...	9	21.95
9/9	...	...	10	55.55	1	2.43
9/10	1	14.28	1	5.55	...	...
9/11	...	...	1	5.55	...	...
10/9	1	14.28	1	5.55	...	...
10/10	3	42.85	1	5.55	...	...
10/11	...	...	1	5.55	...	...
11/10	2	28.57	...	...	...	...

TABLE II

Gill raker counts in adults and juveniles of species of *Scomberomorus* from Indian seas

Species and localities	No. of specimens	Gill rakers																												
		Upper limb					Lower limb												Total counts												
		0	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	13	14
S. commerson (Lac.)																																
Ratnagiri ...	2	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...
Malwan ...	3	...	...	2	1	...	...	...	...	1	2	...	...	...	...	...	...	...		...	...	...	2	...	1	...	...	...	...	...	...
Malpe ...	2	...	...	2	...	...	...	...	...	2	...	...	..	..	..	...	...	...		...	...	...	2	...	...	...	...	...	...	...	...
Vizhingam (juveniles—after Jones 1961) ...	12	5	7	...	...	...	...	1	6	5	...	...	...	...	...	...	...	...	1	4	2	5	...	...	...	...	...	...	...	...	...
Tuticorin ...	24	...	6	18	...	...	...	...	8	13	2	1	...	...	...	...	...	...		...	5	5	11	3	...	...	...	...	...	...	...
Rameswaram ...	1	...	1	...	...	...	...	...	...	1	...	..	..	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...
S. lineolatus (Cuvier)																																
Tuticorin ...	35	...	...	17	15	3	...	...	...	...	...	...	4	17	10	3	1	...		...	...	...	...	...	...	...	...	10	16	8	..	1
Rameswaram ..	4	...	...	4	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...
S. guttatus guttatus (Bloch and Schneider)																																
Veraval ...	1	...	...	1	...	...	...	...	...	...	...	...	..	..	...	1	...	...	..	..	..	...	...	...	...	...	...	...	...	1	...	...
Ratnagiri ...	2	...	...	...	2	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	..	..	..	..	..	..	1	1	...	...
Vizhingam (Juveniles—after Jones 1961) ...	10	3	3	2	2	...	...	...	1	2	5	...	1	1	...	...	...	...	..	..	1	1	2	2	2	...	...	1	1	...	...	...
Tuticorin ...	23	...	1	11	10	1	...	...	...	...	...	...	3	6	12	2	...	...	...	...	...	...	...	...	...	...	1	5	9	8	...	...
Rameswaram ...	21	...	5	15	1	...	...	...	..	...	...	...	1	4	12	4		...	...	...	...	...	...	...	..	1	...	6	11	3	...	...
Waltair (Juveniles—after Jones 1961) ...	5	...	1	4	...	...	...	...	...	1	1	2	1	...	...	...	...	...	...	...	...	...	1	...	1	2	1	...	...	...	...	...

TABLE III

Gill raker counts in species of *Scomberomorus* (adults) from Indian seas (all localities combined)

Species	No. of specimens	Gill rakers																									
		Upper limb					Lower limb										Total counts											
		1	2	3	4	Mean	3	4	5	6	7	8	9	10	11	Mean	4	5	6	7	8	9	10	11	12	13	14	Mean
1. *Scomberomorus commerson* (Lacépède)	32	9	23	...	...	1.72	9	18	4	1	...	...	...	...	...	3.90	6	5	16	3	1		...	...	...	...	...	5.75
2. *Scomberomorus lineolatus* (Cuvier)	39	...	21	15	3	2.53	...	...	...	...	4	17	12	5	1	8.53	...	...	...	...	...	...	10	18	10	—		111.07
3. *Scomberomorus guttatus guttatus* (Bloch and Schneider)	47	6	27	13	1	2.19	...	...	...	4	11	25	7	...		8.74	...	...	...	...	1	1	11	21	13	...	...	10.93

that does in fact occur in those waters. The available data on this may be summarised as follows:

Fowler (1929) recorded *Scomberomorus leopardus* (Shaw) from the Natal coast based on a specimen measuring 476 mm. obtained at Natal. According to him " Though usually credited to *Cybium interruptum* Cuvier, 1831, the name *Scomber leopardus* Shaw 1801 has priority." Perhaps this statement has also been partly responsible for causing confusion in later ichthyological literature from that area, as we now know that *S. leopardus* Shaw was based on Russell's *Wingeram* (*Scomber wingeram*) from the Coramandal coast, which in turn is a synonym of *Scomber guttatus* Bloch and Schneider, while *C.interruptum* Cuvier is a synonym of *Scomberomorus lineolatus* (Cuvier). Thus Fowler was wrong in presuming *C. interruptum* to be a synonym of *S. leopardus* (Shaw). The salient characters of Fowler's specimen from Natal are given Table IV. However, it is his following statements that beyond any doubt indicate that his specimen was *S. guttatus* for regarding the lateral line he says : " Whole upper or occipital region venulose, extending back along front part of lateral line far as first dorsal, also along each side of spinous dorsal similarly." The body colour is given as, " On sides below dark colour of back 3 rows of dark blotches or spots, sometimes connected as short bars or streaks." No accompanying figure is given, but the venulose condition of the lateral line is characteristic of *S. guttatus* and is not met with in *S. lineolatus*. The colouration is rather confusing as only blotches and spots and not streaks are met with in *S. guttatus*. However, the spots may be rounded or oval.

Earlier, Barnard (1927) recorded *Scomberomorus lineolatus* (Cuvier) from the Natal coast, characterising the species as : " Depth equal to length of head, $4\frac{3}{4}$ – 5 in length of body. Eye $6\frac{1}{2}$—7 in length of head, 2 in snout. Maxilla reaching to level of hind margin of eye. Upper teeth not very much smaller than lower teeth. D. XVI, 16+9—10. A. II, 14+10. Anal arising below middle of soft dorsal. Scales mostly absent. Lateral line gently curving downwards, and becoming horizontal below about the 4th or 5th finlet..... *Colour*, Silvery, bluish black above, sides with numerous short longitudinally elongated spots spinous dorsal dark." Smith (1949) considered *Scomberomorus lineolatus* and *S.interuptum* as synonyms of *Scomberomorus leopardus* (Shaw) and his description of the latter does not deviate much from Barnards description of *S.lineolatus* given above, it runs as follows : " Depth about $4\frac{1}{2}$. D. XV—XVI, 16—17+9—10. A. 16+10. 6 feeble gill rakers. L.l. almost straight from below dorsal. Spots usually horizontally elongate...." It is quite evident from this that a species with a higher dorsal and anal finlet count of 9—10/10 combined with the sides of the body having longitudinally elongated spots occurs in South African waters, and these characters fitting with those for *S. lineolatus*. However, the matter is far from settled, as the figure of *S. leopardus* given by Smith (1949, pl. 64, fig. 841) and reproduced here as Plate I, fig.B, clearly shows the following characteristics for a specimen 635 mm. long.

(1) A short head, much shorter than depth of body.

(2) A very short pectoral, the length of which is contained about 9.5 times in fork length.

(3) The second predorsal distance is distinctly shorter than the fork length, being about equal to the distance from the origin of the second dorsal to the tip of the first dorsal finlet from the caudal base.

(4) The snout short, being about 2.75 in head length.

TABLE IV

Comparison of certain characters of *Scomberomorus guttatus* (Bloch and Schneider) with those in literature for the species, and its synonyms

Characters	Bloch and Schneider 1801	Cuvier, 1831		Günther, 1860	
	Scomber guttatus	*Cybium guttatum*	*C. kuhlii*	*C. guttatum*	*C. croockewitii*
(1)	(2)	(3)	(4)	(5)	(6)
Fin counts :					
First dorsal ...	XV	XVI	XV	XVI	XV
Second dorsal (total) ...	19 + 8	2, 17 + 8	1, 18 + 8	19 — 20 + 8 — 10	— 17 + 7
Anal (total) ...	20 + 7	2, 19 + 7 — 8	2, 17 + 8	21 — 22 + 7 — 8	2, 18 + 7
Pectoral ...	18	...	...	...	...
Gill rakers ...	...	...	...	...	...
Depth in total length ...	...	...	...	5	6
Depth in standard length ...	...	...	...	...	...
Head in total length ...	...	...	...	ab 5	6.3
Head in standard length ...	...	...	...	...	..
Eye in head ..	..	..	...	...	...
Markings on side of body ...	...	...	...	Above blue, beneath silvery ; back and sides with numerous round blackish spots ; immature specimens sometimes uniform; first dorsal black.	A broad blackish band from dorsal to anal ; first dorsal entirely black.
Distribution ...	Tranquebar, India.	Pondichery and Malabar, India	Java and Bombay	East Indian seas	Sea of Banka

TABLE IV—(*Contd.*)

Characters	Day, 1878		Kishinouye, 1923		Fowler, 1929
	C. kuhlii (7)	*C. guttatum* (8)	*C. guttatum* (9)	*C. koreanum* (10)	*Scomberomorus leopardus* (11)
Fin counts :					
First dorsal ...	XVI	XVI–XVII	XVI	XIV	XVI
Second dorsal (total) ...	5 — 6, 17 — 18 + 8	4 —5, 14 — 15 + 8—10	19 — 20 + 8 — 9	19 — 21 + 9	5, 14 + 9
Anal (total) ...	4, 18 + 7	3, 17 — 19 + 7 — 9	21 + 8	18 + 21 + 7	6, 15 + 9
Pectoral ...	29*	21	...	...	...
Gill rakers ...	...	...	2 + 8	3 + 10	3 + 10
Depth in total length ...	5 ...	5	...	...	...
Depth in standard length ...	...	...	...	...	4.3
Head in total length ...	5.5 —'6	5.0 — 5.3	...	...	...
Head in standard length ...	...	...	...	...	5
Eye in head ...	5	5.25 — 5.5	...	...	6.3
Markings on side of body ...	Silvery on sides and below : After death sides with dark hue and no bands or spots.	Back and sides with three rows of round or rather horizontally oval spots.	Body silvery greyish with several rows of dark spots on the side. Both dorsals* dorsal finlets and caudal black.	Back greyish blue, belly silvery. Three or more rows of small greyish spots along lateral median line, Fins except pelvics and anal blackish.	Grey blue above lateral line, body below and lower side of head silvery white. On sides below dark colour of back rows of dark blotches or spots sometimes connected as short bars or streaks.
Distribution ...	Seas of India. (14½" specimen figured from Bombay).	Seas of India, Malaya, Archipelago and China.	Widely distributed in Indo-Pacific region also, Australia. Abundant in Taiwan.	West coast and south coast of Chusan.	476 mm. specimen from Natal, S. Africa.

*Probably graphical error.

TABLE IV—(*Contd.*)

Characters		Deraniyagala, 1933 *Scomberomorus* (*Sawara*) *guttatus* (Bloch and Schneider) (12)	de Beaufort, 1951 *Scomberomorus guttatus* (13)	de Beaufort, 1951 *Scomberomorus croockewitii* (14)	Munro, 1955 *Indocybium guttatum* (15)
Fin counts :					
First dorsal	...	XV — XVI	XV—XVI	XV	XV—XVI
Second dorsal (total)	...	4, 14 — 16 + 8 — 9	4, 15—16 or 7, 15 + 8—10	7, 17 + 7	4, 14 — 16 + 8 — 9
Anal (total)	...	4,16 + 8 — 9	3, 15 — 17 or 5, 15+7—9	3, 17 + 7	4, 16+8—9
Pectoral	...	20–23	2, 17 — 18	2, 18	20—23
Gill rakers	...	— + 8	1 — 2 + 8 — 10	2 + 10	1 — 2 + 8 — 10
Depth in total length	...	4	4.7 — 5.6	5.6	4.7 — 5.6
Depth in standard length	...	...	3.7 — 4.4	4.3	...
Head in total length	...	4.25	5.2 — 5.6	6.1	...
Head in standard length	...	...	4.1 — 4.5	4.7	...
Eye in head	...	...	4 — 5.2	5.2	...
Markings on side of body	...	Sides silvery with three rows of almost circular horizontal spots as large as pupil of eye. Anteriorly they are below lateral line but rise above it when it descends under second dorsal.	Sides with several longitudinal rows of dark spots, of ten obsolete.	Dark black band from dorsal to anal.	Three rows of large circular spots almost as large as pupil of eye on sides. Band of spots crosses lateral line and originates under pectoral fin.
Distribution	...	Ceylon, India, Japan, Australia.	Iranian Gulf, Coasts of India, Siam, Indo-China, Formosa (Singapore, Sumatra, Banka, Java, Madura, Celebes, Ambon). In sea and coastal waters, entering rivers.	Sea of Banka.	Coastal waters of Ceylon, Gulf of Mannar.

(5) The second dorsal, anal, and caudal lobes more prominent.

(6) Dorsal finlets 9 and anal finlets 10.

The fish figured would be more akin in the first five characters to *S. guttatus* than to *S. lineolatus*. On the other hand I have not come across 10 distinct anal finlets in *S. guttatus* from Indian waters.

From an examination of the data given by Williams (1960) for *S. lineolatus* from East African waters and a comparison of it with the typical *S. lineolatus* and *S. guttatus* from Indian waters, the characters of which are given in Table V, makes it evident that in the following diagnostic characters Williams' material shows more affinities to *S. guttatus* than to *S. lineolatus* :—

(1) The short head which is less than or hardly equal to the depth of the body. (Head 19.27–20.47 per cent versus depth 19.49–23.2 percent in S.L.)

(2) The short snout (6.56–7.2 per cent in S.L.)

(3) Shorter maxillaries (9.32-10.8 percent in S. L.).

(4) Longest dorsal spine (5.40-6.42 per cent in S.L.).

(5) Height of second dorsal and anal (13.8—16.75 and 12.86—15.43 per cent in S. L. respectively).

(6) Second predorsal distance (46.89—50.00 per cent in S. L.)

TABLE V

Body proportions expressed as thousandths of fork length in *S. guttatus guttatus* and *S. lineolatus* from Indian waters

Characters	*S. g. guttatus*[1] (Fork length 242–800 mm.)		*S. lineolatus*[2] (Fork length 235–800 mm.)	
	Range	Mean	Range	Mean
Head/F.L.	193–216	206	189–219	203
First predorsal distance/F.L.	233–259	243	239–268	252
Second predorsal distance/F.L. ...	450–500	478	493–529	510
Prepectoral distance	196–218	210	202–236	220
Prepelvic distance	231–271	254	237–272	259
Preanal distance	470–535	514	497–534	512
Greatest depth of body	201–236	226	163–196	189
Length of pectoral	114–134	124	133–164	147
Diameter of eye	28–42	36	26—37	31
Length of maxilla	100–116	109	106–120	115
Length of snout	64—77	73	80—86	83
Length of longest gill-raker	10—16	13	10—13	11
Height of first dorsal	55—76	65	46—54	51
Height of second dorsal	122–165	142	109–143	124
Height of anal	123–165	143	109–139	123
Origin of second dorsal to posterior end of caudal peduncular keel	516–548	523	466–506	480
Origin of anal to posterior end of caudal peduncular keel...	473–523	491	483–524	494

[1] 15 specimens 242–526 mm. from Tuticorin ; 2 specimens 452 and 468 mm. from Ratnagiri, and 1 specimen 800 mm. from Veraval, Gujarat.

[2] 25 specimens 235 to 800 mm. from Tuticorin.

Although Williams has given the percentage of each character in relation to standard length (measured from anterior tip of head with jaws closed, to base of central caudal rays) and in Table V. I have given the proportions in thousandths of fork length* for *S. guttatus guttatus* and *S. lineolatus*, it is evident that in the above characters *S. lineolatus* from East African Coast differs from the typical *S. lineolatus* from Indian waters. Whether the lateral line is branched as in *S. guttatus* or simple as in *S. lineolatus* is not known, except that it is " ... formed of small modified scales, from origin in an even curve well above pectoral to a point varying between the origin of the second dorsal and the second dorsal finlet, thence becoming, mainly downwards, finally rising slowly in a straight line to the caudal peduncle." A very good photograph of a 640 mm., specimen of *S. lineolatus* from East African waters showing immediate post-mortem colouration is given by Williams (1960). However, I have not come across such a colour pattern in freshly landed *S. lineolatus* up to 800 mm. long, examined from both the east and west coasts of India. The immediate post-mortem colour of the body is given by Munro (1960) as : " Body iridescent blue grey above lateral line, silver below becoming whitish ventrally. On the sides of body a series of about six to eight interrupted horizontal black lines (above lower base of pectoral) much narrower than the interspaces. Anteriorly usually only one of the lines is above the lateral line, posteriorly they are replaced by a number of short oblique black lines. Under the 1st or 2nd dorsal finlets the series of horizontal lines becomes somewhat confused and only two to three of the lines continue through to the caudal peduncle. The horizontal black lines on the body are interrupted to varying degrees, the lines being almost intact in places, and broken up into a series of small rectangular "spots" in others. Upper areas of caudal peduncle and median keel black, lower areas dusky, " In formalin preserved specimens the body is dark brown above lateral line and paler below." " The pattern of interrupted black horizontal lines on the sides is as in the post-mortem colouration, but the degrees of clarity of the lines varies considerably between specimens." Thus both in the post-mortem or in the preserved state, the markings on the body of the East African *S. lineolatus* is said to be very distinctive although the number and degree of interruptions of the horizontal black lines are considerably variable from specimen to specimen and from side to side. The colourations in the Indian specimens of *S. guttatus* and *S. lineolatus* are figured by Jones and Silas (1961, 1962), (Also see plate II, fig. A.) These differences between the typical *S. guttatus and S. lineolatus* from Indian waters on the one hand and from Western Indian Ocean on the other pose several problems with some of the following possibilities:

(1) That in South African waters a species closely related to *S. guttatus* or a sub-species of the latter occurs, the typical *S. guttatus* thus being not present in the Western Indian Ocean. As far as is known this species or sub-species has a striking colour pattern and also a definitely higher dorsal and anal finlet count.

(2) That two species closely related to *S. guttatus* and *S. lineolatus* each occurs in South African waters.

(3) That in East African waters what has been considered as S. *lineolatus* is not in fact the typical *S. lineolatus* as found in Indian waters, but may be a closely related species or sub-species of it.

* Fork length measured here is from tip of snout to caudal fork depressing small fleshy flap extending posteriorly to indicate end of hypural [see Jones and Silas, 1960. *Indian J. Fish.*, 7 (2) : 371-73]. This would correspond to the standard length measurements given by Williams (1960).

(4) That in East African waters what has been considered as *S. lineolatus* is nothing but a closely allied species or sub-species of *S. guttatus* as mentioned under item 1.

The picture is far from clear and it will be desirable if good series of specimens from Western Indian Ocean at present known under the names *S. lineolatus* and *S. leopardus* are examined and compared with the typical *S. guttatus* and *S. lineolatus* which occur along the Indian coast. It is felt that on account of the differences already mentioned, until such time that such a study could be carried out it will be difficult to evaluate the status and relationships of these forms from the Western Indian Ocean.

SYNONYMS

(Alphabetically arranged)

1. *Scomberomorus guttatus guttatus* (Bloch and Schneider), 1801

Cybium crockewitii Bleeker, 1859
Cybium guttatum Bleeker, 1845
Cybium guttatum (in part) Pillay, 1929
Cybium guttatus Sorley, 1933
? *Cybium interruptum* Pearson, 1912
Cybium kuhlii Cuvier, 1831
? *Cybium leopardus* Fourmanoir, 1957
Indocybium guttatum Munro, 1955
Scomber guttatus Bloch and Schneider, 1801
Scomber wingeram Russell, 1803
Scomber leopardus Shaw, 1803
? *Scomber wingeram* Schinz, 1822
Scomberomorus croockewitii Munro, 1943: de Beaufort. 1951
Somberomorus guttatus Fowler, 1905b
Scomberomorus guttatus guttatus Jones and Silas, 1962
Scomberomorus (*Indocybium*) *guttatus* Munro, 1943
Scomberomorus (*Sawara*) *guttatus* Deraniyagala, 1933a
Scomberomorus (*Scomberomorus*) *guttatus* (in part) Fraser-Brunner, 1950
Scomberomorus kuhlii Hardenberg, 1936
Scomberomorus kuhlii Hardenberg, 1937
Scomberomorus (*Pseudosawara*) *kuhlii* Munro, 1943
? *Scomberomorus leopardus* Fowler, 1929
? *Scomberomorus lineolatus* (*nec* Cuvier?) Fowler, 1934

2. *Scomberomorus guttatus koreanus* (Kishinouye), 1915

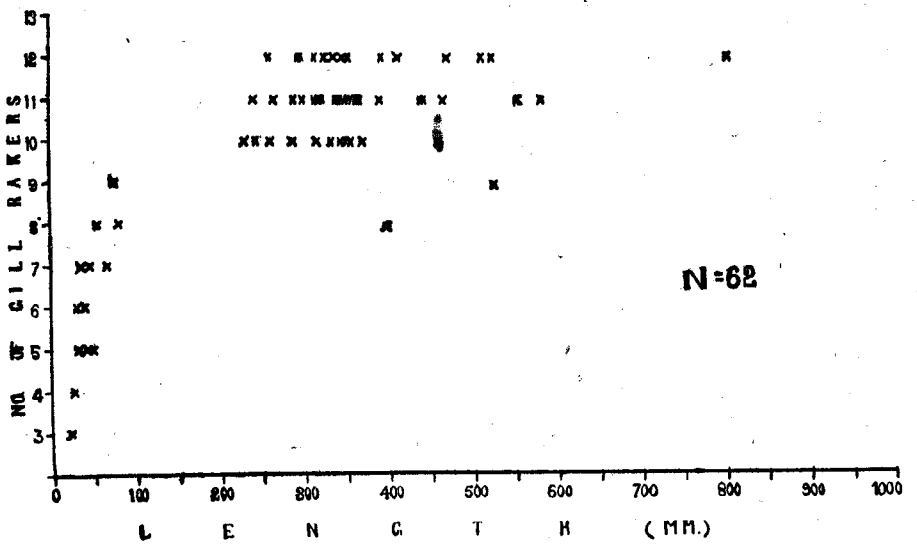
Cybium coreanum Parks, 1939
Cybium koreanum Kishinouye, 1915
Sawara koreanum Soldatov and Lindberg, 1930
Scomberomorus (*Pseudosawara*) *koreanus* Munro, 1943
Scomberomorus (*Scomberomorus*) *semifasciatus* (in part) Fraser-Brunner, 1950

For the different synonyms and combinations, more references are listed in the section Annotated Bibliography."

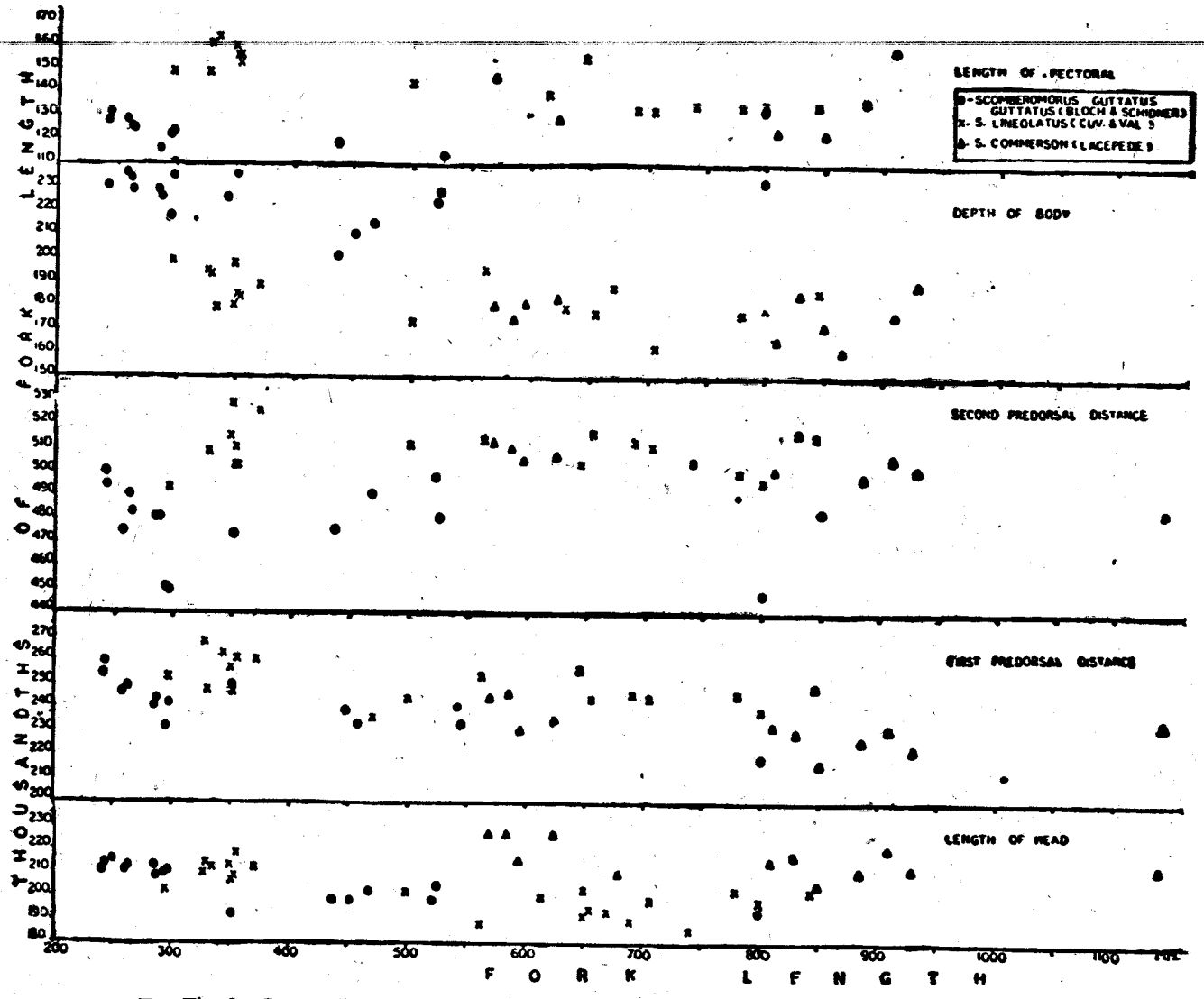
TABLE VI

Common and Vernacular Names

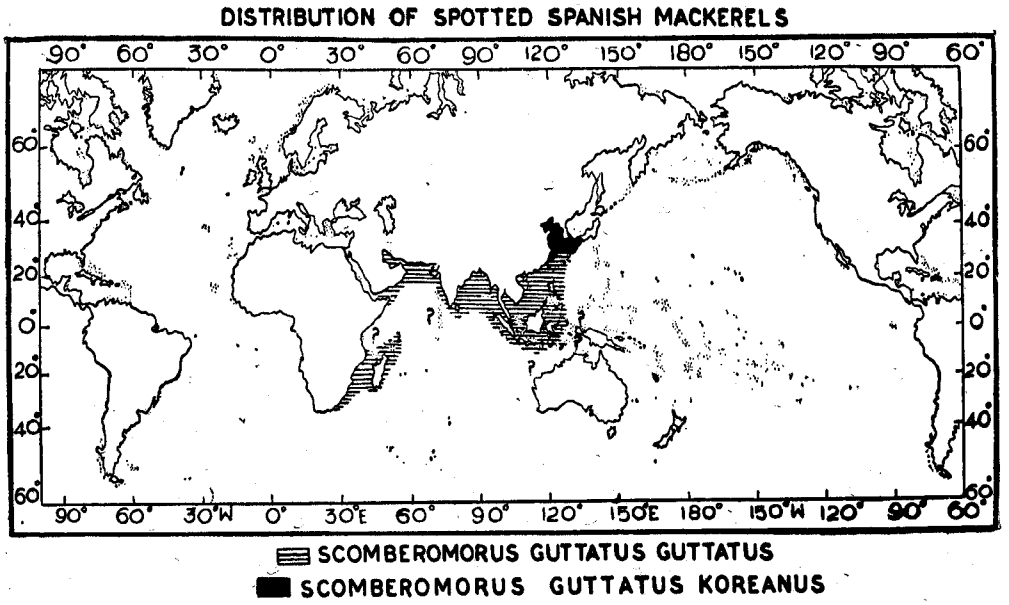
Country	Standard common name	Vernacular name(s)
	I. *Scomberomorus guttatus guttatus* (Bloch and Schneider)	
Borneo (West)	...	Tengiri.
Ceylon	... Spotted seer	Spotted spanish mackerel ; Aru maha ; Alu thora ; Ganu thora ; Sekkal thora ; Bambra tora ; Anjilava (young) (*Sinhalese*). Nei Arekula ; Anjilia (*Tamil*).
China		Kan yu ; Kaou yu ; Kau ü, eaou yu.
Indo-China	...	Ca song toi ; Ca thu ; Ca chan.
India	... Spotted spanish mackerel Seerfish	Tuwar ; Touri ; Towar : Kargan ; Surmai ; Surma Hadra (spotted) (*Marathi*). Khullkul (*Canarese*). Anjal (*Tulu*). Ney-meen ; Arrakeeah ; Varimeen ; Seela (*Malayalam*). Vanjiram ; Wantasaran ; Cheela ; Katta-cheela (*Tamil*). Vanjaramu ; Wingram (*Telugu*). (Some of the vernacular names mentioned above are also used to denote *S. commerson*, and *S. lineolatus*).
Indonesia	...	Gepanterde tenggiri
Iranian Gulf	...	Ghobad ; Ghobart ; Ghobab ; Sheer.
Japan	...	Kahpah.
Malaya	...	Tenggiri ; Tenggiri papan ; Luding ; Tohok langi.
Philippines	... Spotted spanish mackerel	Spotted seer ; spotted tanginigi.
Union of South Africa	...	Snoek ; Kingfish.
	II. *Scomberomorus guttatus koreanus* (Kishinouye)	
Japan	...	Hirasawaral



Text Fig. 2.—Graph showing increase in number of gill rakers during growth in juveniles and adults of *Scomberomorus guttatus guttatus* from Indian waters.



Text Fig. 3.—Scatter diagrams showing relationships for five characters in specimens of *S. guttatus guttatus*, *S. lineolatus* and *S. commerson*, from Indian waters.



Text Fig. 4.—Geographical distribution of the spotted spanish mackerels, namely, *Scomberomorus guttatus guttatus* (Bloch and Schneider), and *S. g. koreanus* (Kishinouye) of the Indo-Pacific.

ADDITIONAL REMARKS AND COMPARISONS BETWEEN INDIAN SPECIES OF *SCOMBEROMORUS*

Jones and Silas (1961) drew attention to some of the important differences between the Indian species of *Scomberomorus*, and the Wahoo. Additional data are given below:

(1) Gill rakers : Reference may be made to Tables II and III, and also to text-fig. 2. As will be seen from the latter, the full complement of gill rakers is attained in *S. g. guttatus* by the time the fish reaches about 200 mm. in length. The data given for larvae and juveniles of *S. commerson* by Jones (1961) show that in that species the full complement of gill rakers is attained by the time the fish reaches about 100–130 mm. in length. No information is available for *S. lineolatus*.

(2) Lateral line : The venulose branched condition of the lateral line in *S.g.guttatus* is shown in plate II, figs. B and C. This may be compared with the non-branching lateral line seen in *S. lineolatus* shown in plate II, fig. D. In large specimens of *S.commerson*, as in *Acanthocybium solandri*, perpendicular dorsal and ventral branchings of the lateral line may be seen. But for this, the lateral line in it is simple as in *S. lineolatus*.

(3) Head: Compared to *S. commerson* the head is relatively smaller in both *S. g. guttatus* and *S. lineolatus* (Text-fig. 3, and plate III, figs. A, B & C).

(4) First predorsal distance : The distance between the tip of the snout and the anterior insertion of the spinous dorsal is relatively greater in *S. lineolatus*, than in *S. g. guttatus* and *S. commerson* (Text-fig. 3).

(5) Second predorsal distance: The distance between the tip of the snout and the anterior insertion of the second dorsal is distinctly greater in both *S. commerson* and *S. lineolatus* than in *S. g. guttatus* (Text fig. 3).

(6) Greatest depth of body: Size for size, the body is distinctly deeper in *S. g. guttatus* than in *S. lineolatus* and *S. commerson*. The available data for sizes between 200--800 mm. (Text-fig. 3) show hardly any overlap in this character between the first and the other two species.

(7) Length of pectoral fin: On the other hand the pectoral fin is relatively shorter in *S. g. guttatus* than in *S. lineolatus* and in *S. commerson* (Text-fig. 3, and Plate III, figs. A. and C.).

(8) The caudal peduncular keel: This is not so well developed in *S. g. guttatus* and in *S. lineolatus* (Plate III, figs. D & E). Jones and Silas (1961) have given more information on this character for the three species.

GEOGRAPHICAL DISTRIBUTION

The known distributional ranges of *S. g. guttatus* and *S. g. koreanus* are shown in text-fig. 4. A disjunct distribution of the spotted spanish mackerel in the Western Indian Ocean may be noted. This is puzzling, especially in view of the continuous distribution of *S. g. guttatus* along the rest of its distributional range. As already mentioned, the spotted spanish mackerel of the Western Indian Ocean needs restudy, and until such time it is tentatively placed under *S. g. guttatus*. The possibility of a distinct subspecies of *S. guttatus* occurring in the Western Indian Ocean just as *S. g. koreanus* occurs at one extreme end of its range of distribution cannot be overruled.

S. guttatus is not truly oceanic in habit as some of its congeners, but is essentially known from coastal waters and is found between 40°N. lat. and about 33°S. lat., and about 27°E. long. to about 140°E long. in the Indo-Pacific. The subspecies *S. g. koreanus* has a restricted distribution, being known from Chosen and adjacent waters west of Korea perhaps extending on to Japanese waters. Kishinouye (1923) speaking of *Cybium koreanum* (= *S. g. koreanus*) remarks that "It is remarkable that this species ascends the brackish parts of rivers" and that it "……can withstand water of very low density." "Generally speaking fishes of the Scombridae and Cybiidae are adapted to water of lower density, 1.022--1.025, while plecostean fishes prefer water of higher density 1.025--1.027." The same tendency of ascending estuaries of larger rivers is also seen in the case of the typical form *S. g. guttatus* as it has been recorded from river mouths and estuaries (Hardenberg, 1936; Hora, 1953).

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Scomberomorus guttatus ; taxonomic notes.

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Scomberomorus (*Indocybium*) *guttatus*
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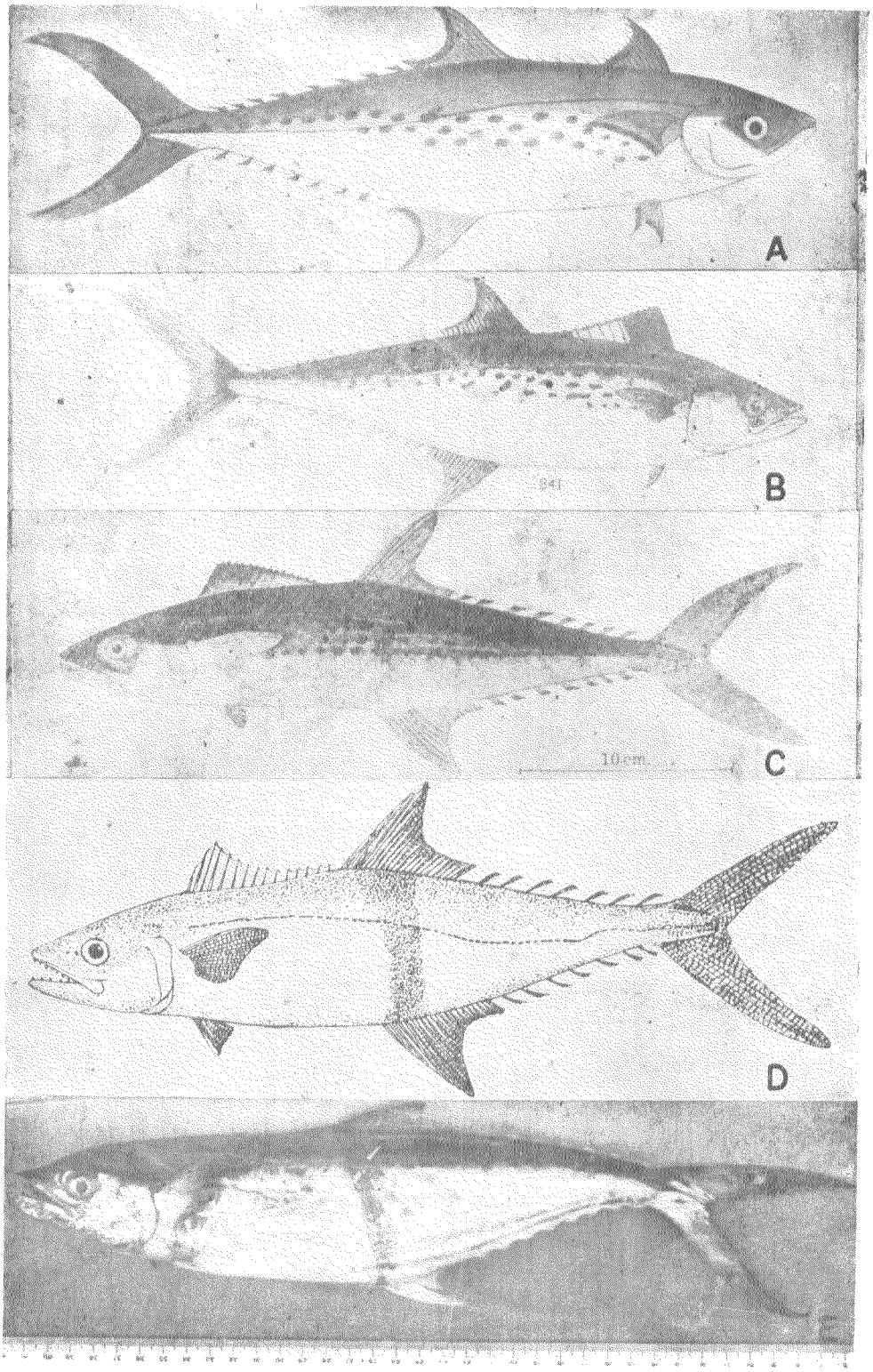
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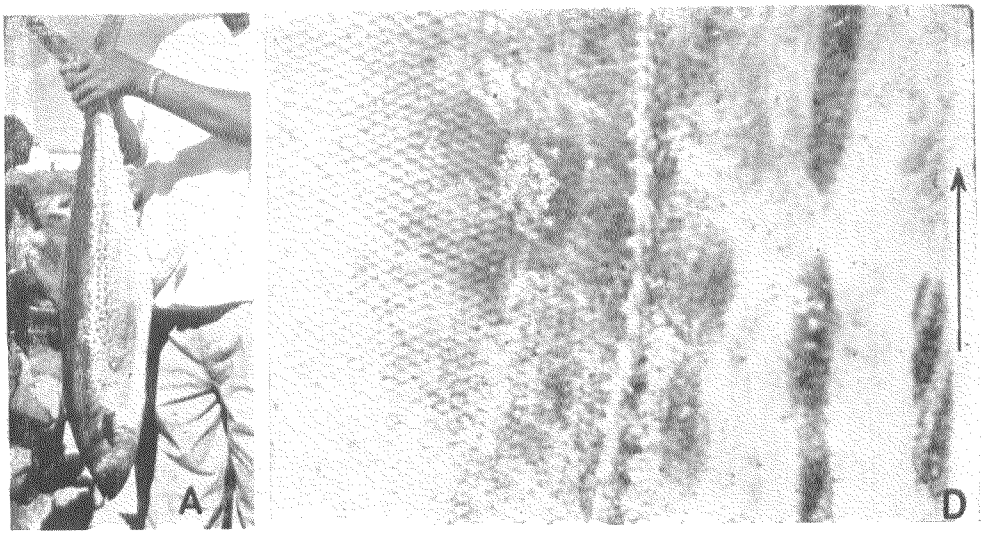
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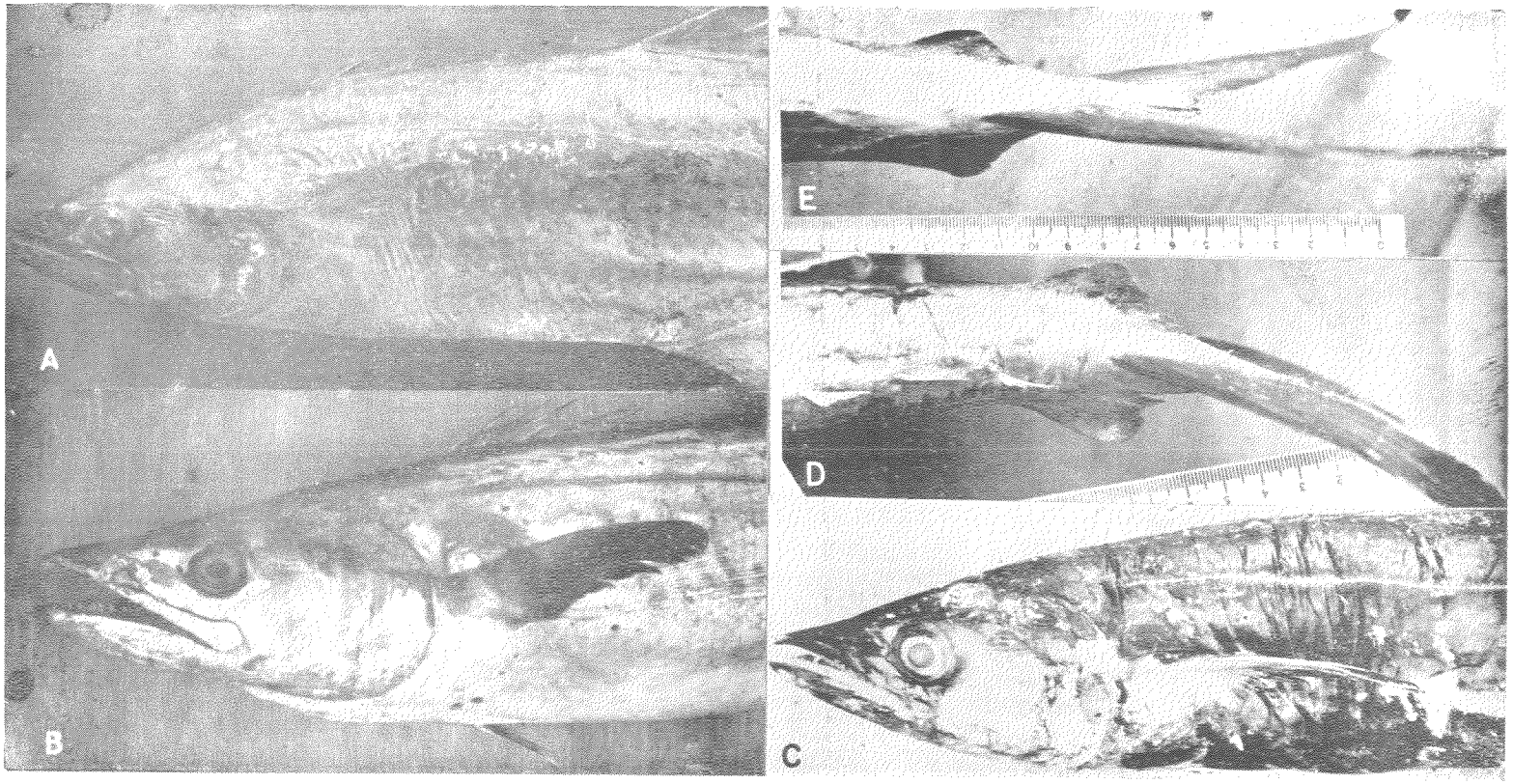


A. The *Wingeram*, after Russell (1801) from Coromandel Coast, India ; B. *Scomberomorus leopardus* (Shaw), 25 inch specimen from South African waters (after Smith, 1961) ; C. *Scomberomorus guttatus* (Bloch and Schneider) 35 cm. specimen from Shangtung coast, China (after Wang, 1935) ; D. *Scomberomorus croockewitii* (Bleeker), 45 cm. holotype (after de Beaufort, 1951) ; and E. *Scomberomorus guttatus guttatus* (Bloch and Schneider), 31 cm. specimen caught in gill net off Tuticorin, Gulf of Mannar.





A. *Scomberomorus guttatus guttatus* (Bloch and Schneider), 80 cm. specimen caught off Veraval, Gujarat, Western India; B and C. Lateral line of specimen 50 cm. showing characteristic branching at (B) just above gill opening and pectoral, and (C) below second dorsal ; D. Simple unbranched lateral line in *Scomberomorus lineolatus* (Cuvier) in a specimen 60 cm. long. (The arrow in each figure indicates antero-posterior direction).



A. *Scomberomorus guttatus guttatus* (Bloch and Schneider), head and anterior part of body of a specimen 80 cm. from Veraval, Gujarat, Western India ; B. *S. commerson* (Lacépède), 78 cm. from Kilakarai, Ramnad Coast, Gulf of Mannar ; C. *S. lineolatus* (Cuvier), 72 cm. from Tuticorin, Gulf of Mannar ; D. Conspicuously prominent wing-like caudal peduncular keel of same ; E. Relatively illdeveloped caudal peduncular keel of specimen mentioned under A.

EGGS, LARVAE AND JUVENILES OF INDIAN SCOMBROID FISHES

BY

S. JONES AND M. KUMARAN
Central Marine Fisheries Research Institute

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 Schhneider)
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)

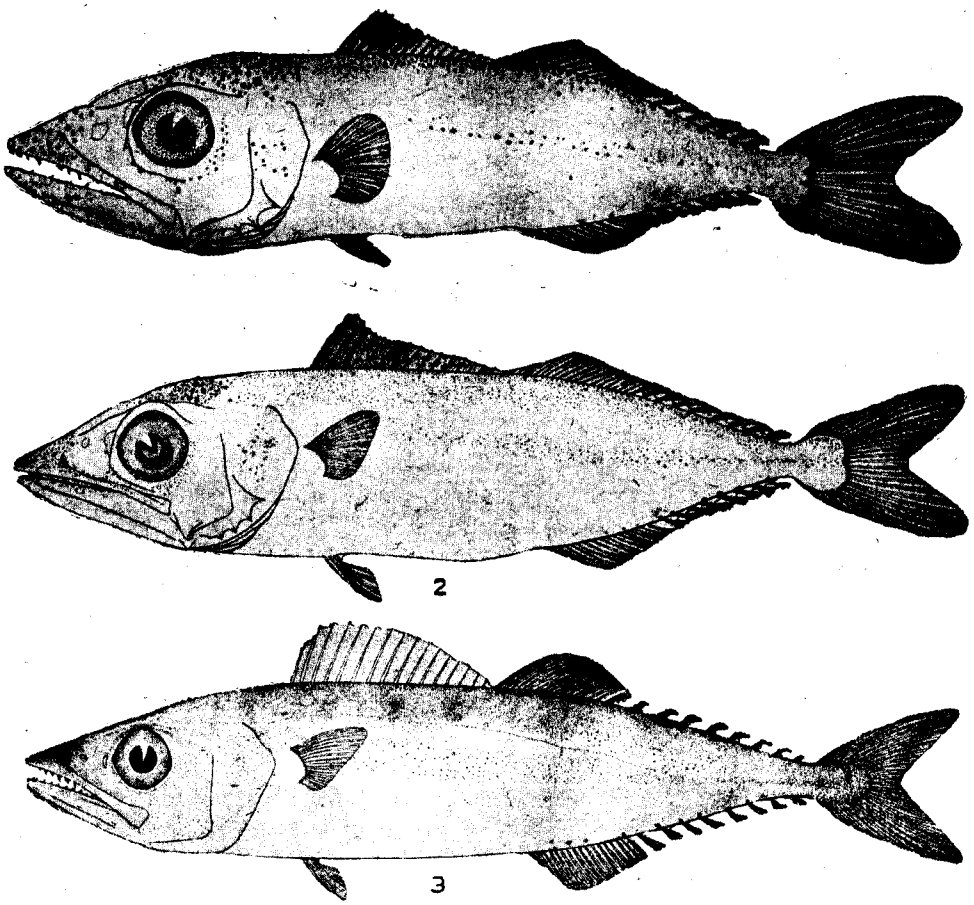
DESCRIPTION OF LARVAE

FAMILY : SCOMBEROMORIDAE

Scomberomorus guttatus (Bloch and Schneider)

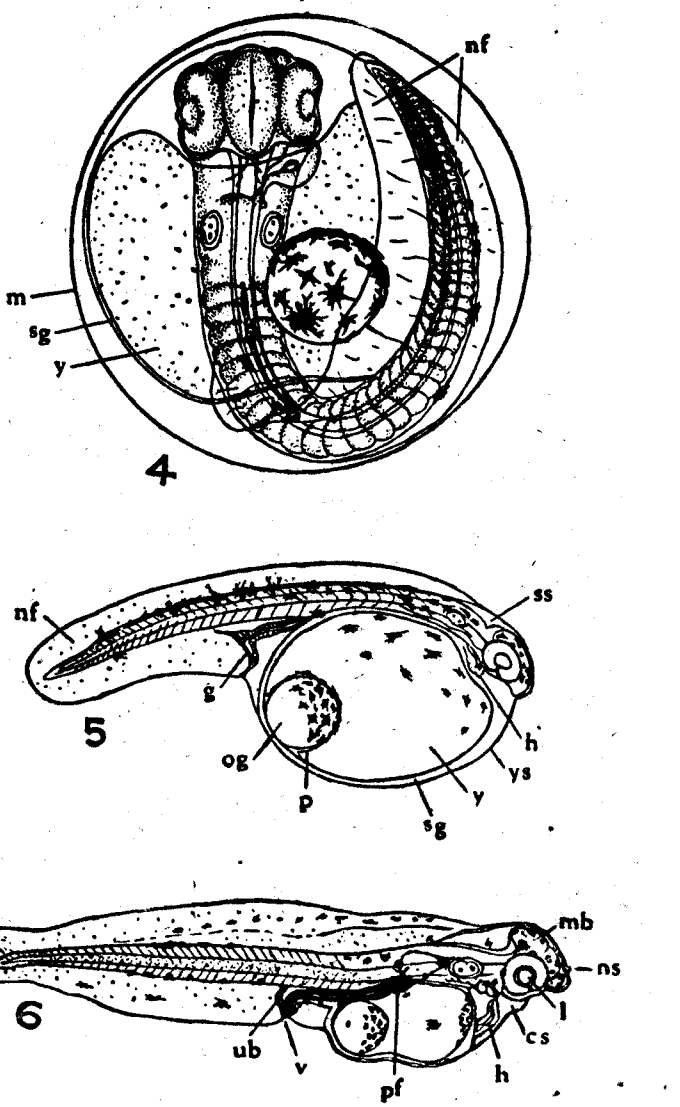
The spotted seerfish forming a fairly important fishery along the Indian coast during certain months is distributed widely in the Indo-Pacific from the Persian Gulf to the Western Pacific from Formosa and Japan to Indonesia.

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)

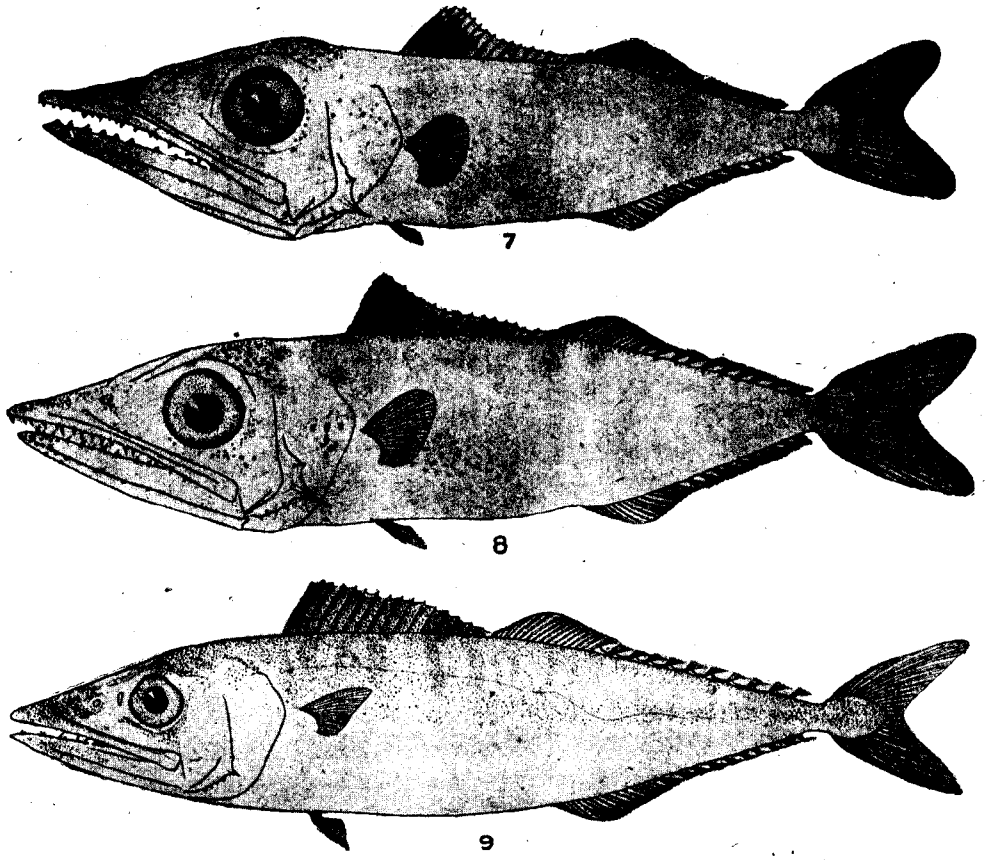
Three juvenile specimens described by Jones (1961) are reproduced here (Figs. 1-3). The head of juvenile of about 15 mm. is conspicuously large, being 2.7 in standard length. Snout is bluntly pointed and it is 1.5 times the diameter of eye. Preopercular spines are short and their tips do not reach the 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)

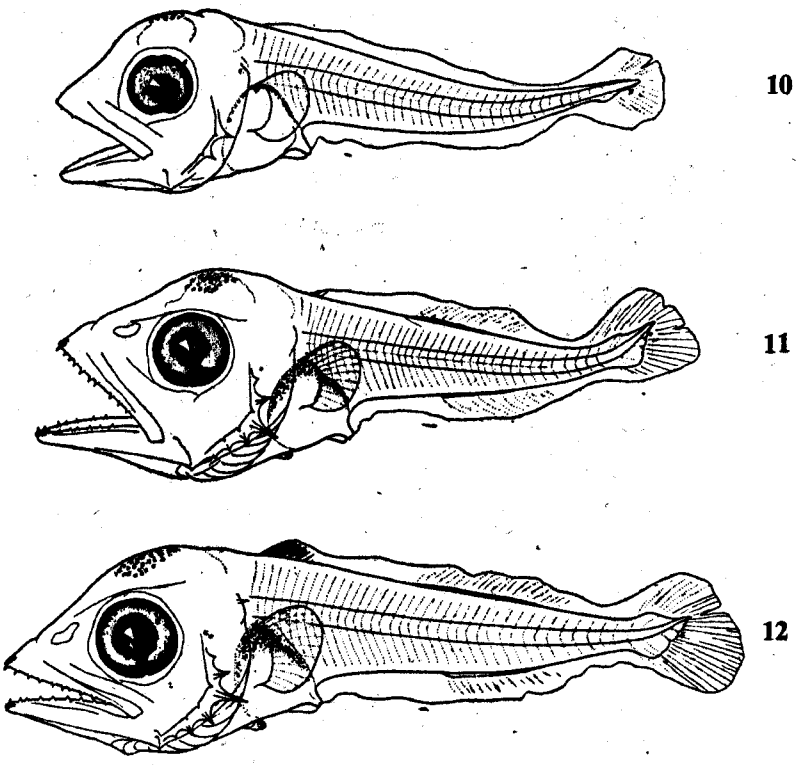
Scomberomorus lineolatus (Cuvier)

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)

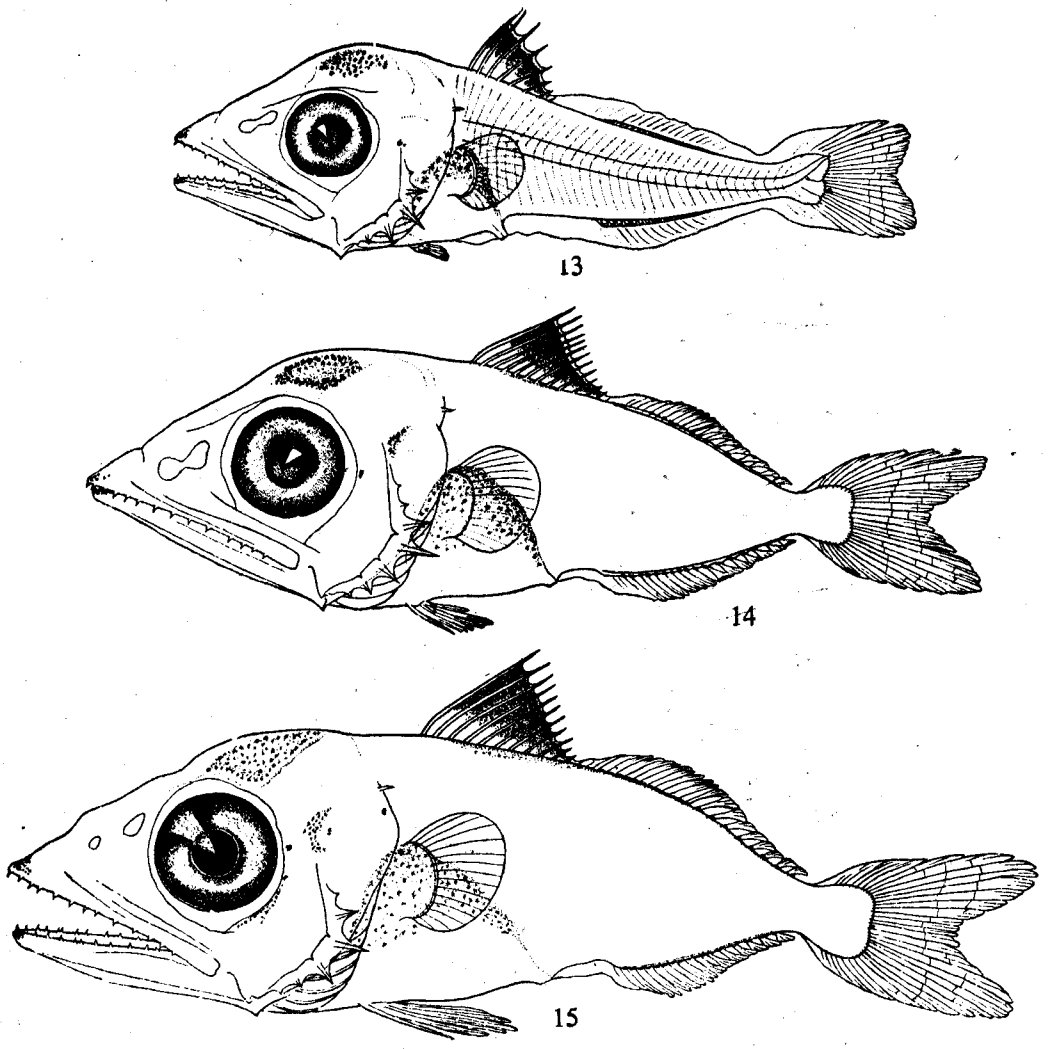
The yellowfin tuna is widely distributed in the warmer parts of the Indian and Pacific Oceans. The larval and juvenile stages of this species have been described by Wade (1950 and 1951), Matsumoto (1958) and Jones (1959c). The smallest recognizable specimen from Indian waters measured 3.88 mm. and was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



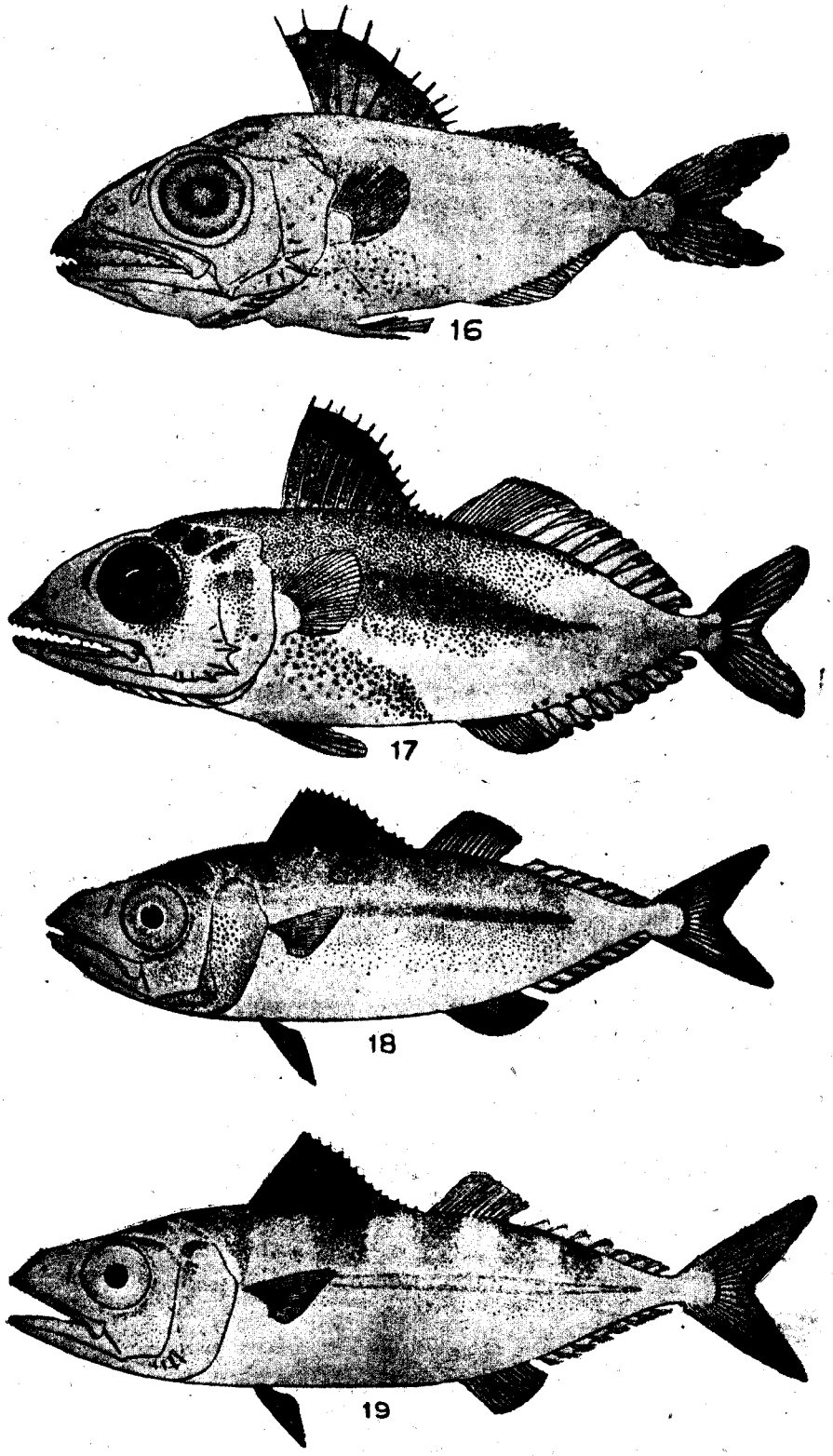
Figs. 10–12. *Neothunnus macropterus*. Fig. 10—3.88 mm., Fig. 11—5.25 mm., Fig. 12—6.85 mm. (Reproduced from Jones, 1959c).

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

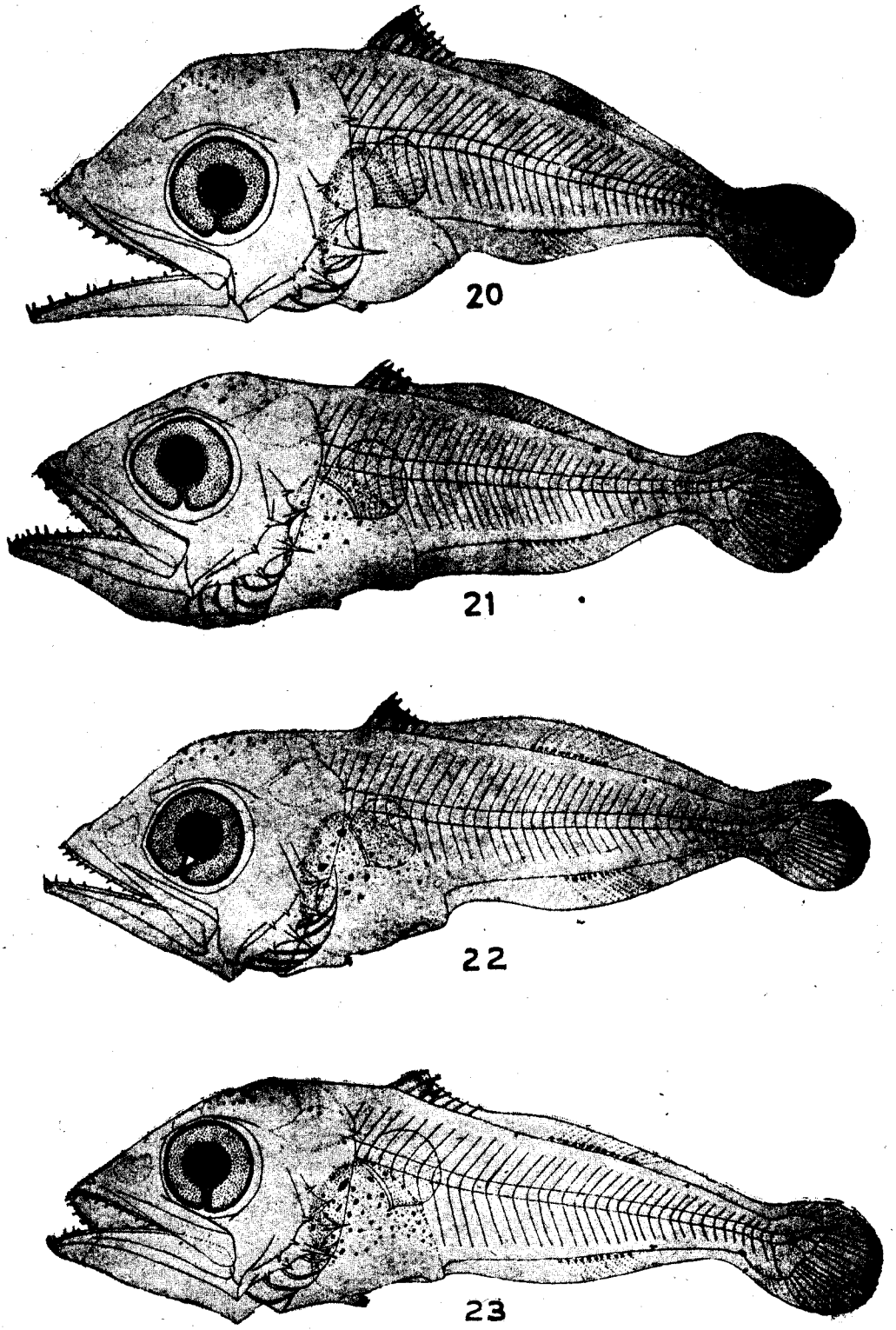
specimens of over 7 mm. total length. In specimens of about 5 mm. the dorsal outline tapers from the region of the head to the end of the tail and the ventral outline is rounded in the abdominal region and tapers gradually to the end of caudal. The snout is pointed and the diameter of the eye is less 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 Wade, 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 germo* (= *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 and 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).

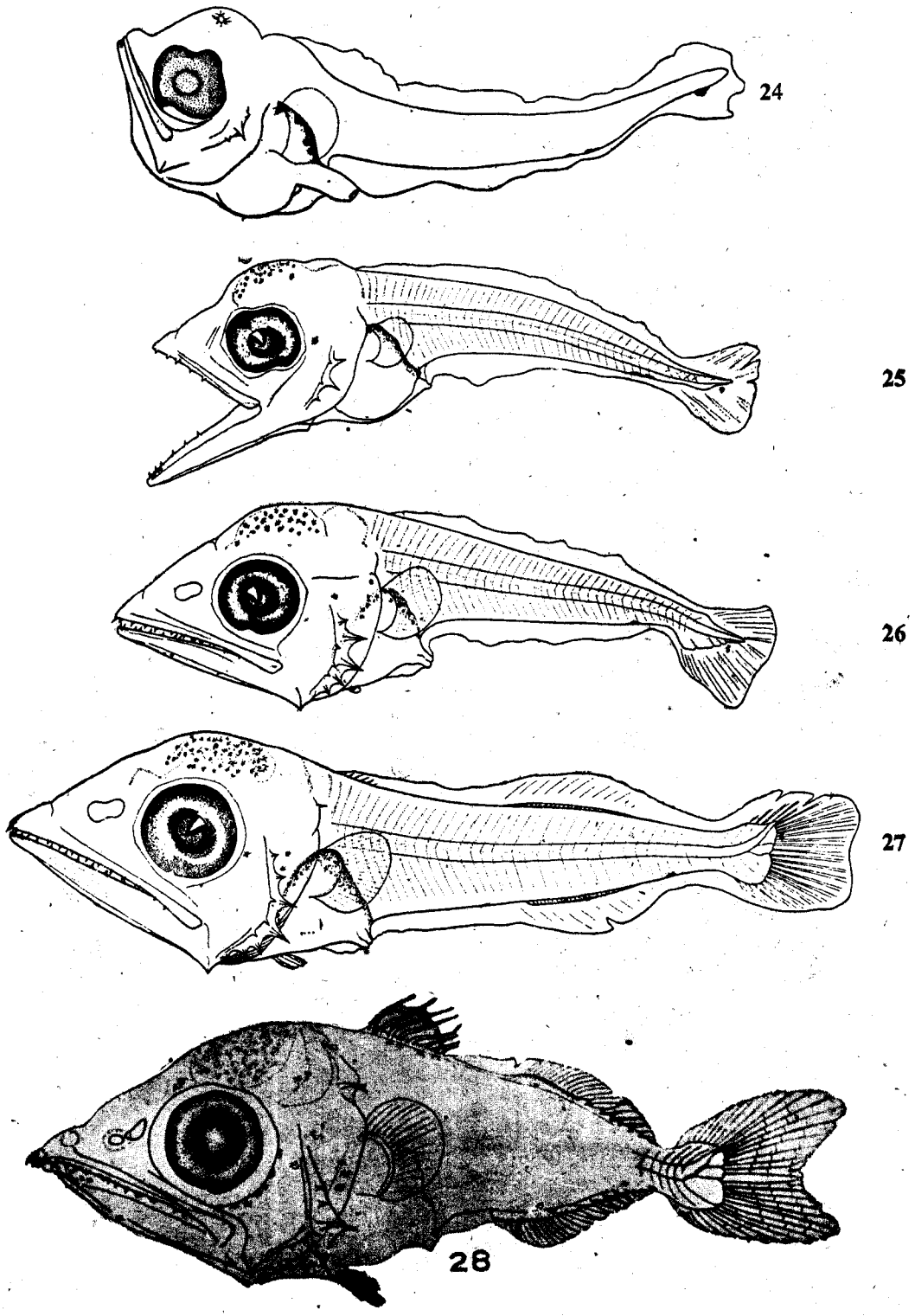
Figures of larval and juvenile stages of *K. pelamis* are reproduced in Figs. 24-32. The early larva has a large head in comparison to the body which is long and slender. The greatest depth is just posterior to the eye and the dorsal and ventral outlines taper gradually to the end of the caudal fin. The abdominal sac is characteristically small and is situated anteriorly. In specimens upto 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)

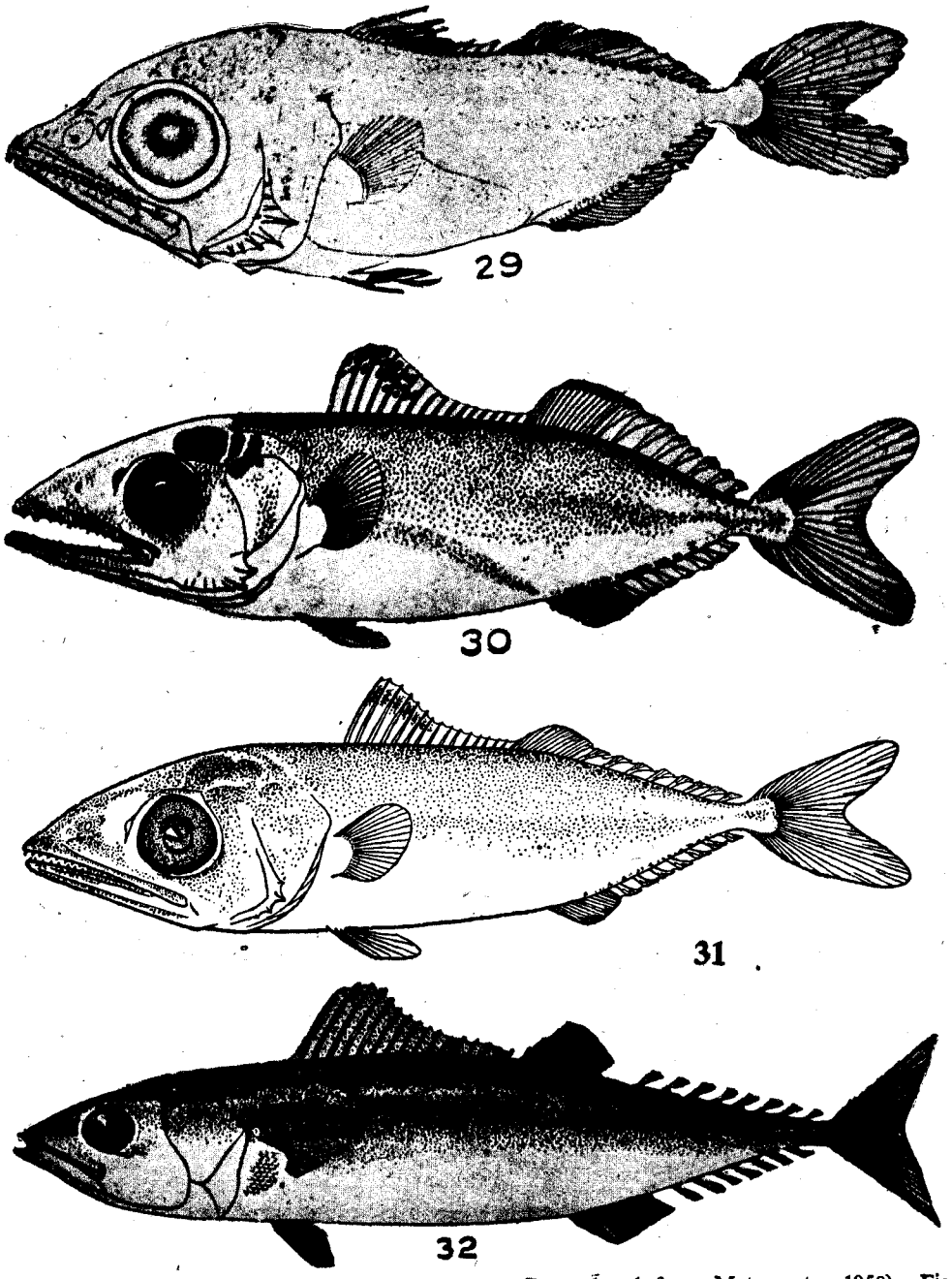
The little tunny is widely distributed in the Indian Ocean and some parts of the Western Pacific and forms a fishery of some magnitude at several places along the coasts of India. Wade (1951) and Matsumoto (1958 and 1959) have described the larval stages of *Euthynnus yaito* from the Philippine and Hawaiian 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

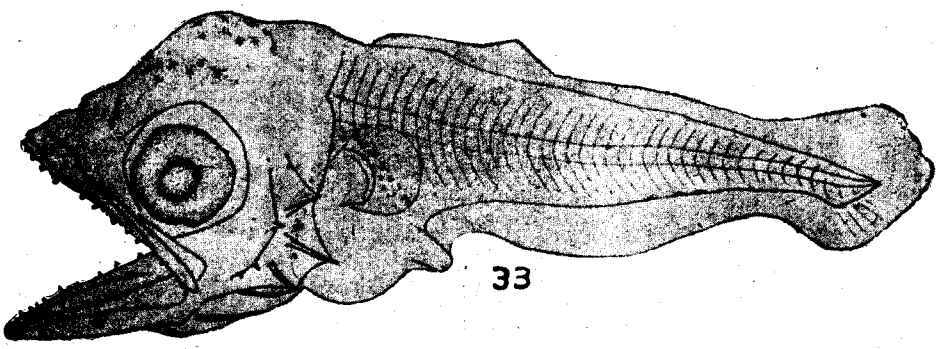


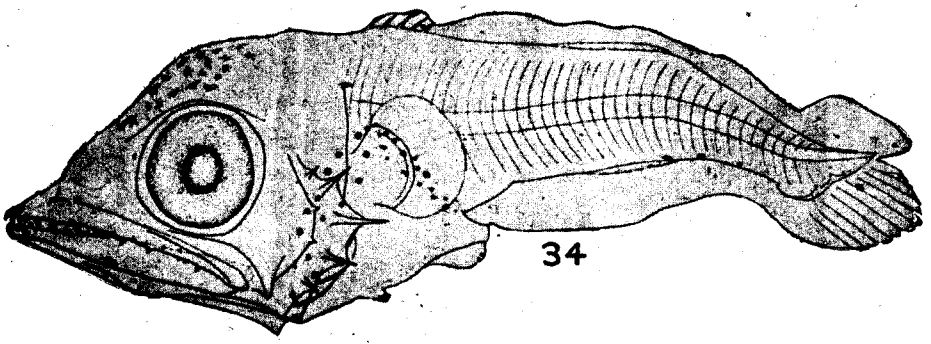
Figs. 24–28. *Katsuwonus pelamis*. Fig. 24.—2.97 mm., Fig. 25.—3.6 mm., Fig. 26—5.08 mm., Fig. 27.—7.08 mm. (Reproduced from Jones, 1959) Fig. 28.—8.75 mm. (Reproduced from Matsumoto, 1958)

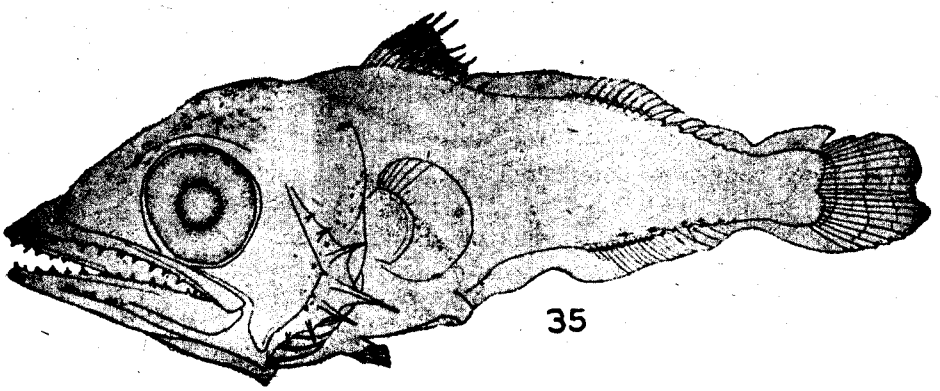
later stages. Eye is rather large and its diameter in larvae upto 5 mm. exceeds the length of the snout whereas in larger specimens the snout is elongated and is more than the diameter of the eye. In specimens of about 7.5 mm. the body becomes much deeper, the abdominal sac is more elongate and the vent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

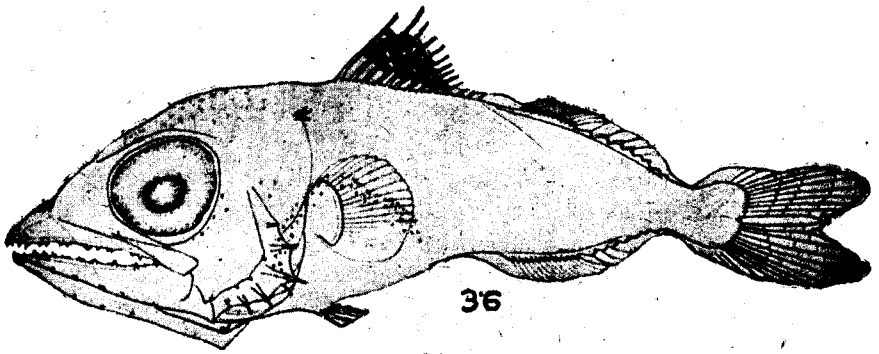


Figs. 29–32. *Katsuwonus pelamis*. Fig. 29.—14.25 mm. (Reproduced from Matsumoto, 1958). Fig. 30.—21 mm. (Reproduced from Schaefer and Marr, 1948). Fig. 31.—27 mm. (Reproduced from Jones, 1959*c*). Fig. 32.—113 mm. (Reproduced from Eckles, 1949).









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* (Lacèpède) 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).

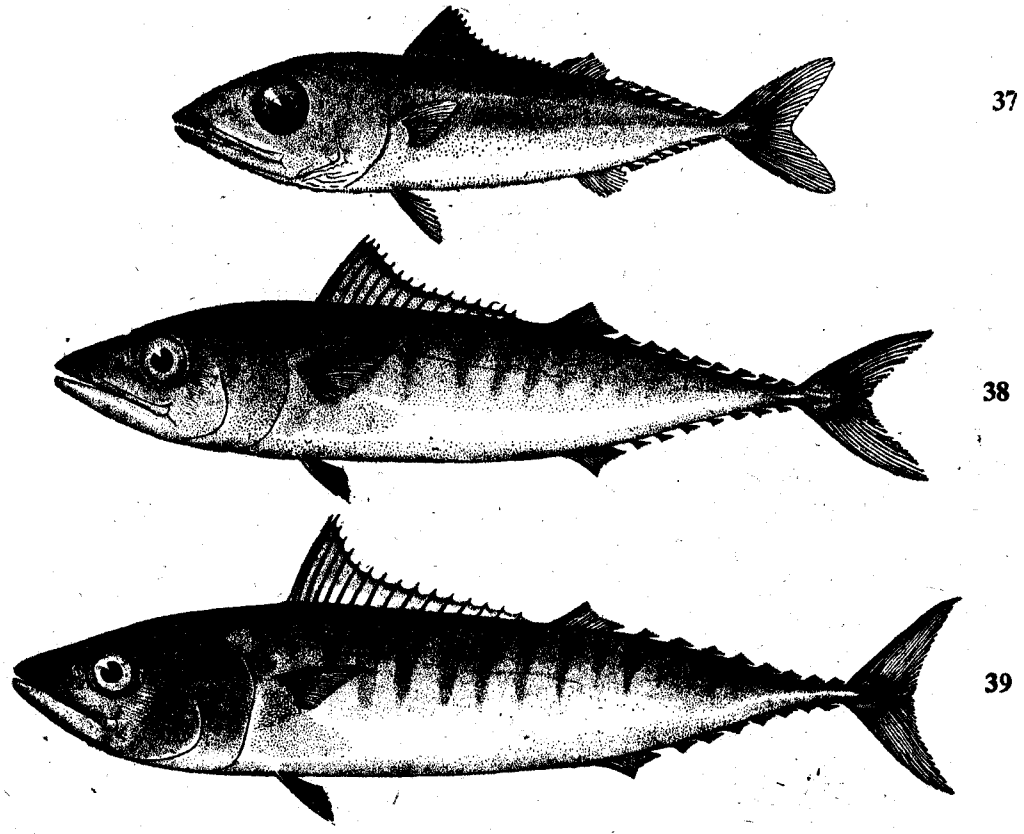
In the postlarval stages of *Auxis* the snout is short and pointed and its length is less than the diameter of the eye. Mouth is oblique and the maxillary reaches to a vertical below the middle of the eye. The head is not so large as in the other larval tunas and the dorsal outline of the head appears 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 midlateral 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, 1960*a*)

According to Jones (1962) a re-examination of the juvenile *Auxis* 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.

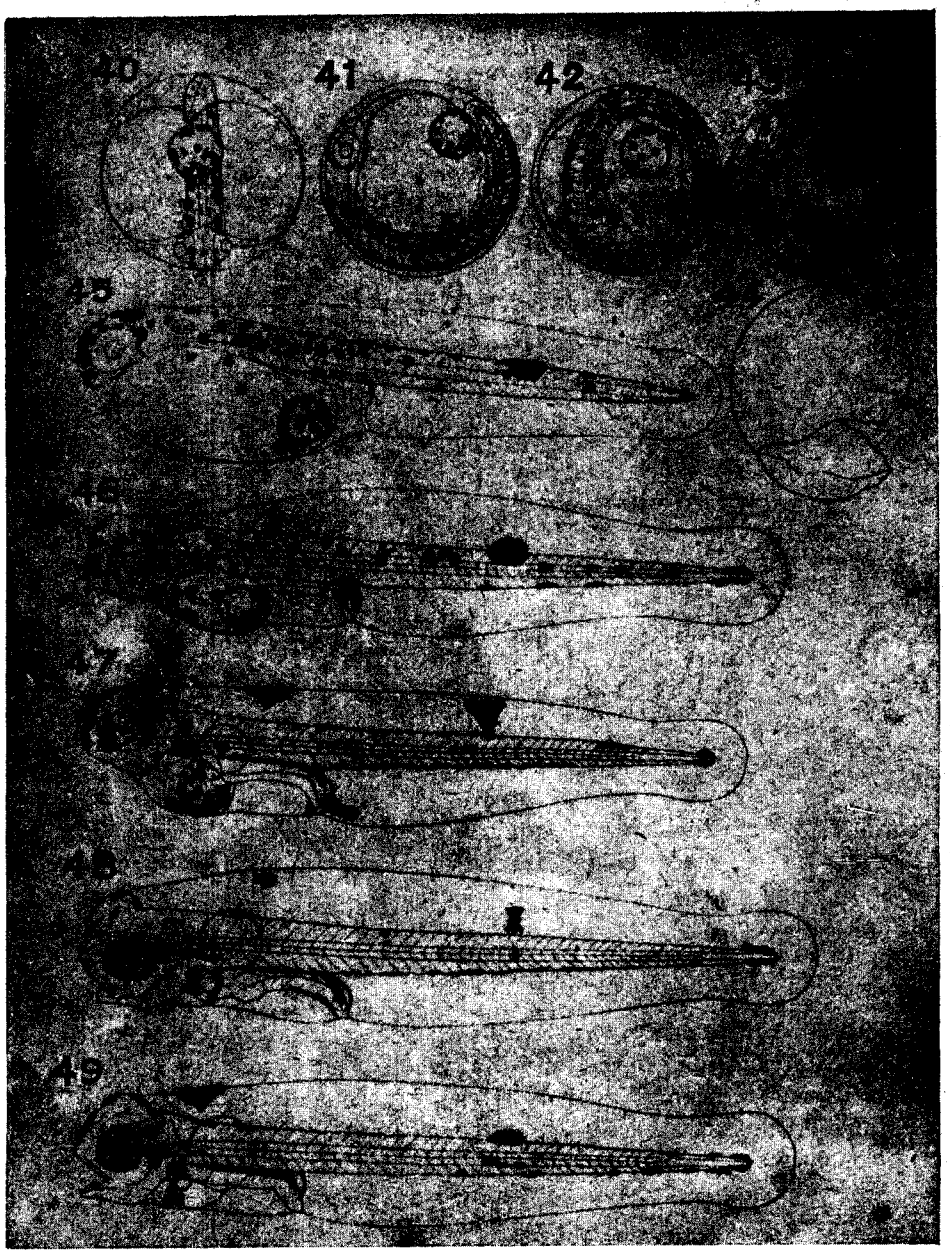
Auxis thynnoides Bleeker

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).

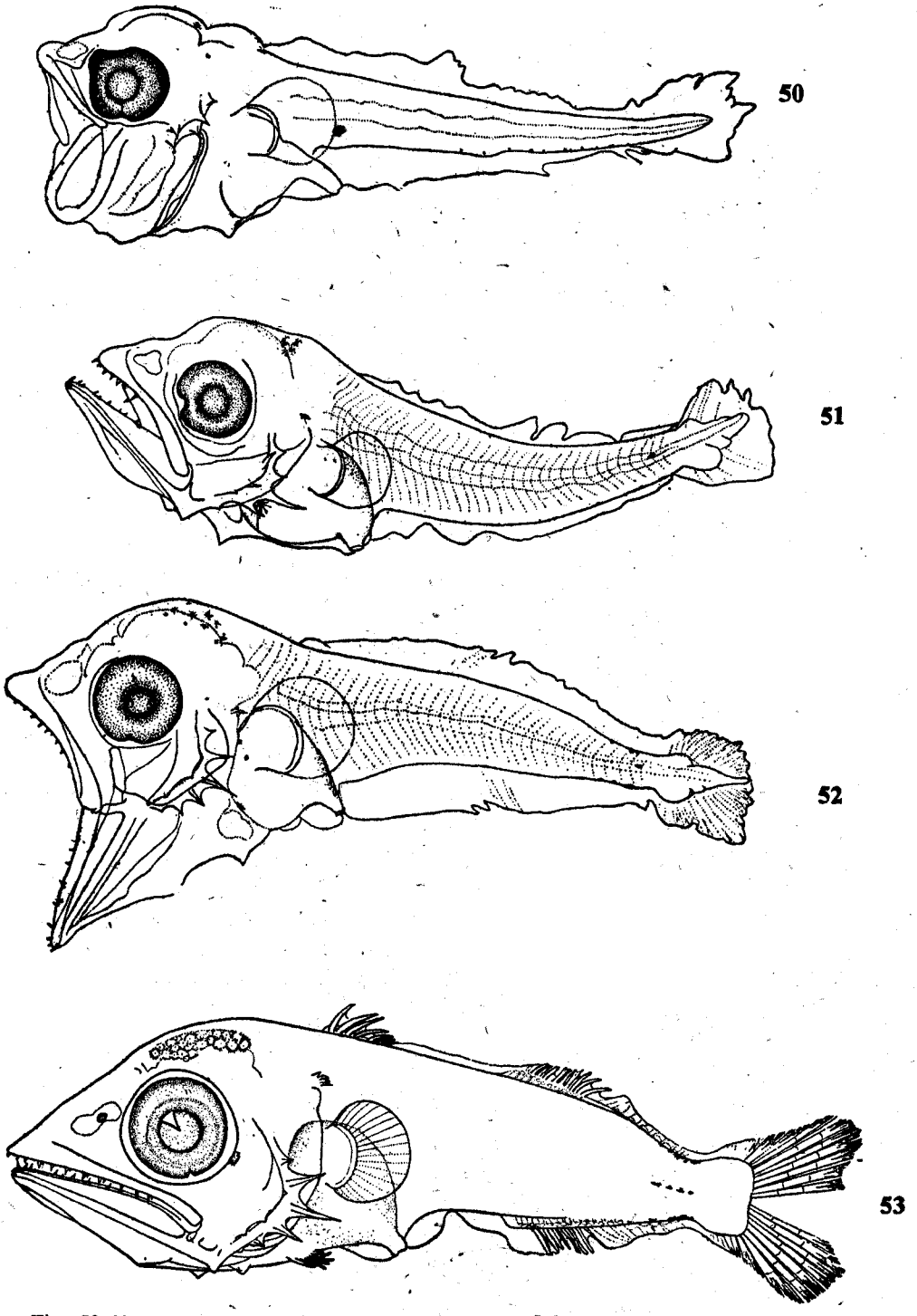
Sarda orientalis (Temminck and Schlegel)

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.

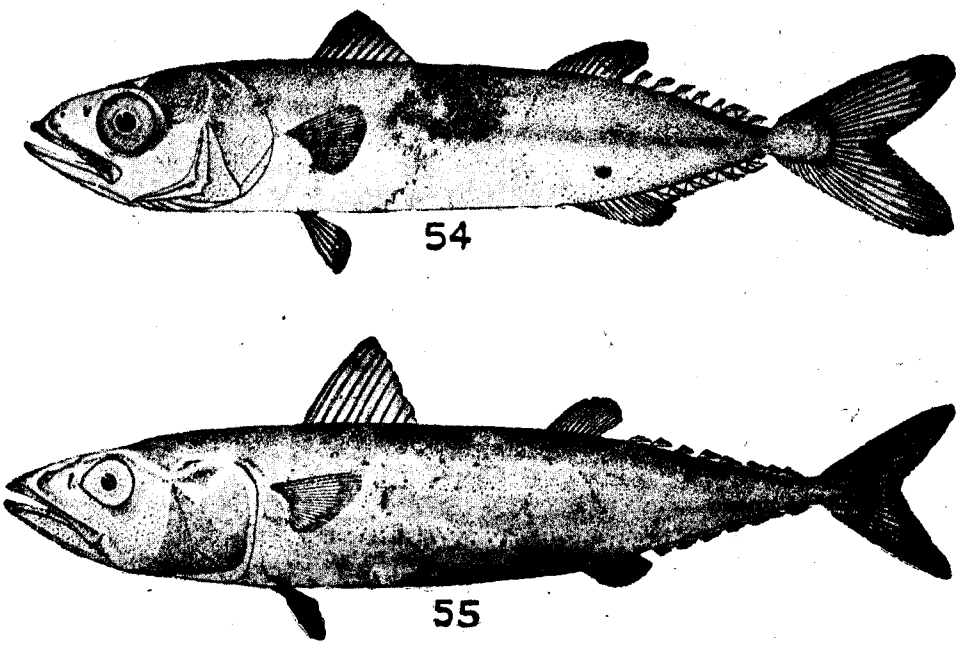
larva of *Sarda* sp. by Klawe (1961b) collected off Baja California where both *S. orientalis* and *S. chilensis* occur is reproduced here (Fig. 59) so as to facilitate identification of the



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, 1960*b*)



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.

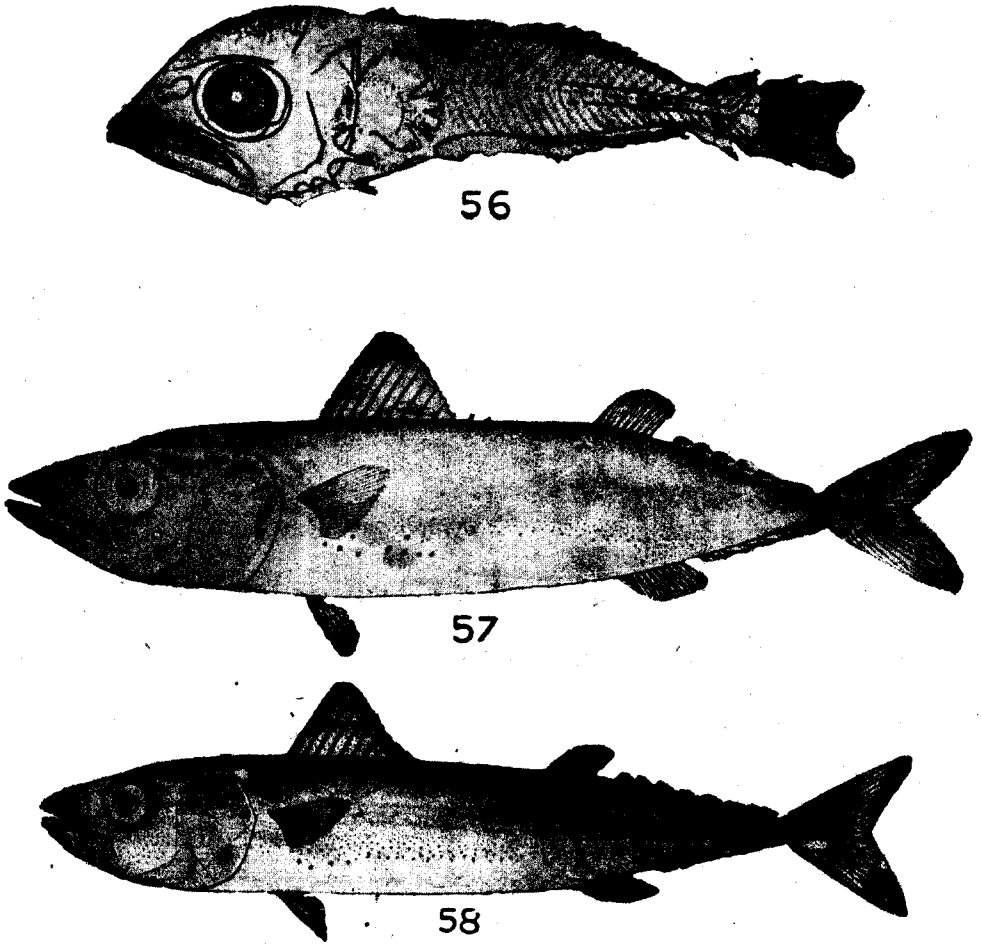
Juveniles are reported to occur occasionally along the Kerala coast. and the figure of the earliest juvenile known from Indian waters (Jones, 1960b) is reproduced in Fig. 60. In juveniles of about 80 mm. length twelve transverse bands which are incomplete ventrally are present over the body which gradually 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

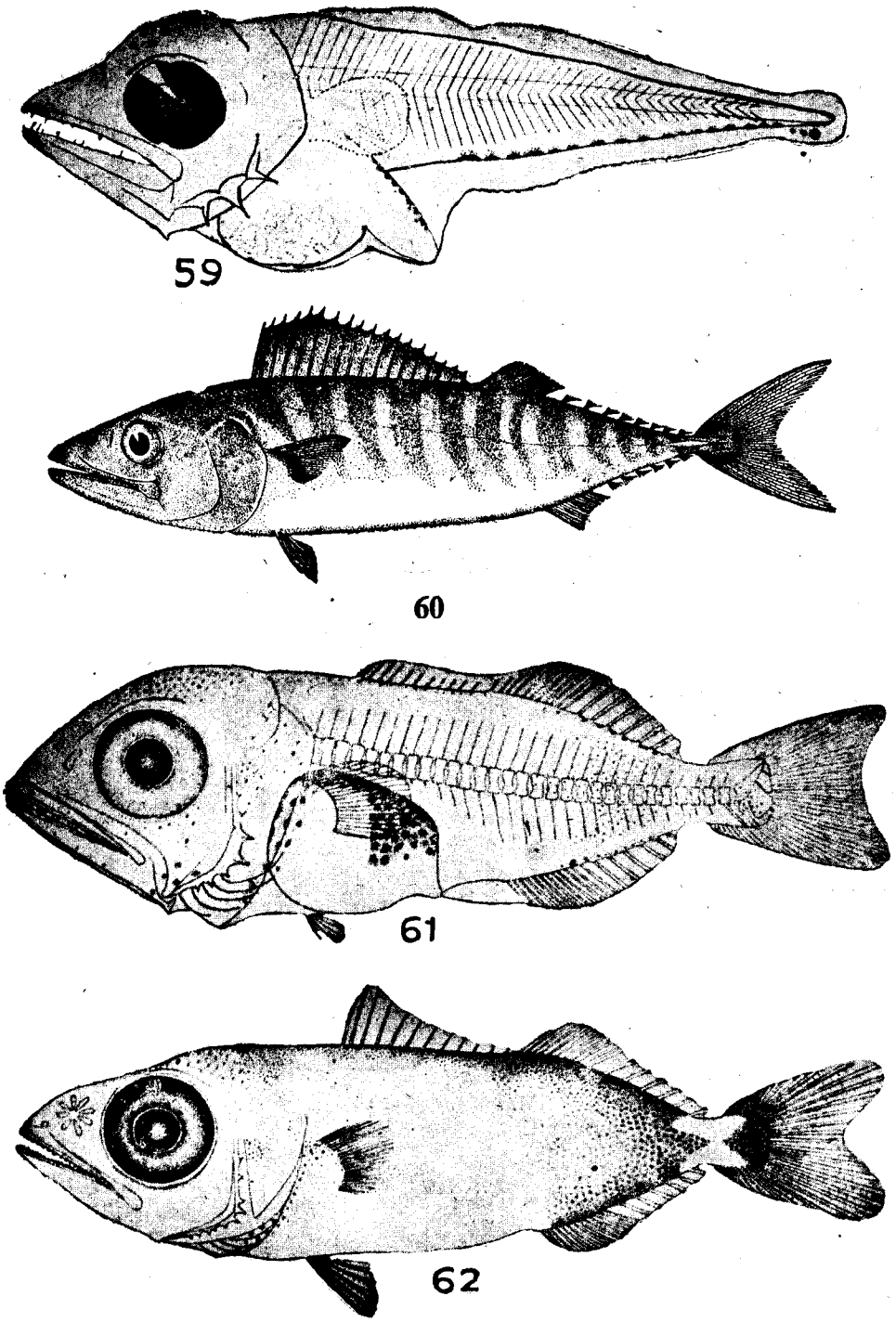


Figs. 56–58. *Auxis thynnoides*. Fig. 56.—8.1 mm. (Reproduced from Yabe and Ueyanagi 1961). Fig. 57.—33 mm., Fig. 58.—54 mm. (Reproduced from Wade, 1949)

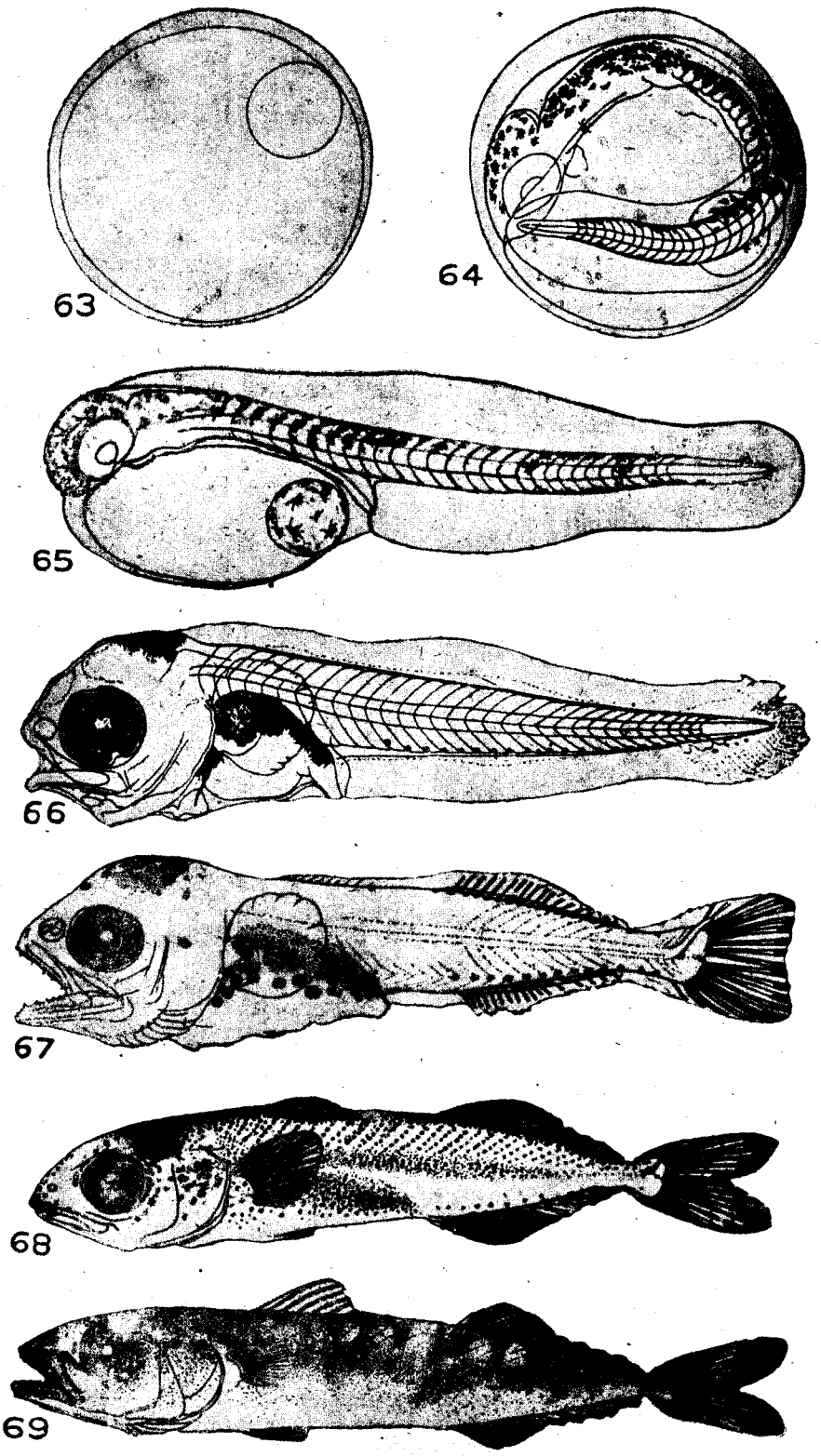
considerably and the head is about 6 in total length. Chromatophores are no more visible on the dorsal side of the body but a row of pigments is seen along the midventral line from vent to the urostyle. The peritoneum of the body cavity is well pigmented. Teeth are absent. At about 5 mm. (Fig. 66) the 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, 1961*b*). Fig. 60.—*Sarda orientalis*, 80 mm. (Reproduced from Jones, 1960*b*). Fig. 61.—*Grammatorcynus bicarinatus*, 8.5 mm., Fig. 62.—*G. bicarinatus*, 17.5 mm. (Reproduced from Wade, 1951)

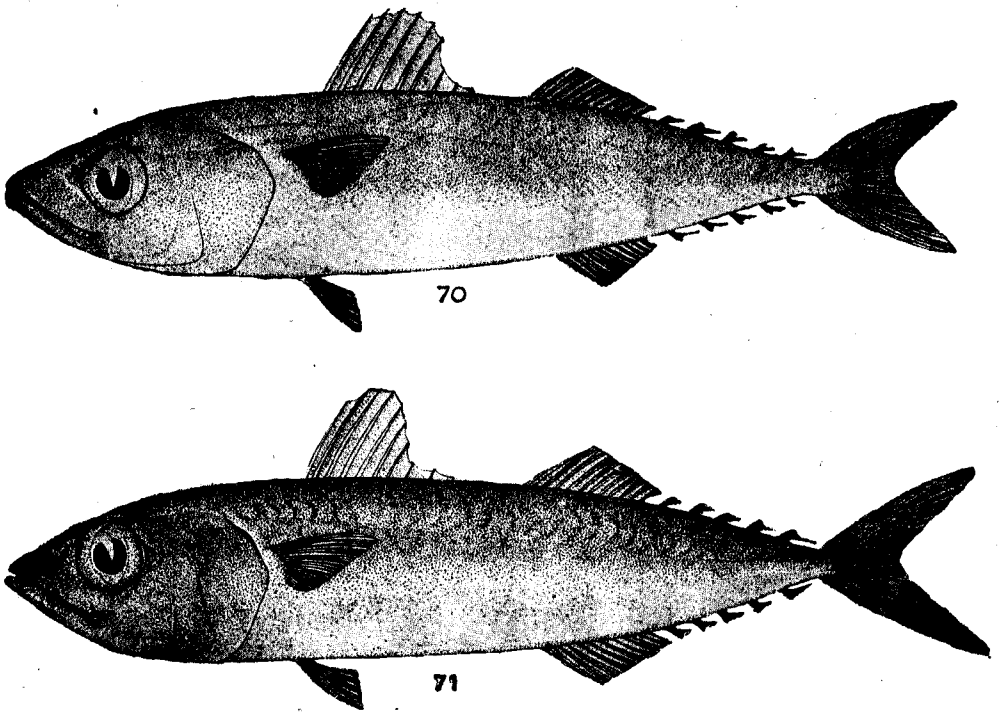


Figs. 63–69. *Scomber japonicus*. Fig. 63.—Unfertilized, ripe egg 1.1 mm., Fig. 64.—Pelagic egg with well developed embryo., Fig. 65.—Newly hatched larva 3.0 mm., Fig. 66.—5.0 mm., Fig. 67.—9.4 mm. Fig. 68.—19 mm., Fig. 69.—49.0 mm., (Reproduced from Uchida *et al.*, 1958).

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.

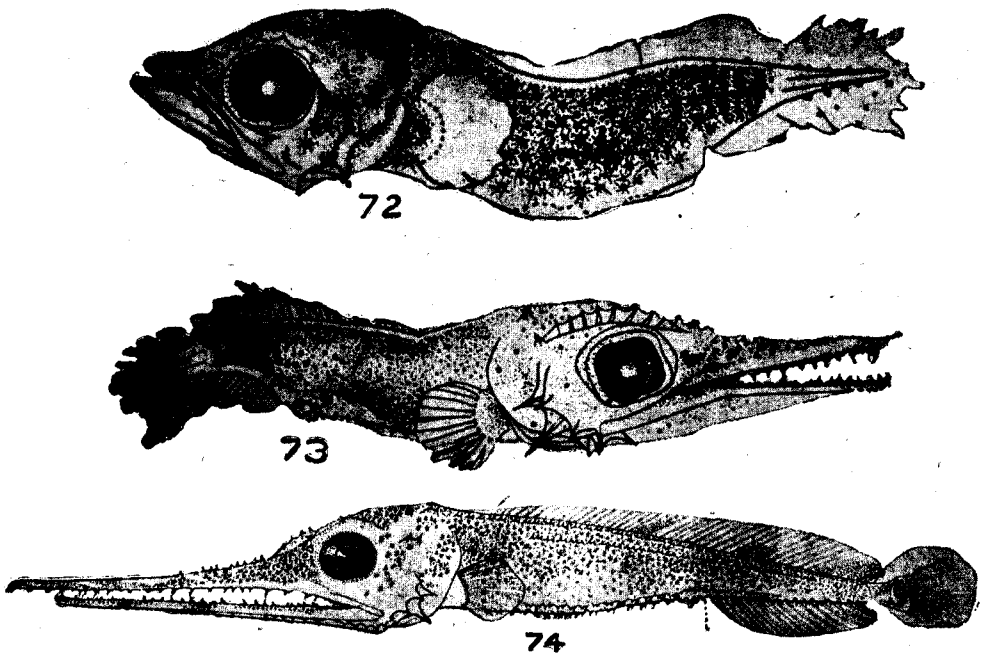
In the 8.5 mm. stage (Fig. 61) the head is large and the body is deep. The diameter of the eye is more than the length of the snout. There are spines along the edges of the preoperculum as in tuna larvae but differ from the spines of the latter in being conspicuously short. Pigmentation is present from 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

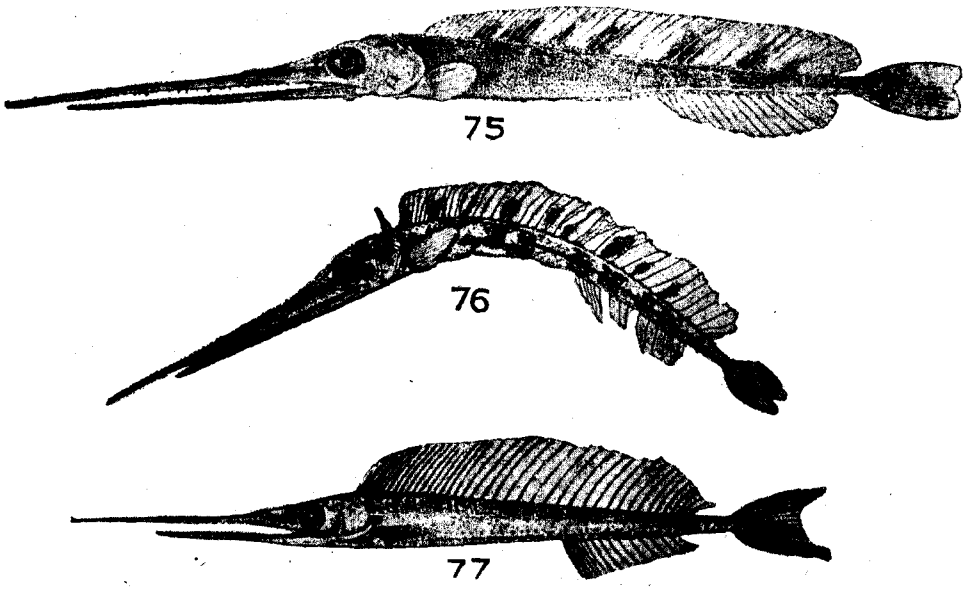
The swordfish has a wide range of distribution in the Indian, Pacific and Atlantic Oceans. Larval and juvenile stages of swordfish from the Atlantic and the Pacific have been described by Arata (1954), Nakamura *et al.* (1951), Yabe (1951) and Yabe *et al.* (1959) Taning (1955) has dealt with the distribution 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.



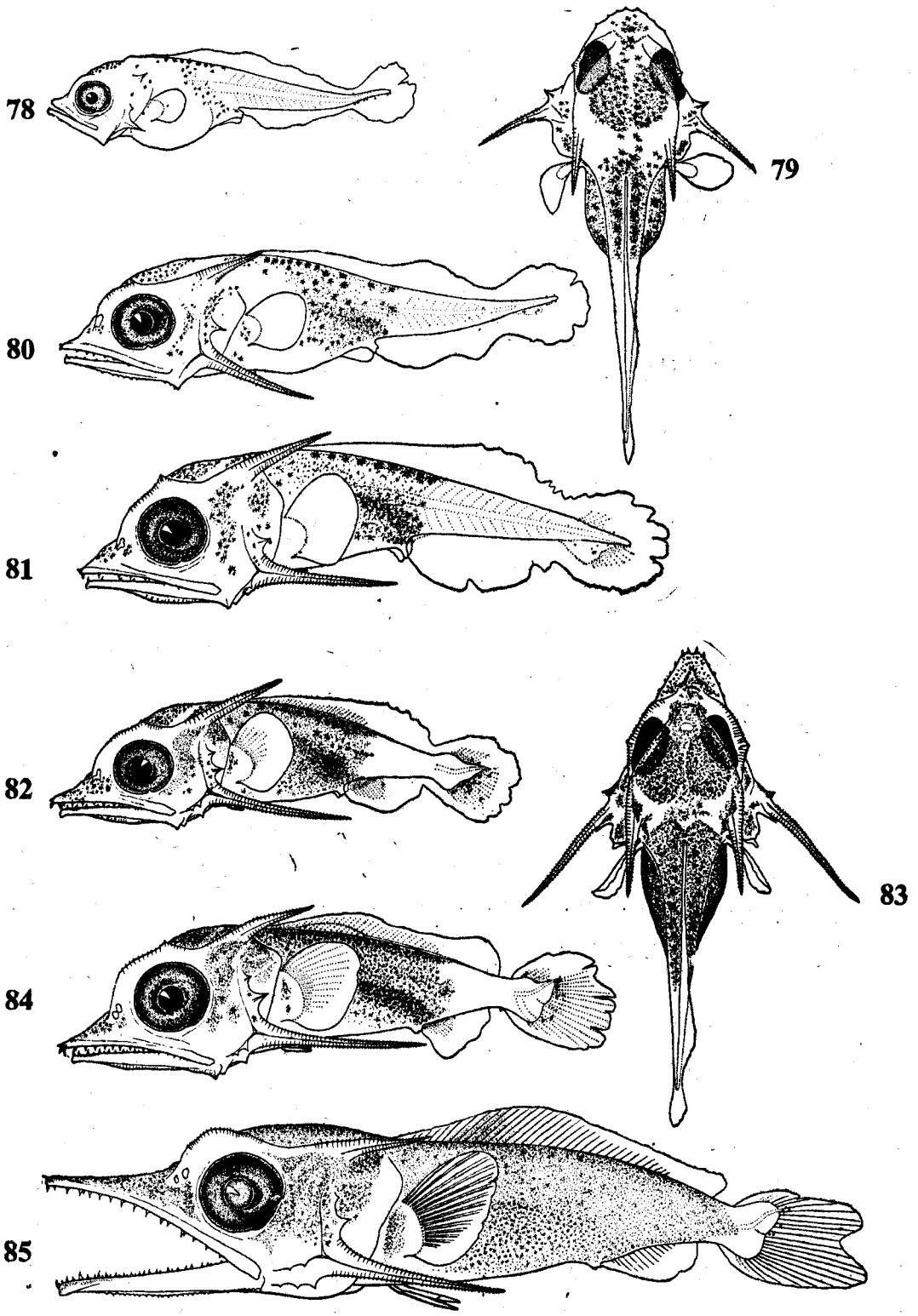
Figs. 75–77. *Xiphias gladius*. Fig. 75.—46.3 mm., (Reproduced from Taning 1955). Fig. 76.—73 mm. (Reproduced from Yabe *et al.*, 1959). Fig. 77.—252 mm. (Reproduced from Nakamura *et al.*, 1951).

FAMILY : ISTIOPHORIDAE

Istiophorus gladius (Broussonet)

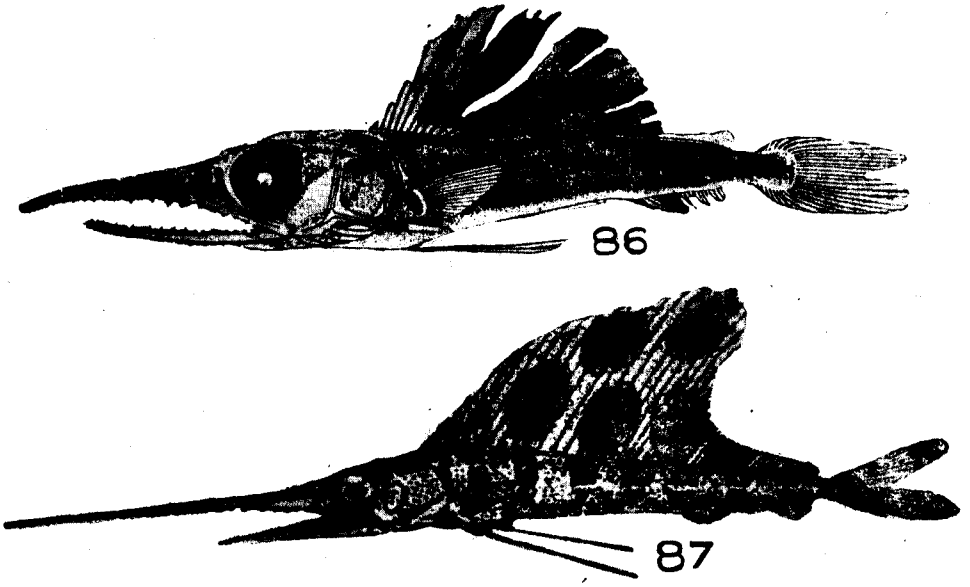
It appears that for reasons given elsewhere (Jones and Silas, 1962) the sailfish of the Pacific and the Indian Oceans comprise only of a single species. For the purposes of this study the two are considered to be synonymous and the specific name *gladius* which has priority over *orientalis* or any other 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. *Istiophorus 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, 1959*a*)

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 meauring 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.

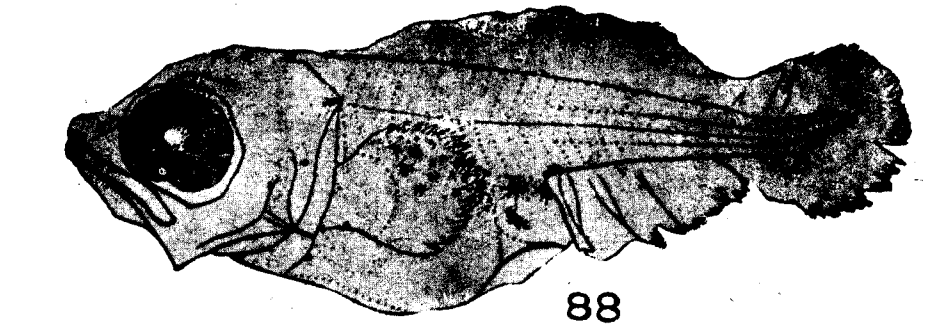


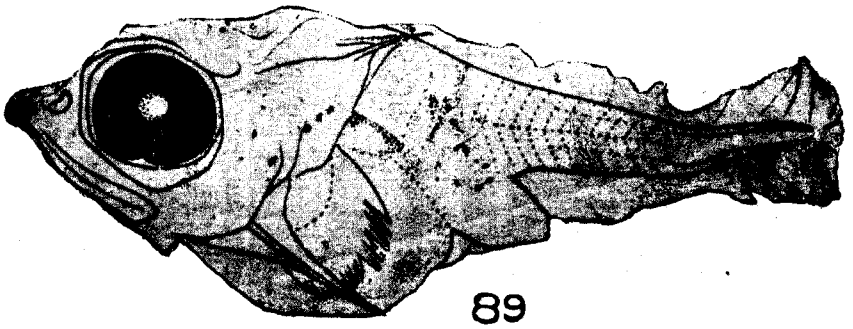
Figs. 86–87. *Istiophorus gladius*. Fig. 86.—23.5 mm., (Reproduced from Yabe, 1953*a*). Fig. 87.—127 mm. (Reproduced from Deraniyagala, 1949).

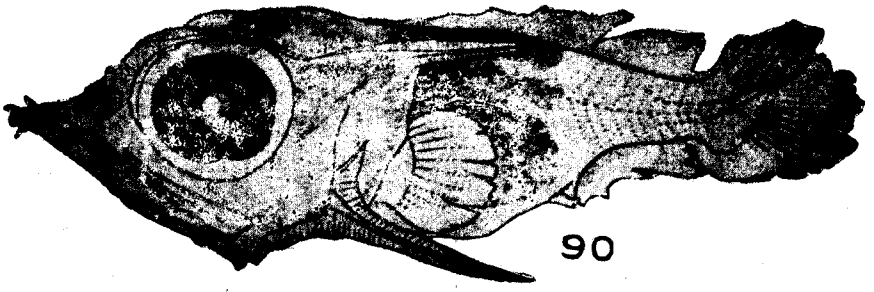
Makaira audax (Philippi)

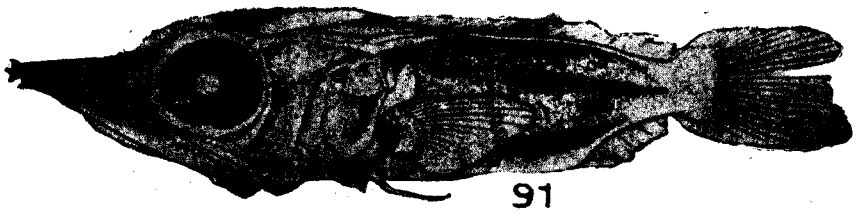
The striped marlin, *Makaira audax* is distributed in the tropical and sub-tropical areas of the Indian and Pacific Oceans in varying degrees of abundance. Larval stages of *M. mitsukurii* (=*M. audax*) collected from the North Pacific, South Pacific and the Indo-Australian Archipelago have been described 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





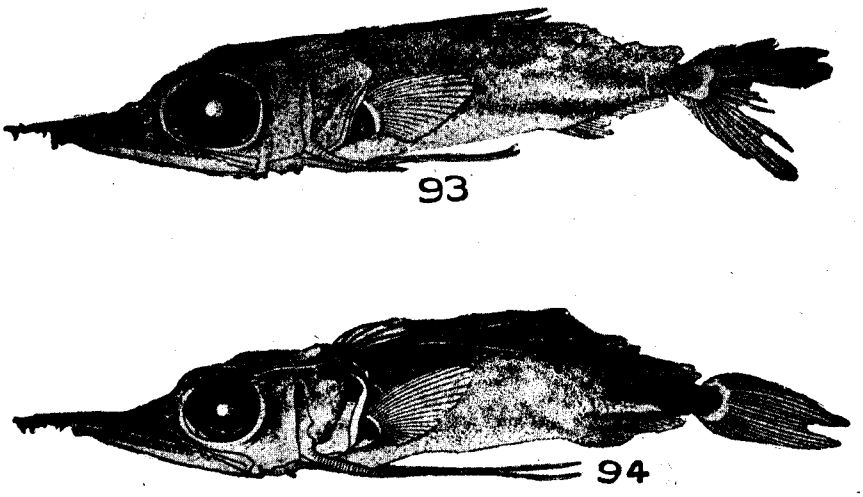






Figs. 88–92. *Makaira audax*. Fig. 88.—2.9 mm., Fig. 89.—3.1 mm., Fig. 90.—5.0 mm., Fig. 91.—7.9 mm., Fig. 92.—10 mm., (Reproduced from Ueyanagi, 1959).

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).

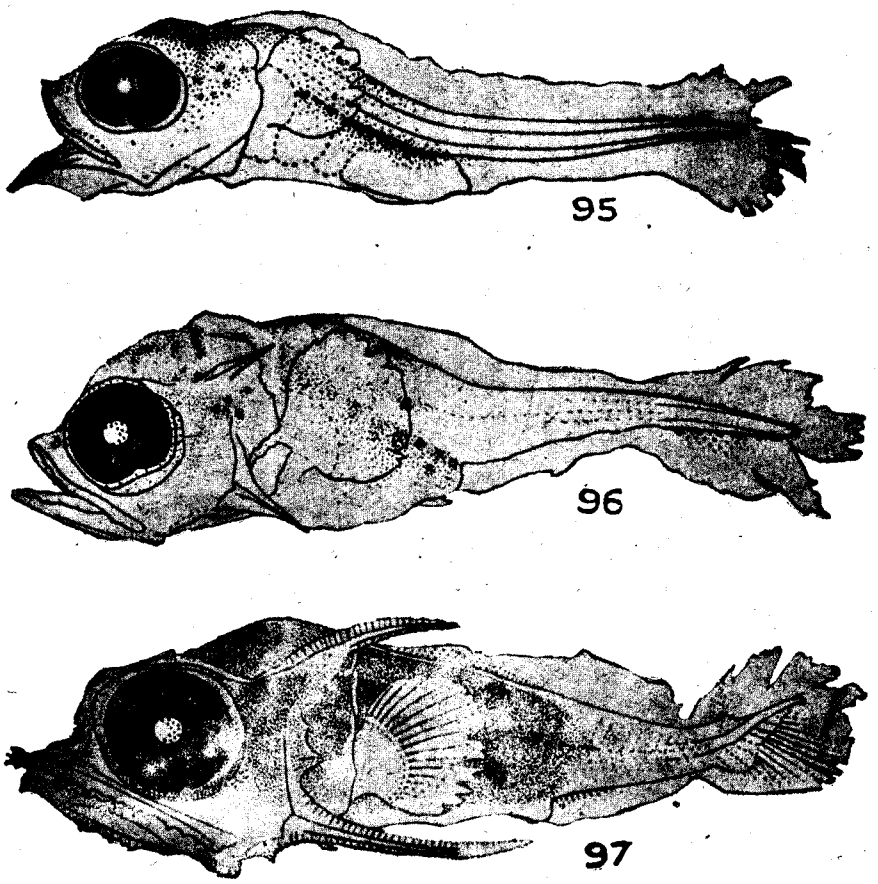
Makaira mazara (Jordan and Snyder)

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)

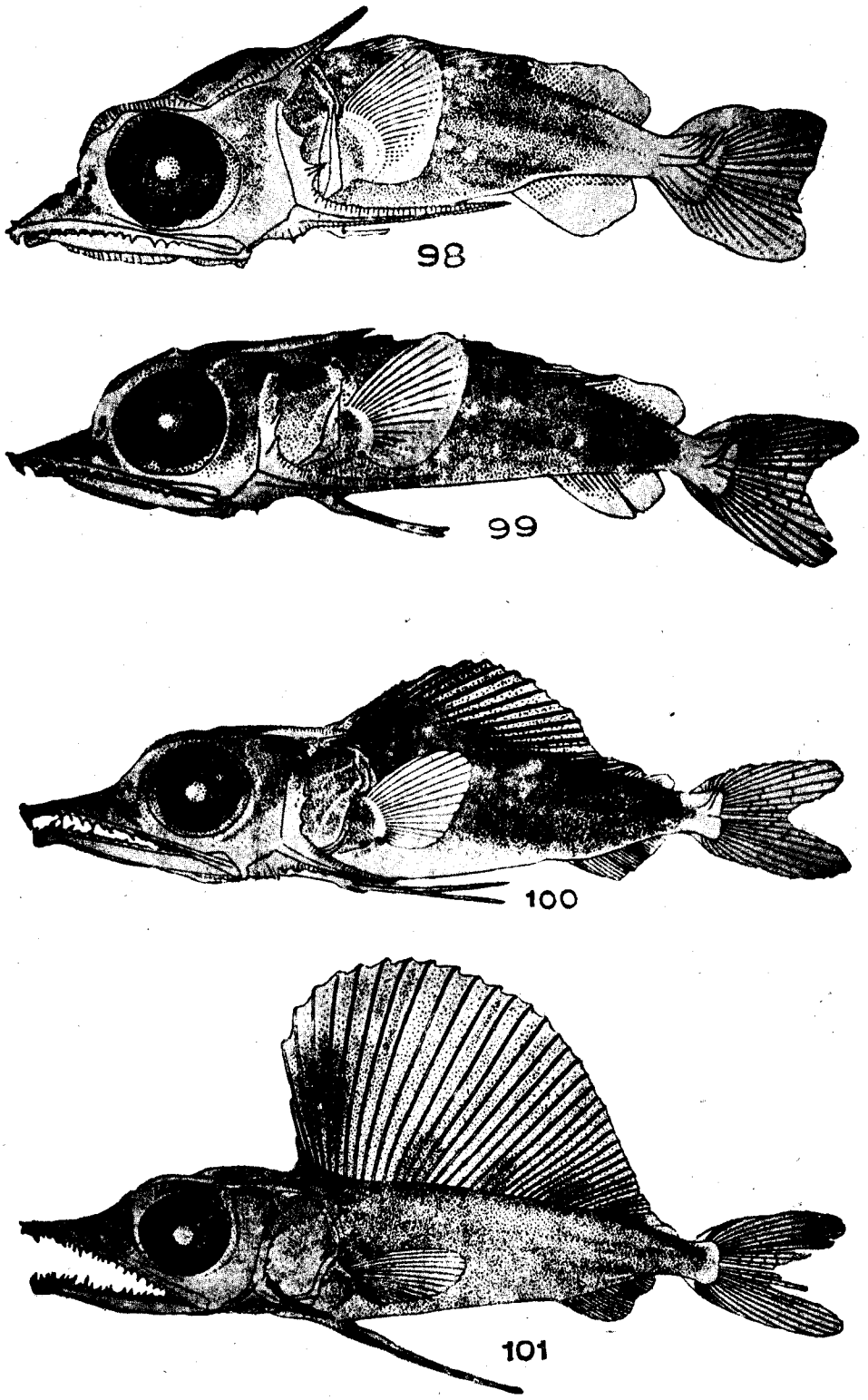
The black marlin, *Istiompax indicus* (= *Marlina marlina*) is found in comparative abundance in the Western Pacific. Its western limit in the Indian Ocean, is Tanganyika coast and Pemba.



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.

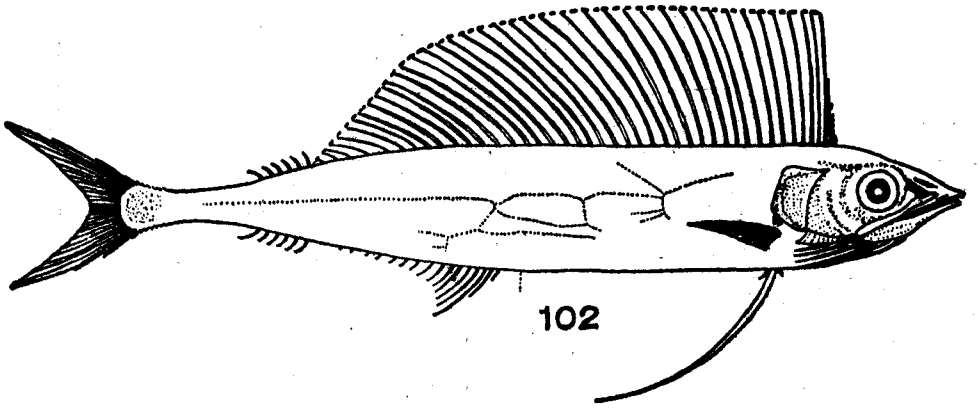
The larvae have characteristically short snout and the eye is large. Pectoral fin was found to be rigid even in postlarval stages. Centre of eye is at a higher level from the horizontal line from snout. Chromatophores are not developed in the middle portion of the body in specimen measuring 3.5 mm. and 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.

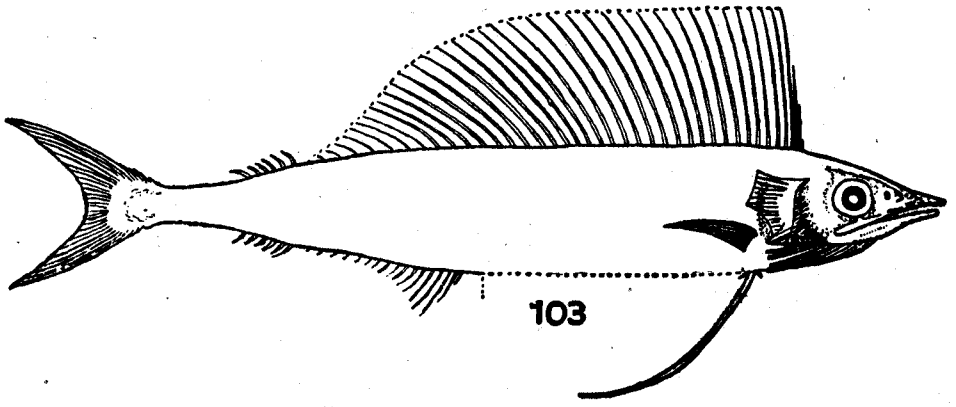


Figs. 98-101. *Makaira mazara*. Fig. 98.—8.6 mm., Fig. 99.—11.6 mm., Fig. 100.—16.3 mm., Fig. 101.—23.2 mm. (Reproduced from Ueyanagi and Yabe, 1959).

Tetrapturus angustirostris (Tanaka)

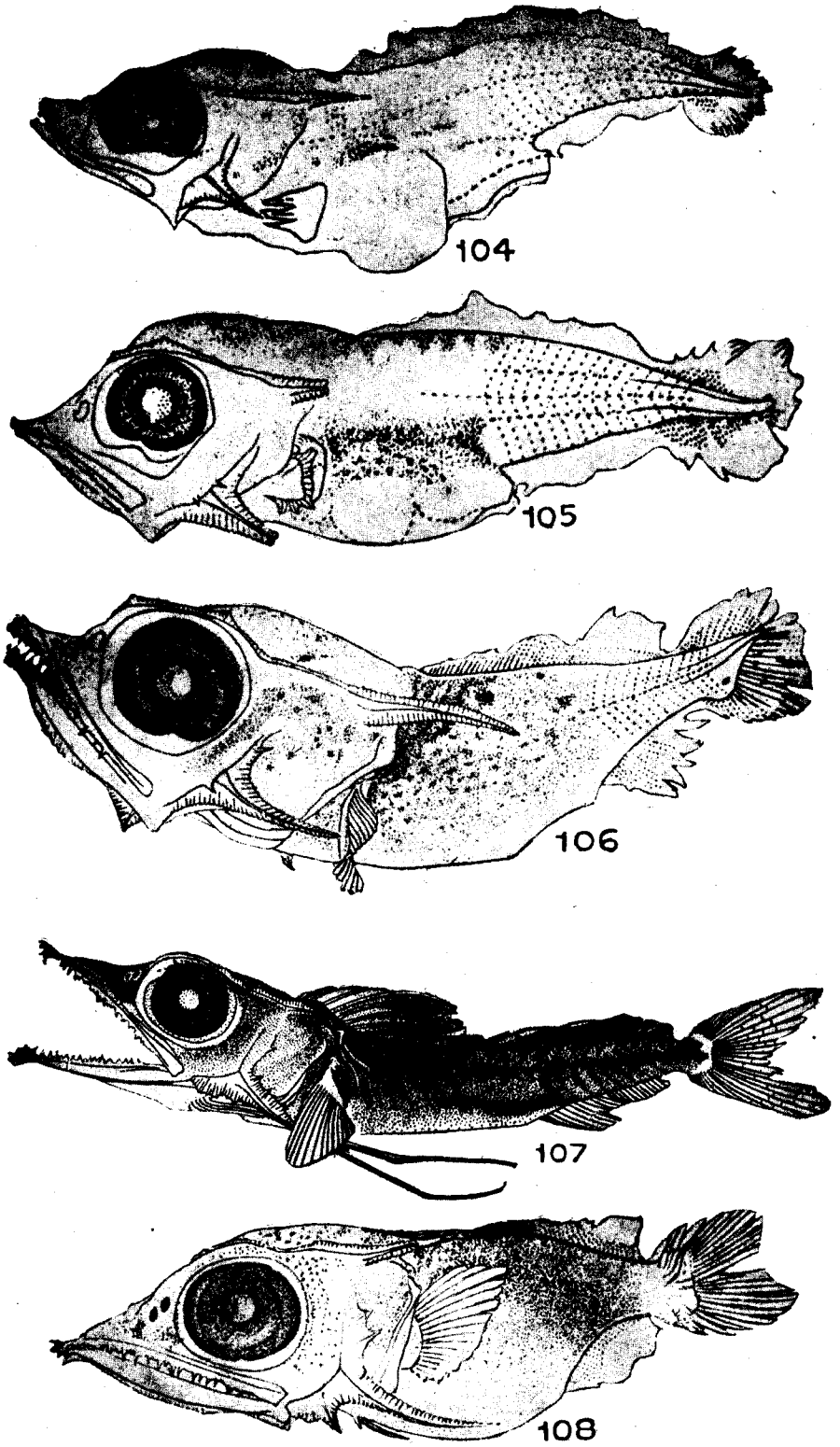
Shortnosed spearfish which is reported to occur in appreciable numbers east of Formosa and the Philippines do not form a significant fishery anywhere. Its occurrence in the Indian Ocean was reported by Yabe *et al.* (1958). We have not come across any specimen of this species from Indian waters.





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, 1960*a*). Fig. 107.—26.5 mm. (Reproduced from Ueyanagi and Yabe, 1960). Fig. 108—*Tetrapturus augustirostris*, 7.4 mm. (Reproduced from Ueyanagi, 1960*b*).

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RAPPORT SUR LA CAMPAGNE DE PÊCHE AU THON À LA PALANGRE DERIVANTE, FAITE PAR LE "MARAN ATHA"* DANS LES ENVIRONS DE MAJUNGA (CÔTE NORD-OUEST) DU 21 SEPTEMBRE AU 15 OCTOBRE 1961

BY

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Au cours de cette campagne 10 poses de ligne ont été effectuées. Les 5 premiéres poses ont été faites sous la conduite de M. Fourmanoir, les 5 dernières sous la conduite de M. Crosnier.

1°—*Conditions de travail*

Elles ont été identiques à celles exposées dans notre rapport sur la campagne des mois de Juillet et d'Août.

La ligne utilisée mesurait 4, 5 km et portait 156 hameçons, ses autres caractéristiques sont indiquées sur le schéma ci-joint.

Toutes les manoeuvres ont été exécutées à la main.

Habituellement la ligne a été filée de 5h15 à 6h00 et relevée, soit de 13h à 16h soit de 15h à 18h.

A part 2 sorties (N° 2 et N° 4) où de forts vents ont soufflé, le temps a été plus favourable qu'en Juillet et Août le régime des alizés ayant été remplacé, comme c'est la règle en cette saison, par l'alternance quotidienne des vents de terre et de mer.

2°—*Zone prospectee*

La route suivie à partir du port a toujours été le 20 vrai de manière à gagner rapidement l'accore du plateau continental ; les lignes ont été posées un peu au large de ce dernier (6 à 10 milles) soit à des distances du port de Majunga de l'ordre de 50 km.

La dérive en course de pêche, sous l'action du courant et des vents, a été de l'ordre de 1 mille à l'heure et orientée vers le Sud-Ouest.

3°—*Appats utilises*

Nous avons employé exclusivement des mulets (*Liza macrolepis*) et des "martaolana" (*Macrura kanagurta*). Ces appâts, qui se trouvent en abondance sur le marché de Majunga, donnent toute satisfaction à condition d'être choisi de taille convenable (18 au kilo environ).

*Maran Atha, dundee de 14m moteur 35cv, dépouvru de treuil la remonteê, de la lignes se faisait à la main.

4°— *Resultats*

Ils sont consignés dans le tableau ci-joint : les poids notés correspondent pour les thons et les poissons épée à des poissons vidés mais non étêtés et pour les requins à des poissons vidés et étêtés. Les poids de thons et poissons-épée dévorés par les requins et mentionnés dans l'avant-derniére colonne ne sont pas inclus dans les colonnes " Résultats " qui indiquent les poids commercialisables.

Analyse des resultats

(*a*) *Rendements*

Le rendement moyen par pose a été de 240 kg pour les thons et les poissons-épée et de 175 kg pour les requins.

Durant la campagne de Juillet et Août le rendement moyen en thon n'avait été que de 199 kg ; cette augmentation de rendement est vraisemblablement en liaison avec la diminution de l'agitation de la mer consécutive à la fin du régime des alizés. Cette relation entre l'état d'agitation de la mer et les rendements a été vérifiée à plusieurs reprises au cours des recherches que nous poursuivons depuis un an, elle est inattendue et difficilement explicable pour des lignes pêchant en profondeur.

Lors des premiéres sorties le nombre d'avançons cassés a été assez grand, ceci est dû en partie à un blocage des émerillons par le goudron utilisé pour l'entretien des avançons.

(*b*) *Repartition des especes*

Elles sont consignées dans les tableaux ci-dessous :

Espèces	Répartition en nombre exprimée en % (1)	Répartition en poids exprimée en % (Poissons vidés) (2)
Thon jaune	72,22	47,09
Thon jaune	0,69	0,37
Thon aux gros yeux	1,38	0,87
Bonite á ventre rayé	...	...
Marlin bleu	0,69	1,77
Marlin rayé	1,38	2,59
Voilier	4,86	5,21
Requin	18,75	42 05
Divers	...	...

(1) en tenant compte des poissons dévorés par les requins.

(2) sans tenir compte des poissons dévorés par les requins.

Date	Ligne filée		Ligneé relevée		Temperature			
	de	á	de	á	Surface	50 m.	100 m.	150 m.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
22— 9—61	5h10	6h00	12h45	15h30	...	25,50	25,20	19,95
25— 9—61	5h20	6h00	12h30	15h20	...	...	...	...
28— 9—61	5h30	6h10	12h40	15h35	25,40	25,25	25,05	21,75
1—10—61	5h15	6h10	13h00	16h00	...	...	...	...
4—10—61	5h30	6h20	13h00	15h45	...	...	...	...
6—10—61	5h30	6h10	14h45	17h30	26,20	25,35	24,70	20,05
8—10—61	5h30	6h10	14h50	17h45	26,12	25,32	25,00	20,55
11—10—61	5h10	6h00	14h50	17h50	26,20	25,80	24,85	20,65
13—10—61	5h10	6h00	15h00	18h10	26,80	25,65	24,60	20,80
15—10—61	5h10	6h00	14h50	17h20	26,85	25,20	23,30	20,80

Date	Salinité				Résultats en Kg.			Poids en Kg. de Thons et Poissons-Epée dévoré's par les requins	Nombre d'avan-cons cassés
	Surface	50 m.	100 m.	150 m.	Thons	Poissons Epée	Requins		
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
22— 9—61	...	...	...	...	318	100	240	100	5
25— 9—61	...	...	...	...	29	42	190	60	5
28— 9—61	...	...	...	...	90	0	60	0	2
1—10—61	...	...	...	...	185	0	200	30	0
4—10—61	...	...	...	...	282	78	245	60	0
6—10—61	35,30	35,30	35,31	35,23	168	0	196	24	1
8—10—61	35,27	35,30	35,39	35,24	102	40	201	30	0
11—10—61	35,28	35,29	35,26	35,24	350	0	61	48	1
13—10—61	35,30	35,28	35,22	35,23	399	92	120	118	2
15—10—61	35,29	35,27	35,23	35,19	125	0	244	15	0

En ne considérant que les thons et les poissons-épée les répartitions deviennent :

Espéces	Répartition en nombre exprimée en %	Répartition en poids exprimée en %
Thon jaune	88,88	81,29
Thon blanc	0,85	0,65
Thon aux gros yeux	1,70	1,50
Marlin bleu	0,85	3,05
Marlin rayé	1,70	4,48
Voilier	5,98	9,00

Par rapport aux captures faites en Juillet et Août on note une diminution du Thon blanc (qui n'a jamais été abondant). La raréfaction de cette espéce ne semble pas dûe à des variations de température puisque celles que nous avons notées au cours de cette campagne sont sensiblement identiques à celles relevées en Juillet et Août.

Pour les requins les répartitions sont les suivantes :

Espéces	Répartition en nombre exprimée en %	Répartition en poids exprimée en % (Poissons vidés et étêtés)
Isurus oxyrinchus	29,62	33,55
Carcharinus floridanus	37,03	32,54
Prionace glauca	11,11	9,76
Galeocerdo cuvier	7,40	7,46
Alopias superciliosus	3,70	6,17
Carcharinus iranjae	3,70	5,61
Alopias pelagicus	7,40	4,88

Signalons qu'un *Isurus oxyrinchus* et un *Carcharinus iranjae*, tous deux de grande taille (200 kg environ), se sont détachés au moment d'être mis à bord.

L'abondance d'*Isurus oxyrinchus* en fin de saison fraiche, déjà signalée par M. Fourmanoir, est confirmée.

(*c*) *Poids des captures*

Tous les chiffres donnés dans ce paragraphe correspondent à des poissons vidés.

L'unique Thon blanc capturé pesait 16 kg et les 2 Thons aux gros yeux 15 et 23 kg.

Pour le Thon jaune la répartition pour les 5 dernières sorties a été la suivante :

Poids en kg ...	4	5	6	7	9	14	15	16	17	18	19	23	24	29	30	31	32	33	34	35	37	38	40	42	45
Fréquence ..	1	1	4	1	1	1	2	1	6	2	4	1	1	2	1	1	3	4	3	1	1	1	1	1	1

Les 2 Marlins rayés capturés pesaient 54 et 66 kg, l'unique Marlin bleu hissé à bord avait un poids de 75 kg. Quant aux Voiliers leur poids sont donnés dans le tableau ci-dessous :

Poids en kg ...	12	28	29	34	38	40
Fréquence ...	1	1	1	1	1	2

(*d*) *Repartition des captures sur les hamecons*

Elle est indiquée dans le tableau ci-dessous établi avec les résultats des 5 dernières sorties et en tenant compte des poissons dévorés par les requins. Les hameçons compris entre 2 bouées successives sont numérotés de 1 à 13.

N° de l'hameccn ..	1	2	3	4	5	6	7	8	9	10	11	12	13
Especes :													
Thon jaune ...	1	4	6	4	8	6	6	4	3	4	2	4	2
Thon aux gros yeux ...	0	0	0	0	0	0	1	0	0	0	0	0	1
Poissons-épée ...	2	0	1	0	0	0	0	0	0	0	0	0	0
Requin	2	0	1	0	0	1	0	1	4	1	1	1	1

Les répartitions suivant les hameçons sont plus homogènes que lors des essais de Juillet et Août mais le faible nombre de captures, sur lequel est basé ce tableau, le rend assez peu significatif à notre avis.

Dans le tableau ci-dessous nous donnons la répartition suivant les hameçons des poids des thons jaunes. Chaque chiffre correspond au poids d'un exemplaire, les chiffres entre parenthèses se rapportent à des thons dévorés par les requins et dont les poids ont été estimés.

N° de l'hameçon	1	2	3	4	5	6	7	8	9	10	11	12	13
Poids des poissons vidés (en kg)	4	19–(20)	(33) 16–19 (40) (40)–6	32–42 18–5	(20) 29–37 34–(6) 34–(16) 45	40–33 34–(32) 6–32	34–6 17–(15) 17–(15)	29–17 33–7	19–(15) 6–	(20)–6 23 16	6–33	32–12 6–34	9–5

(*e*) *Contenus stomacaux*

Ils étaient très altérés, et essentiellement formés de petits calmars. Quelques *Chiasmodon niger* ont été trouvés. A noter l'absence totals d'Amphipodes pélagiques.

(*f*) *Periodes d'activite quotidienne du thon du point de vue alimentaire.*

Les visites de lignes faites en cours de pêche laissent supposer que le thon mord à l'hameçon du lever du soleil à 10h00 et de 15h00 au coucher du soleil. Les heures les plus favorables à la pêche seraient donc les mêmes que celles notées pour la traîne.

CONCLUSIONS

Cette campagne a confirmé l'intérêt que présente la pêche à la longue-ligne dans la région de Majunga.

Pour le thon les rendements ont été plus élevés qu'en Juillet et Août, comme nous l'avons indiqué ceci semble être en relation avec l'état de la mer. Il est vraisemblable que durant les jours de grand calme de la saison chaude des rendements encore meilleurs pourront être obtenus.

Cette campagne où il a été utilisé exclusivement des appâts trouvés sur place montre d'autre part que le bottage des lignes, à Majunga ne pose pas de problème.

Le " MARAN ATHA "-devant travailler aux Comores en Novembre et Décembre, les recherches dans la règion de Majunga seront poursuivies vraisemblablement en Janvier.

2. *ESPADONS* (Bilfishes) *Istiophorides*

Cotes Ouest de Madagascar.

L'Utilisation de la ligne dérivante de 150 hameçons à partir de 1960 a permis d'obtenir les premiers renseignements précis, sur les *Istiophorides.*

Les appats Nemipterus, Liza macrolepis, Rastrelliger kanagurta ont été les memes que pour les Thons.*

Au cours de soixante sorties la répartition a été la suivante :

Istiophorus gladius ou " Voilier" 30 exemplaires, poids moyen 31 kg poids maximum 45 kg.

Makaira nigricans ou Marlin bleu 29 exemplaires poids moyen 60 kg poids maximum 120 kg dont 11 endommagés par les Requins.

Makaira mitsukurii ou Marlin rayé 4 exemplaires poids moyen 58 kg poids maximum 68 kg.

Istiompax indicus ou Marlin noir-Un exemplaire de 145 kg.

Nous n'avons pas remarqué de changement dans la répartition et la fréquence des différentes espèces d'Istiophoridés en fonction des saisons.

COMORES.

Noms locaux : Mbassi Kouri (Istiophorus) Ndwaro (Makaira)

Grande Comore

La région Sud-Ouest ets très réputée pour les Espadons. Les villages d'Iconi, Salimani, Fomboni sont spécialisés dans la pêche en dérive des gros poissons pélagiques du large parmi lesquels les Istiophoridés constituent la moitié des prises. Une centaine de pirogues à double balancier pratiquent la pèche jusqu'à 7 miles au large, le principal appat est un *Cypselurus* pêché à l'aube avec une fine ligne en Nylon traînée an ralenti. Les lignes sont encore en coton, elles sont rendues imperméables et imputrescibles après 5 à 7 applications de la sève d'une écorce fraîche aux remarquables propriétés tannantes. La reserve de ligne est de 300 à 400 métres.

Le Voilier *Istiophorus gladius* constitute 45% des prises, *Makaira nigricans* 40%, le Marlin rayé 15% il est plus commun qu'au Nord Ouest de Madagascar.

Anjouan.

Cinq ou sept pirogues seulement capturent occasionnellement les Espadons avec *Hemirhamphus, Sardinella, Selar* ou *Caesio* p. sp.

* Confer. La Pêche du Thon à Madagascar, Bull. Madagascar N°185.

En 1960 seulement 40 voiliers et 21 Marlins ont été débarqués à Mutsamudu et Pomoni.

Reunion

Nom local : Empereurs.

La pêche est pratiquée à la traine avec des lignes en chanvre non tannées et également avec de fortes lignes en Nylon. L'appat est *Selar crumenophtalmus* ou *Decapterus p. sp.*

Le *Marlin bleu* est l'espèce dominante, le poids moyen des captures est de 85 kg. Le Marlin rayé est plus rare qu'à Madagascar et aux Comores probablement en relation avec les eaux plus froides.

3. *MAQUEREAUX*

Rastrelliger kanagurta (Russel)

Nous n'avons observé qu'une seule espèce de Rastrelliger dans les eaux de Madagascar, répandue du Nord au Sud. Au Nord Ouest elle est présente toute l'année au Sud (Fort-Dauphin) elle se rérefie en saison fraîche (à partir de Mai) période qui correspond en général à l'arrivée des bancs de petit *Scomber japonicus.*

Les pêcheries n'ont été observées qu'au Nord-Ouest de Madagascar où la plus grande quantité des Rastrelliger est retenue par les barrages à mer descendante pendant les grandes marées de vive-eau.

Les pêches de Rastrelliger à l'aide de filets tramails simples ou mixtes ne sont qu'expérimentales. La station marine de Nosy-Bé a également procédé en 1958 à des pêches nocturnes à la lumière en utilisant le filet carré dit Blanket-Net relevé à l'apparition du poisson. Au cours de vingt sorties Rastrelliger à été le poisson dominant à 80%, la moyenne des prises a été de 150 kg par nuit.

Signalons que le filet mesurait 16 mètres de côté. en plus de la source lumineuse la remontée en surface était facilitée par un appâtage avec de la chair et des foies de Tunnidés et Carangidés.

Les autres années il nous a paru moins abondant que *Selar cumenophtalmus* au cours des observations de nuit. Dans la région de Nosy-Bé, les bancs de Rastrelliger de 15 à 50 m. de long, évoluent rapidement en des sens alternés au dessus des fonds de 8 à 12 mètres, les opercules largement ouverts pour la filtration de macroplancton et microplancton. Les individus de taille moyenne 77-19 cm ont été observés en bancs de 100 à 1000 les exemplaires de grande taille 28-25 cm ne se déplacent souvent que par bandes d'une quinzaine.

Dans la région Ouest de Madagascar où les eaux sont troublées par les argiles en suspension une petite quantité de Rastrelliger est prise en chalutant sur les fonds à crevettes (P. indicus, monodon, semisulcatués) inférieurs à 9 mètres.

Aux Comores Rastrelliger n'est connu que dans le lagon de Mayote où il est abondant, il n'a pas été signalé à la Réunion.

Scomber japonicus Houttuyn

L'espèce n'est connu qu'à Fort-Dauphin, une petite quantité est prise à la traine pour être utilisée ensuite comme appat.

Les exemplaires observés la 2ème quinzaine d'Avril 1960 mesuraient 22 cm en moyenne.

CYBIIDES Seer fishes—Faux thons, Maguereau Bonite

I. *Cybium Commersoni (Lecepede)*

L'espèce est répandue sur toutes les côtes de Madagascar les noms locaux sont " ANGOHO " (prononcer Angu) au Nord Ouest, " LAMATRA " à l'Ouest au Sud et à l'Est.

Les principaux centres de pêche sont Tuléar, Morombé au Sud Ouest ; Analalava, Nosy-Bé, Nosy Mitsio au Nord Ouest. Sur le versant Est exposé au mauvais temps la pêche se pratique en baie d'Antongil et à Fort-Dauphin au Sud Est.

(*a*) *Cullear et villages voisins* (S. W. Madagascar)

Cette région est exploitée par les pêcheurs Vezo qui disposent d'une centaine de pirogues. La pêche s'effectue généralement à l'extérieur du récif en utilisant comme appat des bandes argentées du " Hareng des Indes ", *Chirocentrus dorab.*

Les captures les plus abondantes ont lieu d'octobre à Janvier. Le poids moyen est de 11 kg. L'aire de dispersion du Cybium est limitée par suite de l'éffondrement immédiat du plateau continental en dehors du récif barrière.

(*b*) *Region Nord Ouest*

Pendant la période de reproduction de Décembre à Février on capture peu de Cybium. Du mois de Mars au mois de Juin sa répartition est liée à celle des hauts-fonds coralliens de 10 à 20 m. situés à la limite du plateau continental. La dispersion est ensuite progressive, à partir d'Octobre on le rencontre dans toutes les eaux claires du plateau continental.

A Nosy-Bé, sa pêche est surtout intéressante de Juillet à Septembre, elle est faite principalement en dérive au dessus des fonds d'une trentaine de métres avec un *Neripterus* entier comme appat et plus rarement avec des morceaux de Calmars (Loligo). Dans une matinée de pêche une pirogue prend en moyenne quatre Cybium de 7 kg.

De 1956 à 1958, deux bateaux de pêche européens basés entre Majunga et Nosy-Bé ont obtenu à la traine des rendements moyens de 120 kg de Cybium commersoni dans la matinée de pêche lorsque le vent de Secteur Est restait modéré. La ligne de traîne en chanvre mesurait 30 à 50 m., le bas de la ligne était constitué d'un fil d'acier de 70—80/100 de mm long de 2 m., l'appat artificiel était fourni par des crins colorés en jaune rouge et bleu fixé aur hameçon Mustad pour le Thon de 6/0.

A l'Est de Majunga on observe en Octobre des concentrations de petits Cybium de 2 à 3 kg, une cinquantaine peuvent être pris à la traine avec une embarcation motorisée dans la matinée ou la soirée.

Dans cette région les fonds de nature sableux sont peu importants 12 à 15 métres.

(*c*) *Region Sud-Est, Fort-Dauphin.*

Probablement en relation avec les eaux plus froides, 23° en Août, les Cybium dans cette région sont de grande taille, à Fort-Dauphin le poids moyen approche de 15 kg en fin de saison chaude. Da pêche est pratiquée par une trentaine de pirogues sans balancier avec comme principal appat Hemirhamphus et Rastrelliger en saison chaude, Scomber japonicus au début de la saison fraîche.

* * *

A Madagascar C. Commersoni est le poisson qui a la première place dans l'économie de la pêche. Presque toute la production est vendue salée et sèchée.

Aux Iles Comores C. Commersoni ne se rencontre que dans le lagon de Mayotte. Peu abondant il est rare d'en prendre plus de deux au cours d'une matinée de traine. L'espèce n'a jamais été pêchée dans les autres îles Anjouan et Grande Comore exposées au large.

II. *Cybium lineolatus* (C. V.)

La distribution de *C. lineolatus* à Madagascar est encore mal connue, au Nord Ouest où les nombreuses baies favorisent les concentrations, il est désigné sous le nom de " Tefo ".

Contrairement à *Cybium Commersoni* on ne le prend qu'en très petit nombre à la traine à l'aube ou le soir, ses proies sont généralement plus petites.

Un quart seulement des Tefo est pris à la ligne, surtout pendant les mois d'Avril et Mai où il se rassemble pour chasser le *Anchoviella indicus*. Les trois quarts sont pris au filet de dérive et plus rarement au filet fixe. La méthode au filet semble avoir été introduite par les Arabes, elle repose sur la tendance qu'a *C. lineolatus* à remonter la nuit en surface ce qui permet d'utiliser avec succès des filets de faible hauteur.

Il y a quelques années les Malgaches pêchaient avec un filet de 50 m. de long et de 1,80 m. de haut en coton, beaucoup ont maintenant adopté le filet en Nylon que nous leur avons proposé dont les caractéristiques sont les suivantes : longueur 200m., maille de 6 m/m de côté, fil Nylon 1615 m. au kilo, hauteur 33 mailles 1/2. Pour faciliter la mise à l'eau le filet est légèrement plombé, un plomb de 40 g. tous les 9 métres environ. Une forte pirogue peut utiliser 2 filets, la profondeur au dessus de laquelle s'effectue la dérive ne doit pas dépasser 16 m. la meilleur profondeur est entre 6 et 8 métres ce qui amène parfois près des mangroves.

La saison de pêche s'étend de Mars à fin Août avec un rendement plus élevé en Mai et Juillet (60 kg par nuit). En 1961 la moyenne des sorties n'a pas dépassé 10 jours par mois en saison fraiche par suite de la fréquence des vents d'Est et du Sud et l'interruption normale de la pêche de nuit lorsque la lune est levée.

En Avril la dimension moyenne (longueur jusqu'à l'échancrure caudale) des "Tefo" pris au filet était de 72 cm, en juillet elle était de 75 cm. Le plus gros exemplaire mesurait 85 cm.

Les passages de *C. lineolatus* correspondent souvent à ceux de *Chorinemus lysan* qui est prise en quantité égale au filet de dérive. Seuls de très jeune *C. commersoni* sont parfois trouvés dans les filets principalement en Septembre et Octobre.

III. *Acanthocybium solandri* (Cuvier) et Valenciennes.

MADAGASCAR

Le plateau continental étant très étendu à l'Ouest de Madagascar les références d'A. Solandri espèce vivant au bord des grands fonds sont limitées aux captures de non bateaux de recherche: Seulement 6 exemplaires en cinq ans dont deux pris à la ligne dérivante à 7 et 12 miles de la rupture de pente continentale et quatre à la traine. Des expériences de trois ans, représentant 100 sorties de pêche en dérive et au mouillage au dessus des fonds de 130 à 300 m du Nord-Ouest de Madagascar, sans aucune observation d'A. Solandri ont prövé qne les eaux Malgaches étaient peu favorable à l'espèce.

De la côte sud pourtant plus accore et de la côte Est aucune indication sur la présence d'A. Solandri ne nous est parvenue. Par contre les conditions géographiques favorables à Acanthocybium se rencontrent aux Comores et à la Réunion.

COMORES—Nom local : Gourou

Pour ces îles presque dépourvues de plate forme insulaire (à l'exception de Mohéli) l'Acanthocybium est un poisson de très grand intérêt. Des lieux de concentration ont été observés à la pointe Nord d'Anjouan à la Grande Comore et à Mayotte tout près de la bordure extérieure du récif barrière. Dans les eaux taès claires de ces îles des groupes de 5 à 10 Acanthocybium ont été vus à une vingtaine de métres de profondeur.

A Anjouan, lorsque la mer est calme à la pointe Nord ou la pointe Ouest, trois A. Solandri de 17 kg en moyenne peuvent être pris en deux heures de traine matinale ou en soirée. La profondeur optimum varie de 150 à 600 métres, atteinte souvent à moins d'un kilométre de la côte.

La répartition vers le large est comparable à celle du brochet de mer Sphyraena barrascouda elle semble atteindre une quinzaine de miles à partir de la rupture de pente.

REUNION—Nom local : Thon banane, Thon blanc.

Le " Thon banane " occupe les eaux de la Réunion toute l'année. Au cours d'une mission à la Réunion en juillet—Août 1960 le total des captures pour douze petites barques pourvues d'un moteur hors-bord était de 6 Acanthocybium de 24 kg en moyenne au cours de deux heures de traine. D'après Maurice (1949) les rendements sont beaucoup plus élevés à partir d'Octobre, en Novembre des très grands bancs d'Acanthocybium auraient été observés.

TUNAS (GENUS *THUNNUS*) OF THE WESTERN NORTH ATLANTIC*

PART I. Key to the species of *Thunnus* based on skeletal and visceral anatomy.

BY

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INTRODUCTION

A study of the biology and distribution of tunas of the western North Atlantic was initiated by the Woods Hole Oceanographic Institution in 1950 in response to a need for a comprehensive investigation of tuna populations of this area and the increased interest of sport and commercial fishermen. Our field studies have been concentrated in waters between Bermuda, Nova Scotia, the east coast of the United States and the West Indies and, to a lesser extent, in the Gulf of Mexico and the Caribbean Sea. Fresh and preserved material from the eastern Atlantic and the eastern Pacific have been compared with western North Atlantic species. We have also studied much material in museums and other laboratories.

Investigations have included morphometric and meristic studies, year-round records of body and gonad condition, compilation of catch statistics and size-frequency data, and distributional information gathered through exploratory fishing, correspondence, interviews, questionnaires, and a cooperative tagging program. Recently, studies on the identification of larval and juvenile tunas and analyses on the maturity of gonads from histological preparations have been initiated.

The classification of tunas and the tuna-like fishes, a controversial topic for many years, continues to elicit divergent opinions on the relative significance of particular characters and mutual relationships.

For this paper, we describe and assign six known species to the one genus, *Thunnus*. Such an assignment was proposed at the Pacific Tuna Biology Conference held in Honolulu in August 1961. Thus, the bluefin of the Atlantic is *T. thynnus thynnus*, the bluefin of the Pacific is *T. thynnus orientalis*, the albacore of all oceans is *T. alalunga*, the bigeye of all oceans is *T. obesus*, the blackfin of the western Atlantic is *T. atlanticus* and the Pacific longtail tuna is *T. tonggol*. We recognize no subgenera nor do we attempt a familial assignment for this genus. Common names used for the species follow the American Fisheries Society list of names (1960).

METHODS AND MATERIALS

The classical studies on Pacific tunas published by Kishinouye (1923) and Godsil and Byers (1944) need to be duplicated on tunas of the western North Atlantic Ocean. Such a formidable undertaking requires much uninterrupted time and many freshly caught specimens. Lacking both requirements, we prepared the following key (Table I) utilizing information gained from X-rays of 80 specimens (preserved or fresh), partial dissections of 73 preserved

* Contribution No. 1256 from the Woods Hole Oceanographic Institution. Supported by grants 19601, F. N. on P. 6172 and 8339 from the National Science Foundation.

specimens, and complete dissections made on fresh specimens of 2 *T. thynnus*, 2 *T. atlanticus*, and 1 each of *T. obesus*, *T. albacares* and *T. alalunga*.

In addition, at the laboratory of Dr. Robert Gibbs of Boston University, skeletal material of all species of western North Atlantic tuna were studied, as well as skulls of 2 *Parathunnus mebachi* described by Godsil and Byers (1944). Mather (author of Parts II and III of this paper) examined 2 skeletons of *T. atlanticus* in the laboratory of Dr. Donald de Sylva and 1 of the same species in the laboratory of Professor Luis Rivas at the University of Miami. Both agreed with Mather that the vertebral count for the respective specimens was 19 precaudal + 20 caudal vertebrae despite the previously published count of 18 + 21 vertebrae (de Sylva, 1955).

Through the kindness of Dr. H. Nakamura, Director of the Nankai Regional Fisheries Laboratory in Japan, we secured one *T. orientalis* and one *T. tonggol* (*Neothunnus rarus*) preserved in formalin. RV ATLANTIS captured for us one *T. tonggol* in the Red Sea (16°43′ N–40°23′ E) on June 15, 1958, and one *T. obesus* taken off the west coast of Africa in May 1961. Dr. M. L. Bauchot kindly furnished a very excellent X ray of *Thynnus argentivittatus* C. V. (MNHN A5814) which Mather had examined in Paris in 1959.

The *T. thynnus*, 25 mm. in fork length, pictured in Plate XII, was part of a collection from the Straits of Messina obtained for us by G. Arena. We have specimens of *T. thynnus*, skeletally and externally identical to those from Messina, taken by our vessels, the RV BEAR and the RV CRAWFORD off the east coast of the United States and by the MV OREGON, operated by the U.S. Fish and Wildlife Service, in the Gulf of Mexico.

Techniques for hard and soft X-ray diagnosis of species are described in Watson (1962). The drawings made of the skeletons and those made from either X-rays or publications of other authors were executed with the aid of a direct projector which projects the image, enlarged or reduced up to 4 times, through the drawing surface. By working with only a very small area at one time distortion was thus reduced to a minimum.

TABLE I

Species Key to Genus *Thunnus*

Genus characteristic : 39 vertebrae, the first of which is no more than one half as long as the second.*

A. *Separation of genus* Thunnus *into two groups***

Skeletal and Visceral Characters		Group I	Group II
1. One or more inferior foramen in caudal vertebrae		Small or inconspicuous in lateral view, Plate VII.	Large, prominent in lateral view, Plate VIII.
2. Posterior hemal zygapophysis on pre-caudal vertebrae bearing hemal arches.		Short, not produced, figs. 14–17.	Long, styliform, figs. 18–21.
3. Livers	ventral surface	Striated by surface vessels	Not striated by surface vessels
	dorsal surface	Emitting 3 or more vascular plexuses	No vascular plexuses
	3 lobes	Subequal or middle slightly larger ; ventrally each lobe distinctly separated from adjoining lobe by cleft.	Right lobe longest ; ventral surface of all lobes confluent, *i.e.*, no clefts visible
Species herein identified		*T. thynnus* *T. alalunga* *T. obesus*	*T. atlanticus* *T. albacares* *T. tonggol*

*This characteristic is identifiable in specimens as small as 9 mm. in fork length in soft X-ray photographs (Watson, 1962). Specimens smaller than 9 mm. have as yet not been X-rayed.

**Characters of each group do not necessarily apply to larvae and juveniles, but do apply to specimens longer than 20 cm. in fork length.

TABLE I-A

B. *Species differences among members of each group from Table I, Part A*

Group I			Group II		
Skeleton	Species	Abdominal Cavity	Skeleton	Species	Abdominal Cavity
Alisphenoid extending ventrally more than half way into interorbital opening, fig. 1; gillrakers exceed other 5 species; Atlantic, 9–15 + 24–29, Pacific, 10–15 + 21–25	*T. thynnus*	Air bladder rounded anteriorly, devoid of dorsal pouch	19 precaudal + 20 caudal vertebrae, fig. 12; gill rakers 4–7 + 15–20	*T. atlanticus*	Air bladder small, 1/4 length of abdominal cavity, bears 2 dorsal pouches anteriorly.
First closed hemal arch inclined 45° anteriorly to length of vertebral column, fig. 31; parapophyses only on vertebra preceeding first closed hemal arch	*T. alalunga*	Air bladder with single dorsal pouch anteriorly, fat organ on right gonad only, Plate XIV	18 precaudal + 21 caudal vertebrae, gill rakers 7–11 + 19–22	*T. albacares*	Air bladder extends more than half the length of abdominal cavity, appressed dorsally to thick white ligament for most of its length. Plate XIII
None of the above skeletal characters apply	*T. obesus*	Air bladder with 2 dorsal pouches anteriorly, extends almost full length of abdominal cavity	18 precaudal + 21 caudal vertebrae; gill rakers 5–8 + 15–18	*T. tonggol*	No air bladder

GENUS *Thunnus* COMPARED TO OTHER SCOMBROID GENERA

Since an investigation of other scombroid genera is only partially completed at this writing we can venture but a few general observations based on our work and the survey of the literature. From the main characteristics ordered in Table II, it is evident that *Katsuwonus*, *Euthynnus* and *Auxis* have many traits binding them to Group II. On the basis of only limited evidence we found *Sarda*, *Gymnosarda* and *Allothunnus* showing slight affinities to Group I but no similarities to Group II.

TABLE II

Scombroid Genera Similar to Group II in Table I-A

Characteristics	*Katsuwonus*	*Euthynnus*	*Auxis*
1. First vertebra NOT reduced in size	X	X	X
2. Number of vertebrae	42	39	39
3. Inferior foramen as in Group II	X extreme	X extreme	X
4. Livers as in Group II	X	X	X
5. Posterior hemal zygapophysis unlike Group I or II			X
as in Group II	X	X	

Possibly the phylogenetic significance of the large inferior foramen found in Group II as well as in the scombroids listed in Table II can be better interpreted by studying soft X-ray

photographs made of larval and early juvenile stages of these genera. Our preliminary studies with this technique discovered these large inferior foramen (like those of Group II) in specimens of *T. thynnus, T. alalunga, T. atlanticus, and T. albacares,* 40 mm. in fork length. At about 20 cm. in fork length, *T. thynnus* and *T. alalunga* display the first visible striation on the ventral surface of their livers. X-ray examination of this sized specimen delineates not large but only small, inconspicuous inferior foramen characteristic of Group I. No conclusions are tenable until we make soft X-ray examination of juveniles (of at least 40 mm. in fork length) representing all scombroid genera.

Discussion

The key in Table I is useful for ready identification of species, either from X-ray photographs or examination of abdominal cavity and gill rakers. It is not intended to replace other keys already published but to expand the view points on the genus *Thunnus* and combine already known affinities into 2 new patterns of relationships. A comprehensive examination of these 6 species of *Thunnus* from every oceanic locality will produce the best key for species identification.

When comparing the findings of our dissections and X-ray examinations with those found in the published literature, many exceptions and a few inaccuracies were noted. Concerning the lateral views of the neurocrania found in Plates I and II, the only valid character to which we could not find exception was that of the alisphenoid in *T. thynnus* occupying more than half of the inter-orbital opening. The supraoccipital crest of *T. alalunga* never extended posteriorly to a position between the neural arches of the second and third vertebrae (de Sylva, 1955). The posteroventral margin of the cranium formed near the upper margin of the basioccipital can be either rounded or angular, both for *T. thynnus* and *T. obesus* in specimens from the western North Atlantic. For Pacific specimens, Kishinouye (1923) reports an angular profile of this area, while Godsil and Byers (1944) noted a rounded margin for their 2 specimens. Our faith in this diagnostic character faltered even though this angular contour was a constant feature in our specimen of *T. alalunga* (fig. 2). The obtuse angle (described by de Sylva, 1955) persisted in *T. albacares* and *T. atlanticus* (figs. 5, 6). From Kishinouye's reproduction found in fig. 7, one can see the similarity of the basioccipitals drawn in figs. 5, 6 and 7.

The method of counting precaudal and caudal vertebrae followed that of Starks (1910) : " abdominal vertebrae are only distinguished from caudal vertebrae by the attachment of ribs." One should add to this statement that the first 2 precaudal vertebrae never bear pleural ribs, and that the first caudal vertebra bears a hemal spine which can be located very easily in X-ray photographs or in dissection by its position just posterior to the first interhemal spine of the anal fin. If one followed Frade's (1933) method of counting, the total vertebral count for *Thunnus* is 38 because he maintains that the 39th or "terminal half-vertebra" (Gosline, 1961) cannot legitimately be assigned a vertebral number. We cannot agree with his view point after studying the caudal skeleton of larval tunas (Plates XI and XII). Frade persists in calling the 39th vertebra the urostyle which it certainly no longer resembles in the adult skeleton. Clothier (1950) is in agreement with Frade. Starks (1901) refers to the 39th vertebra as the hypural, which name we give to the irregular hook-like bone labelled in our figs. 38 and 39. This same " hook-like " bone is termed the urostyle by de Sylva (1955) who refers to the 39th vertebra as the hypural plate. We have adopted the terminology of Gosline (1961). The hypural complex refers to those vertebrae whose neural and hemal spines are incorporated into the caudal fin as it is viewed externally or by X-ray photograph.

Among 40 adult specimens and 8 larval and juvenile specimens of *T. atlanticus*, we found no variation from a count of 19 precaudal and 20 caudal vertebrae. The single exception to this count was located in the laboratory of Dr. Gibbs containing a specimen with 21 caudal and a possible count of 17 precaudal vertebrae (the precaudal region was not intact). Specimens in the laboratories of Professor Rivas and Dr. de Sylva confirmed our vertebral counts by mutual agreement, even though our count was contrary to that published earlier by de Sylva (1955). Our X-rayed specimens represented the type locality for the species as well as the wide geographical range reported for *T. thynnus* in Part III, fig. 9, of this paper (Mather).

Plates IX and X illustrate the normal or typical characteristics of the parapophyses and first closed hemal arch found in our specimens from the western North Atlantic and those published in the literature. However, we can cite too many exceptions for the position of the first closed hemal arch, hence we cannot justify the use of this diagnostic character in an osteological key. Frade (1933) and Kishinouye (1923) position the first closed hemal arch in *T. obesus* on the 10th vertebra while Godsil and Byers (1944) and de Sylva (1955) refer the position of this arch to the 11th vertebra. We have specimens illustrating both conditions. The above 5 authors allocate the 11th vertebra as the position of the first closed hemal arch in *T. albacares*. We have a specimen with this arch on the 10th vertebra. For *T. thynnus* we can cite the reverse exception : instead of the normal 10th vertebra bearing the first closed hemal arch, the 11th vertebra carries it. Although our specimens of *T. alalunga* follow the typical pattern for the 10th vertebra, Frade (1933) lists exceptions to this rule. For *T. atlanticus* and *T. tonggol*, the first closed hemal arch appeared consistently on the 11th vertebra.

A constant trait of *T. alalunga*, regardless of the vertebral number bearing its first closed hemal arch, is that only one vertebra bears parapophyses and it always precedes the first closed hemal arch. Frade (1933) also recorded this observation. Starks (1910) described these parapophyses, usually placed on the 9th vertebra, from a *T. alalunga* taken off San Diego, California. Yet both Kishinouye (1923) and Godsil and Byers (1944) fail to note or picture the abruptly downward bend of the parapophyses on the 9th vertebra. All other species of *Thunnus* have at least 2 and sometimes 3 vertebrae bearing ventrally directed parapophyses preceding their first closed hemal arch.

T. tonggol, identified in Table I on the basis of 3 specimens, was not dissected completely because the specimens were rare. X-ray diagnosis proved sufficient to identify the Japanese specimen as the same species captured in the Red Sea, and to confirm their likeness to the X-ray of *T. argentivittatus* (MNHN A5814). External measurements of the 3 specimens were plotted by Mather (see Part II of this paper) and these corroborated our X-ray findings. The similarities of Kishinouye's (1923) skeletal drawing of *Neothunnus rarus* with our X-ray photographs of *T. tonggol* (from the Red Sea) and specimen MNHN A5814, *T. argentivittatus*, reinforced our belief that *T. argentivittatus* (*non* Cuvier, *see* Rivas, 1961) should be synonymized with *T. onggol*.

The position in the subgenus *Parathunnus* assigned to *T. argentivittatus* (MNHN A 5814), *T. obesus*, and *T. atlanticus* by Rivas (1961) cannot be justified from his description of this subgenus. Two of his key characters for the subgenus *Parathunnus* denote the presence of peripheral striations on the ventral surface of the liver and capillary plexuses on the dorsal face of the liver. Only *T. obesus* reveals these two features. Certainly the presence of these two features on the livers of either *T. atlanticus* or *T. tonggol* (*T. argentivittatus* of Rivas, 1961) would constitute a most unusual exception to the rule. We have not noted such an exception either in our dissections or in the literature. Another point of disagreement we have with

Rivas' description of the subgenus *Parathunnus* concerns *T. atlanticus*. This species has two main branches to the coeliac-mesenteric artery (not 3 as stated by Rivas) and it also has a posterior commissure present (not absent as stated by Rivas, 1961).

SUMMARY

The genus *Thunnus*, comprising six species, possesses 39 vertebrae-the first of which is no more than half as long as the second. This characteristic separates genus *Thunnus* from all other known genera without exception, and it can be diagnosed by soft X-ray photographs in specimens as small as 9 mm. in fork length. *T. thynnus*, *T. alalunga* and *T. obesus* from Group I whose diagnostic features are recognizably different from those in Group II containing *T. albacares*, *T. atlanticus* (found only in the Atlantic) and *T. tonggol* (found only in the Pacific). Each group is then analyzed for specific differences within the group. The key formulated is useful for ready identification of species, either by X-ray photographs or by examination of the abdominal cavity and gill rakers. Species differences apply to individuals 20 cm. or longer in fork length. *T. tonggol* is proposed as the correct name for *T. argentivittatus* (MNHN A5814, Rivas, 1961) supported by skeletal, visceral and external evidence.

ACKNOWLEDGMENTS

Without the current and past support of grants from the National Science Foundation (19601, 6172 and 8339) this study could not have been accomplished. We extend our warmest thanks to the many people who contributed in one way or other to the accumulation of the materials reported on. Dr. T. Abe, from the University of Tokyo, participated in several of the complete dissections required for this work. His precise methods and expert assistance were most invaluable. Appreciative thanks for the illustrations are due to Gale Pasley and Mary Minot whose astute observations revealed characteristics previously overlooked by the author.

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FIG. 1
Thunnus thynnus



FIG. 3
Thunnus obesus

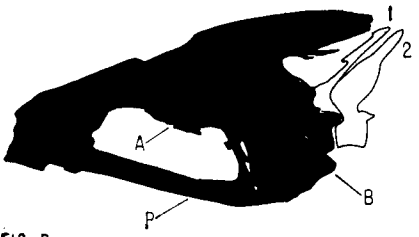


FIG. 2
Thunnus alalunga

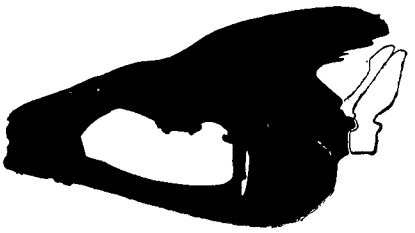


FIG. 4
Parathunnus mebachi
AFTER GODSIL, 1944

I. Lateral view of neurocrania. Fig. 1 *Thunnus thynnus*, Fig. 2 *Thunnus alalunga*, Fig. 3 *Thunnus obesus*, Fig. 4 *Parathunnus mebachi* after Godsil & Byers, 1944. Figs. 1, 2 and 3 drawn from specimens photographed in Figs. 8, 9 and 10. Neural spines of first and second vertebrae 1 and 2. *A* alisphenoid, *P* parasphenoid, *B* basioccipital.

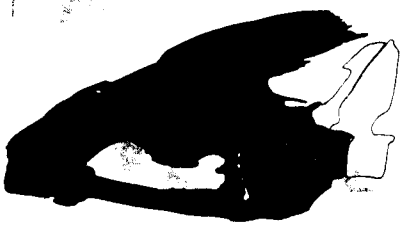


FIG. 5
Thunnus albacares

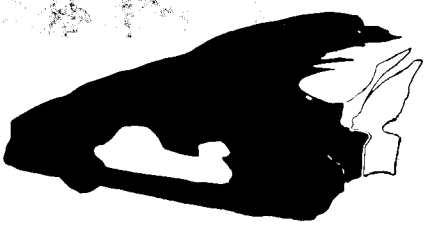


FIG. 7
Neothunnus rarus
AFTER KISHINOUYE, 1923

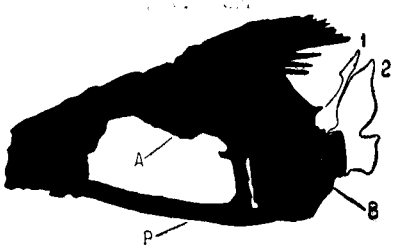
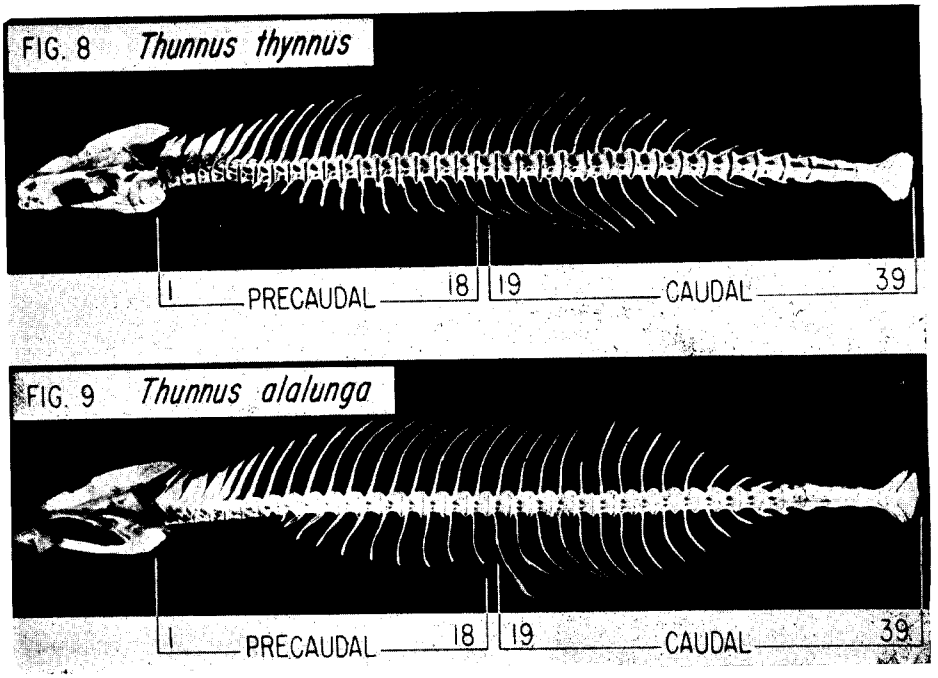
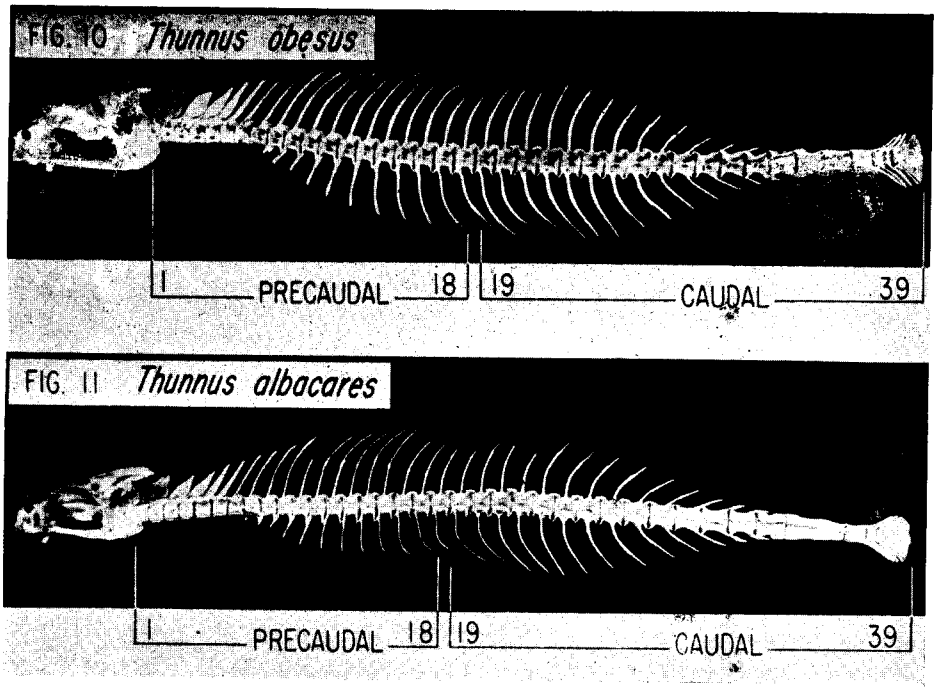


FIG. 6
Thunnus atlanticus

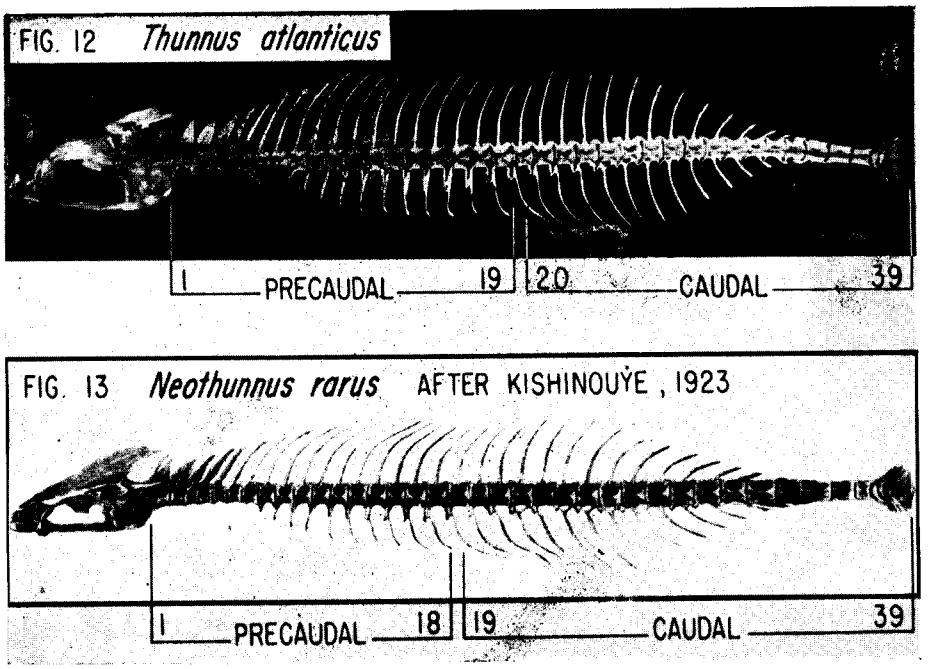
II. Lateral view of neurocrania. Fig. 5 *Thunnus albacares*, Fig. 6 *Thunnus atlanticus* Fig. 7 *Neothunnus rarus* after Kishinouye, 1923. Figs. 5 and 6 drawn from specimens photographed in Figs. 11 and 12. Neural spines of first and second vertebrae 1 and 2. *A* alisphenoid, *P* parasphenoid, *B* basioccipital.



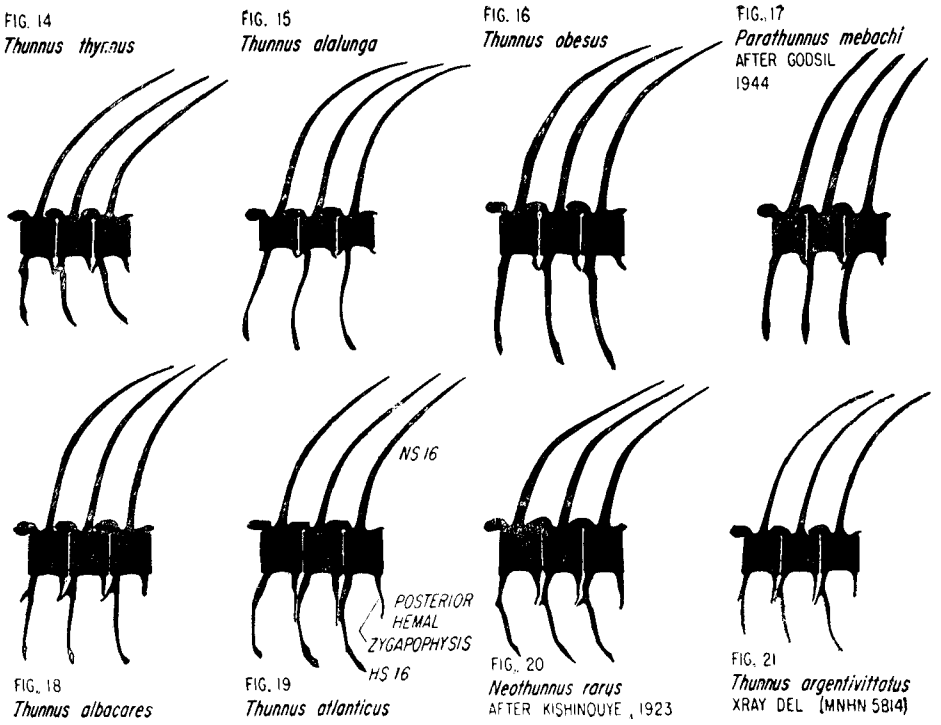
Lateral view of neurocranium and spinal column. Fig. 8 *Thunnus thynnus*, Fig. 9 *Thunnus alalunga*. Fig. 8 a female bluefin tuna, 117.7 cm. in fork length, 75 lb. taken by purse seiner F. Nelson Blount on 10 Oct. 1961 at 41°55'N—70°30'W. Tips of neural spines 12 and 13 broken during dissection. Fig. 9 a female albacore 79.8 cm. in fork length, taken by RV CRAWFORD on long-line at 40° 03' N—67° 37' W on 26 November, 1960. Tip of 23rd neural spine broken.



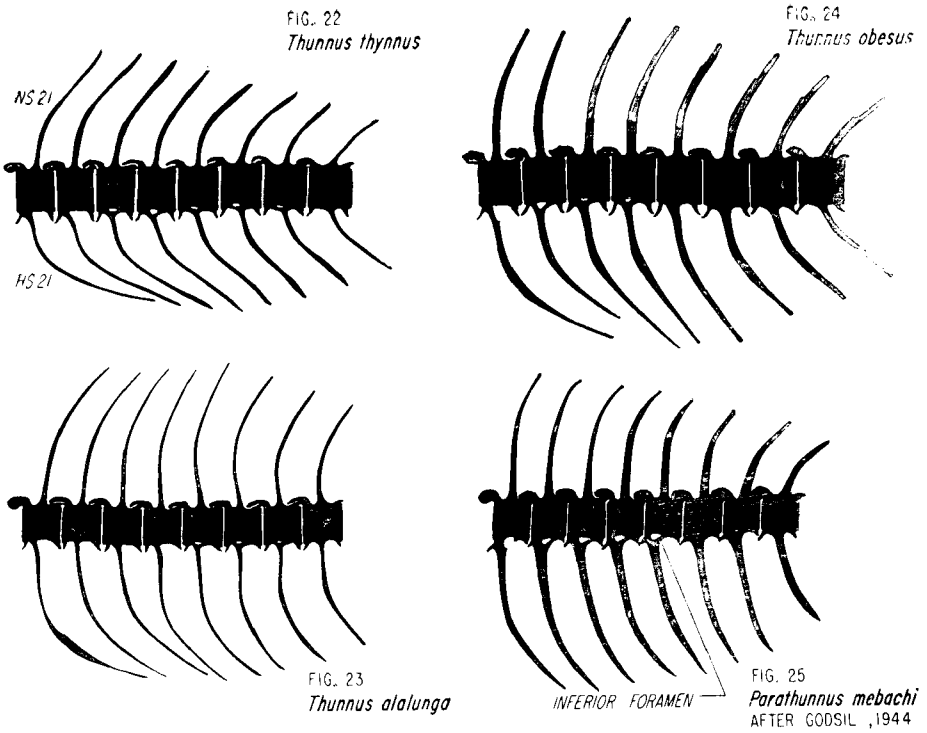
Lateral view of neurocranium and spinal column. Fig. 10 *Thunnus obesus*, Fig. 11 *Thunnus albacares*. Fig. 10 a male bigeye tuna, 120.0 cm. in fork length, taken by RV CRAWFORD on long-line at 40° 03' N — 67° 37' W on 26 November, 1960. Neural spines 17 and 18 broken. Fig. 11 a female yellowfin tuna, 117.7 cm. in fork length, taken by RV CRAWFORD on longline at 36° 56' N — 74° 18' W on 13 November, 1960. Neural spines 11, 22 and 23 broken.



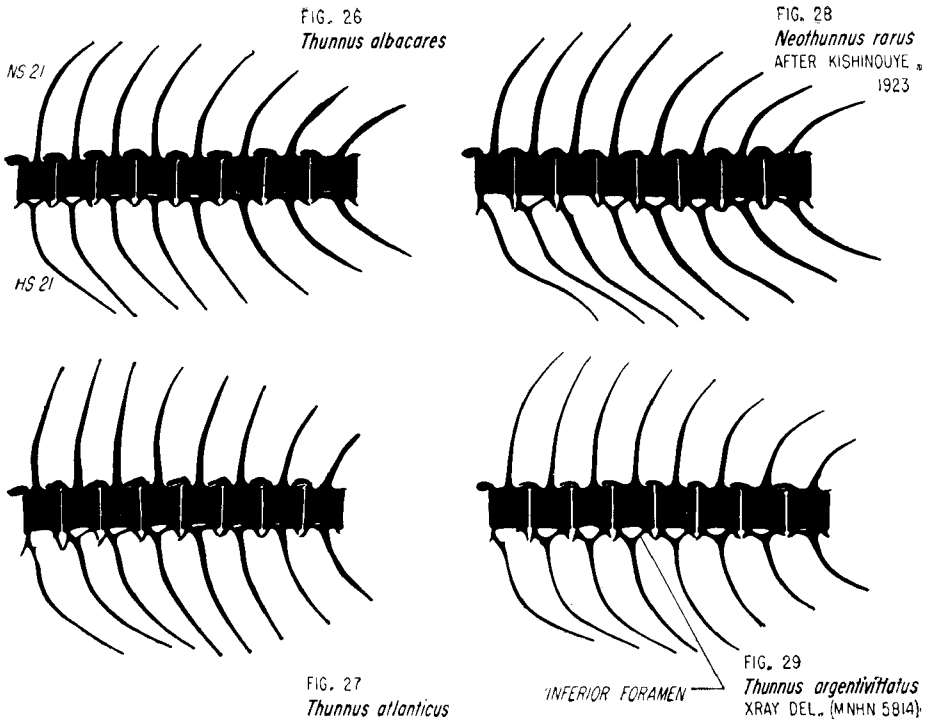
Lateral view of neurocranium and spinal column. Fig. 12 *Thunnu atlanticus*, Fig. 13 *Neothunnus rarus* after Kishinouye, 1923. Fig. 12 a male blackfin tuna, 52.8 cm. in fork length, taken by RV CRAWFORD on long-line at 25° 58. N — 79° 19.5. W on 21 May, 1961. Fig. 13 data not cited by Kishinouye.



Lateral view of precaudal vertebrae, numbers 14, 15 and 16 drawn from specimens photographed in Plates III, IV and V or copied from authorities cited. Fig. 14 *T. thynnus*, Fig. 15 *T. alalunga*, Fig. 16 *T. obesus*, Fig. 17 *P. mebachi* after Godsil and Byers, 1944, Fig. 18 *T. albacares*, Fig. 19 *T. atlanticus*, Fig. 20 *N. rarus* after Kishinouye, 1923, Fig. 21 *Thunnns argentivittatus* (MNHN 5814) delineated from enlargement of contact print of an X-ray supplied by Dr. M. L. Bauchot (specimen 41.8 cm. in fork length). Figures 14–17 illustrate short posterior hemal zygapophyses. Figs. 18–21 illustrate long, styliform posterior hemal zygapophyses. *NS*—neural spine.



Lateral view of caudal vertebrae, numbers 21–28, drawn from specimens photographed in Figs. 8, 9 and 10. Note small inferior foramen common to all 4 specimens. Fig. 22 *T. thynnus*, Fig. 23 *T. alalunga*, Fig. 24 *T. obesus*, Fig. 25 *P. mebachi* after Godsil and Byers, 1944. *NS*—neural spine, *HS*—hemal spine.



Lateral view of caudal vertebrae 21–28 drawn from specimens photographed in Figs. 11, 12 and 13. Note medium and large inferior foramen common to all 4 specimens. The anterior-posterior length of at least 1 inferior foramen on each specimen is about half as long as its centrum. Fig. 26 *T. albacares*, Fig. 27 *T. atlanticus*, Fig. 28 *N. rarus* after Kishinouye, 1923, Fig. 29 *T. argentivittatus* (MNHN 5814) delineated (from X-ray of same. *NS*—neural spine, *HS*—hemal spine.)

FIG. 30
Thunnus thynnus

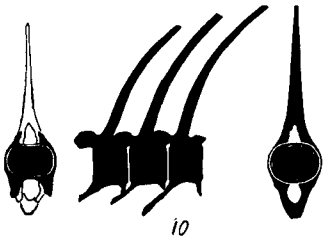


FIG. 31
Thunnus alalunga

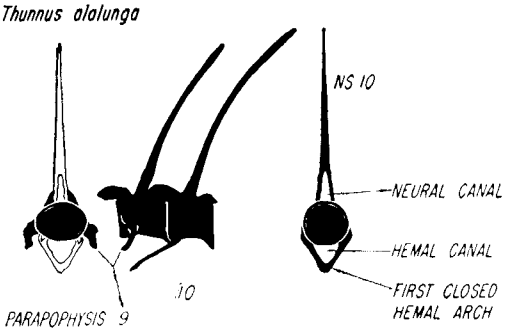


FIG. 32
Thunnus obesus

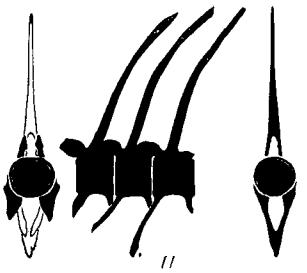
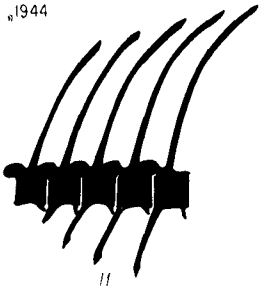


FIG. 33
Parathunnus mebachi
AFTER GODSIL „1944



End and lateral views of precaudal vertebrae which bear parapophyses and first closed hemal arch. Fig. 30 *T. thynnus*, Fig. 31 *T. alalunga*, Fig. 32 *T. obesus*, Fig. 33 *P. mebachi* after Godsil & Byers, 1944. The vertebral number bearing the first closed hemal arch is indicated in each lateral view. Fig. 30, 31 and 32 are drawn from specimens photographed in Figs. 8, 9 and 10.

FIG. 34
Thunnus albacares

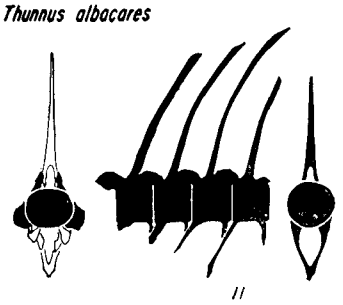


FIG. 36
Neothunnus rarus
AFTER KISHINOUYE, 1923

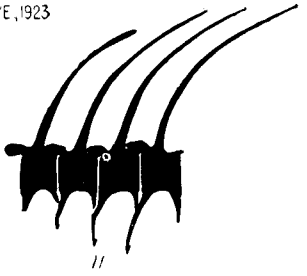


FIG. 35
Thunnus atlanticus

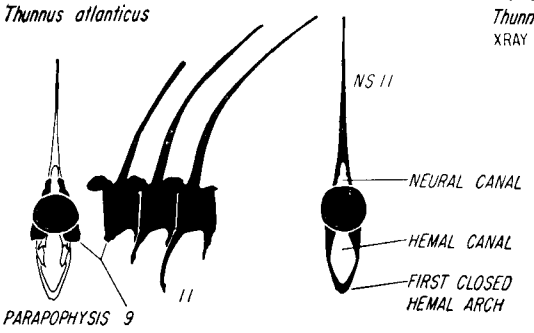
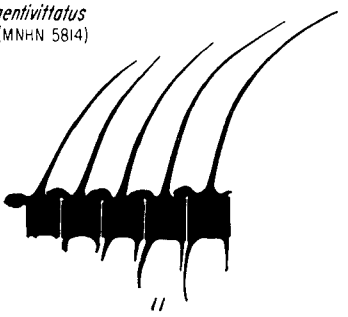


FIG. 37
Thunnus argentivittatus
XRAY DEL. (MNHN 5814)



End and lateral views of precaudal vertebrae which bear parapophyses and first closed hemal arch. Fig. 34 *T. albacares*, Fig. 35 *T. atlanticus*, Fig. 36, *N. rarus* after Kishinouye. 1923 Fig. 37 *T. argentivittatus* (MNHN 5814) delineated from X-ray of same. The vertebral number bearing the first closed hemal arch is indicated in each lateral view. Figs. 34 and 35 are drawn from specimens photographed in Figs. 11 and 12. *NS*—neural spine.

FIG. 38

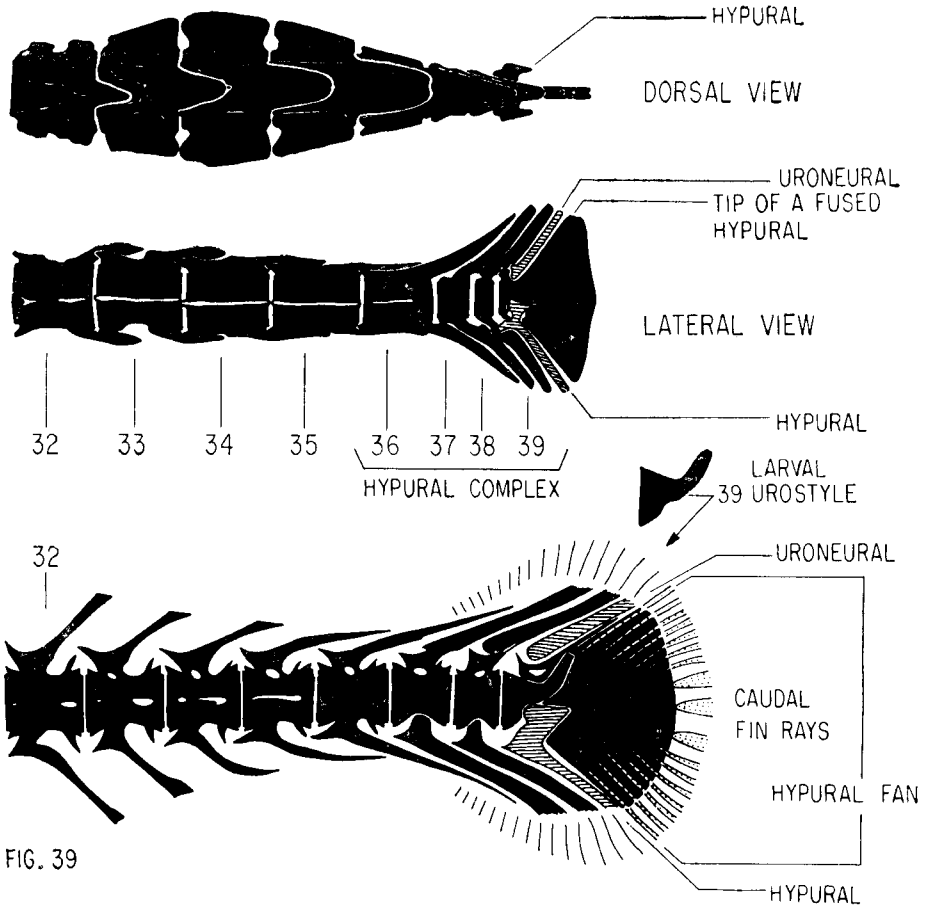
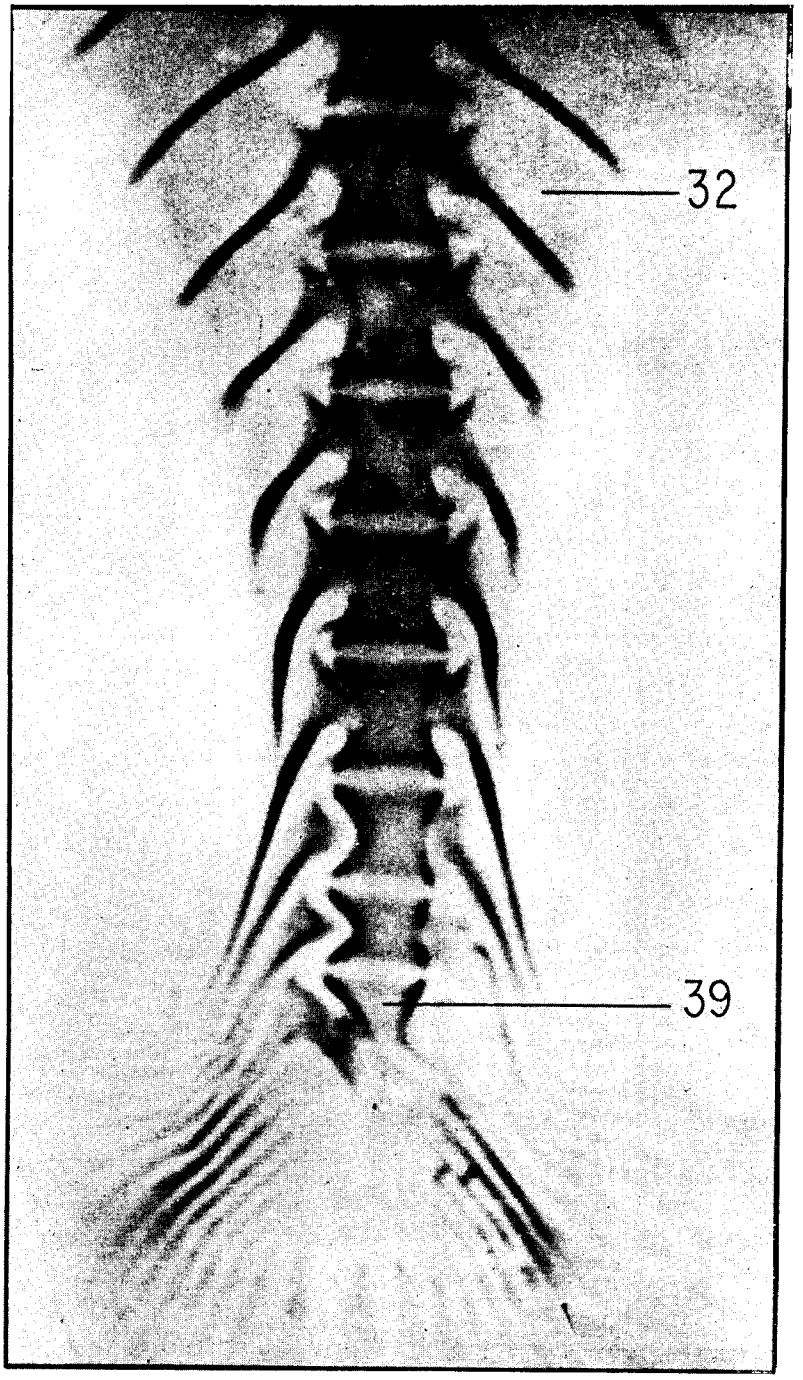
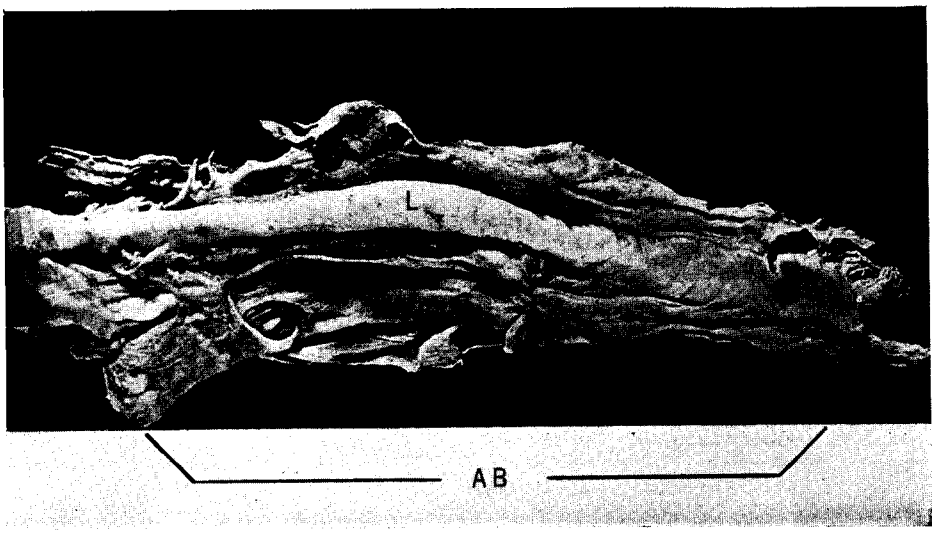


FIG. 39

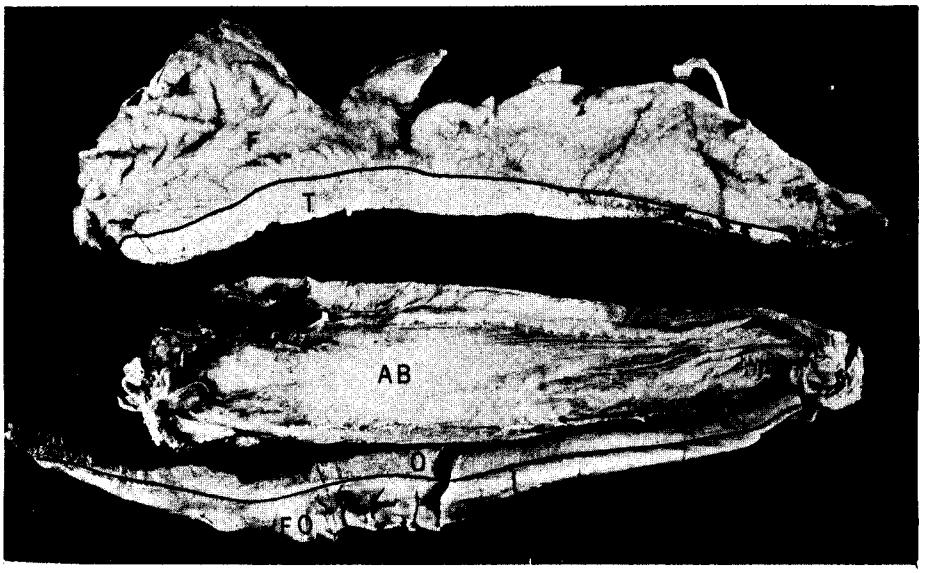
Tail vertebrae, numbers 32–39. Fig. 38 represents dorsal and lateral views of a typical adult *Thunnus* sp. Fig. 39 is a drawing made from microscopic study of a soft X-ray taken of a *T. thynnus*, 25 mm. in fork length. The "lined" bones, termed uroneural and hypural (terminology after Gosline, 1961) are unattached, not fused or appressed, in the adult tail. The hypural fan of the larval form (Fig. 39) is not as yet fused with the 39th vertebra ("urostylar" or "terminal half vertebra" of Gosline).



Photographic enlargement, approximately X32, made from soft X-ray of tail vertebrae, numbers 32–39, of *T. thynnus*, 25 mm. in fork length. Refer to Fig. 39 on Plate XI.



Ligament *L* and air bladder *AB* taken from yellowfin tuna, *T. albacares*, photographed in Fig. 11, Plate IV. This ligament measures 19 cm. in length and 1.2 cm. in maximum width.



Photograph (1.0/1.2) of fat organ *FO* taken from albacore, *T. alalunga*, pictured in Fig. 9, is demarcated from right ovary *O* by inked line. Ordinary gonadal fat *F* of a male albacore from left testis *T* delineated from each other by inked line. Fat organ possesses regular clefts perpendicular to its length. Such clefts are not apparent in the irregular mass of ordinary fat *F*. Incision of knife severed ovary *O* and fat organ *FO* during dissection. Air bladder *AB*. Malealbacare, 108 cm. in fork length, was taken by long-line at 12° 38. N– 69° 17′W aboard cruise 66–4 of the MV OREGON.

TUNAS (GENUS *THUNNUS*) OF THE WESTERN NORTH ATLANTIC*

PART II. Description, Comparison and Identification of species of *Thunnus* based on external characters

BY

FRANK J. MATHER, III

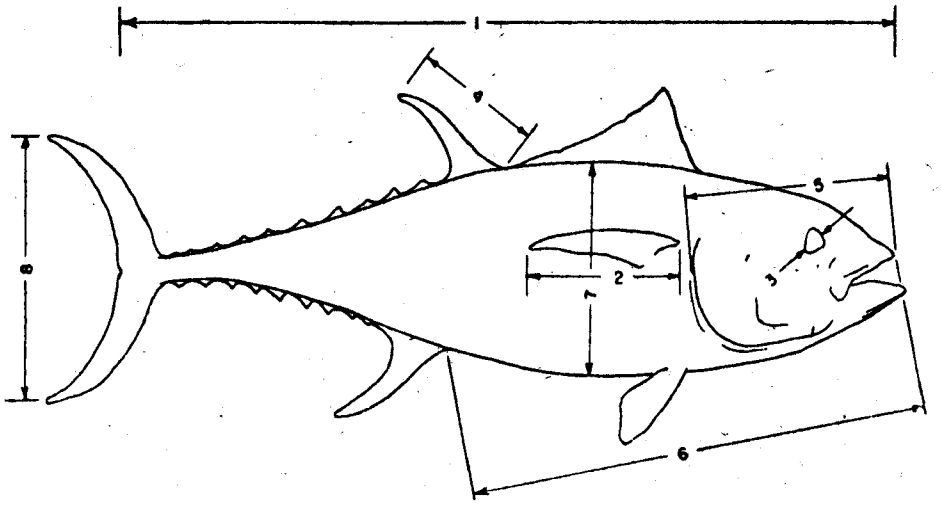
Woods Hole Oceanographic Institution, Woods Hole, Mass., U.S.A.

INTRODUCTION

The identification of tunas (genus *Thunnus*) is difficult, especially when small individuals are concerned, as those of all the species are quite similar in appearance. The respective species develop distinctive characters which facilitate recognition as they grow. Because of this allometric development of certain proportions, and also because of changes in color pattern with growth, tunas of the same species usually differ greatly in appearance at different sizes. Failure to consider these changes has led to much confusion in the literature, and continues to do so.

METHODS AND MATERIALS

To obtain as complete a description of each species as possible, to differentiate between species and to study the possible existence of distinct populations, we examined



Text Fig. 1. Schematic drawing of tuna showing methodology used in taking body preparations. 1. Fork length. (Snout of upper jaw to fork of tail.) 2. Length of pectoral fin. (From most anterior visible point of insertion to tip, with fin laid flat along body.) 3. Maximum diameter of iris. (Measured to edge between yellow or bluish iris and surrounding dark tissue. The maximum diameter is not usually parallel to the longitudinal axis of the fish.) 4. Length of second dorsal fin. (Measured from end of groove of first dorsal fin to tip of second dorsal lobe.) 5. Length of head. (Measured from snout of upper jaw to most distant point on edge of opercle). 6. Snout to insertion of anal fin. (Measured from snout of upper jaw to insertion of anal fin.) 7. Maximum depth. 8. Spread of caudal fin.

* Contribution No. 1257 from the Woods Hole Oceanographic Institution.

many individuals of each species in graded series covering the ranges of sizes available. In addition, every effort was made to sample each species throughout its seasonal cycle and its geographical range. Unfortunately we did not succeed in obtaining series of specimens covering the entire size ranges of the respective species, and the information contained in this section applies only to the sizes indicated in Table I.

Study material included landings of sport and commercial fishermen, fish caught during exploratory and personal fishing trips, and specimens in museum and laboratories.

The counts and caliper measurements taken followed generally the method of Marr and Schaefer (1949) with several supplementary counts and measurements being added as the study progressed. The measurements chiefly considered in this paper are shown in fig. 1. In the following figures, the curves shown for *T. thynnus* were fitted by the method of least squares, and those for the other species by inspection. Because of the density of the data, points were not plotted except on the graph of length of pectoral fin against length of head. The length frequencies of all the fish studied are listed according to species in Table I.

Description of the Genus *THUNNUS*

Proportions expressed in percentage of fork length. Body typically robust (maximum depth .23-.29) and fusiform (maximum width .15-.215), tapering rapidly to a sub-conical head (length .25-.32) and an extremely slender caudal peduncle (minimum depth .023-.03) reinforced and streamlined with a single pair of lateral keels (maximum width .055-.10).

Table I

Length frequencies in 10 cm. groups of specimens of *Thunnus* examined, by species. Groups include lengths from number listed to 1 mm. less than next number.

Fork length in cm.	Species of *Thunnus*				
	alalunga	*albacares*	*atlanticus*	*obesus*	*thynnus*
20*			3		5
30			12		4
40			13		5
50		4	18		26
60		5	8	1	10
70		14	6		22
80	8	11	1		10
90	17	12			6
100	24	15			8
110	1	8		2	14
120		6		4	15
130		7		4	5
140		10		6	7
150		13		7	9
160		8		2	12
170				2	8
180					5
190					5
200					4
210					12
220					12
230					22
240					14
250					8
260					1
270					1

*The fish in this group were all over 25 cm. long and most of them were nearly 30 cm.

Body fully scaled, with a corselet of larger scales in the pectoral region. Anterior portion of lateral line with a distinctive dip, descending posteriorly from the upper margin of the opercle to a point just dorsal to the origin of the pectoral, then rising posteriorly to a point below the third or fourth spine of the first dorsal fin, from which it takes a normal course toward the caudal (Kishinouye, 1923). Snout to fleshy orbit, .08-.105; maxillary (including premaxillary and supramaxillary) .095-.118, usually reaching the vicinity of a perpendicular through the anterior edge of the pupil; diameter of iris .025-.057. First dorsal fin XIII-XIV, inserted .26-.34 from snout, with the first 2 spines the longest (.096-.14) and the distal profile moderately concave, entirely retractable into a dorsal groove. Pectoral fins I, 29-36, inserted close to posterior edge of opercle, length .25-.48, very variable between species, fitting partially into grooves in sides of body when retracted. Ventral fins I, 5, inserted .25-.34 from snout, length .10-.13, retracting into a recess, with an interpelvic process between them (Fraser-Brunner, 1950). Second dorsal fin fixed, count including dorsal finlets, III, 17-21 (usually III, 19-20) inserted .49-.60 from snout, subject to marked allometric development and variation between species, length of lobe .08-.04 ; anal fin similar, III, 17-21 (usually III, 18-19) including ventral finlets, inserted .55-.65 from snout, length of lobe .06-.44. Caudal fin lunate, broadly spread (.23-.42). Gill rakers on first arch 4-15 upper, 15-28 lower, 20-42 total, the longest .03-.04.

Although colour is variable even among tunas of the same species, and fades rapidly after death, it is useful for identification. Members of the genus *Thunnus* are all dusky, dorsally and silvery white ventrally, lacking the dark spots, longitudinal lines, or vermiculations on the ventral, lateral and dorsal surfaces characteristically found in species of *Katsuwonus*, *Sarda*, *Euthynnus* and *Auxis*. Some species also have a gold lateral band medially from head to tail. Lateral and ventral surfaces of most species of *Thunnus* display a whitish pattern of vertical bars or rows of closely spaced spots, with more widely spaced spots between them. This is generally most extensive and prominent in small individuals. With increasing size, this pattern becomes less conspicuous and confined to the preanal areas, while posteriorly it changes to an arrangement of longitudinally elongated white spots, giving the ventral surfaces between the anal and caudal fins a reticulated appearance. On large individuals of the respective species, both these patterns are usually absent or inconspicuous. Tunas in life have brilliant metallic and pearly reflections, especially on their sides and underparts. The finlets of most species are at least partly yellow, with the edgings usually dusky.

Comparison of Species

Counts :

Ray counts, taken for all fins except caudal, proved to be of little value in separating species, but the count of gill rakers on the first arch is very important. The total gill raker count (Table II) separated *Thunnus atlanticus* (less than 25) and *T. thynnus* (more than 33) from the other 3 species. The count of lower gill rakers alone will, in most instances, separate the bluefin (24 or more) from the others (rarely, if ever, more than 23).

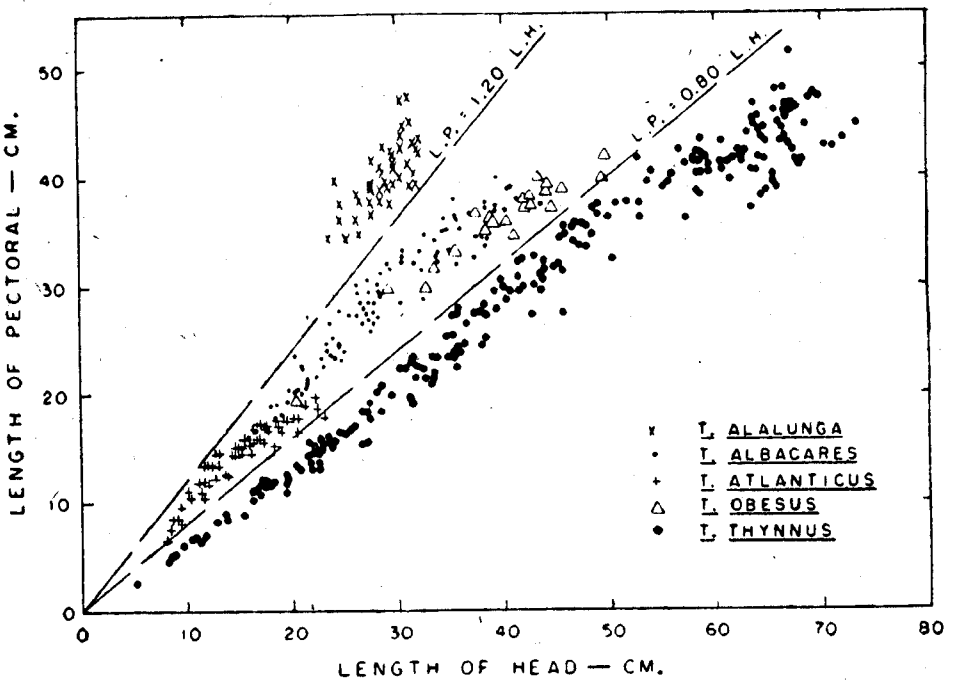
Table II

Frequencies of counts of total number of gill rakers on the first arch for species of *Thunnus*

Species of *Thunnus*	Total gill raker counts																						
	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
atlanticus ...	3	16	24	7	1																			
albacares ...								5	9	22	23	24	6	1										
alalunga ...						1	1	10	19	11	6	2												
obesus ...						1	9	7	9	4														
thynnus ...															3	2	10	35	57	84	43	27	7	1

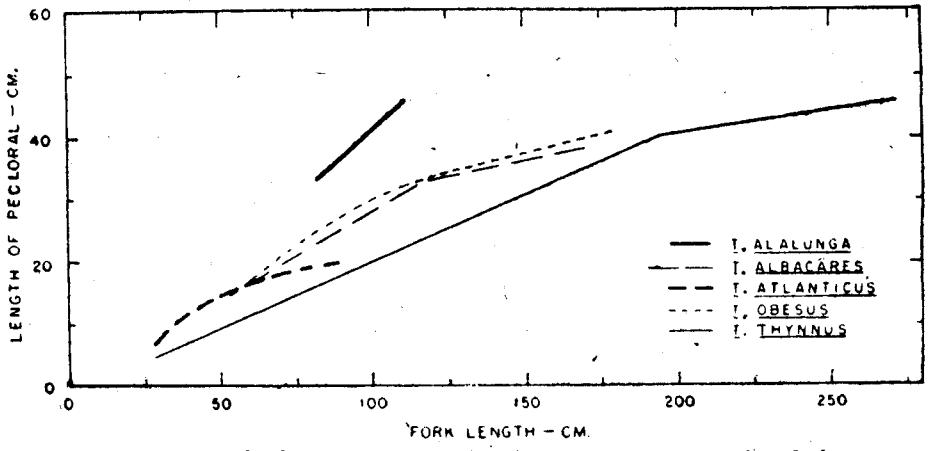
Proportions:

The length of the pectoral fin is important for separating the species of *Thunnus*. its character is most conveniently applied in relation to length of head (Fig. 2). The long



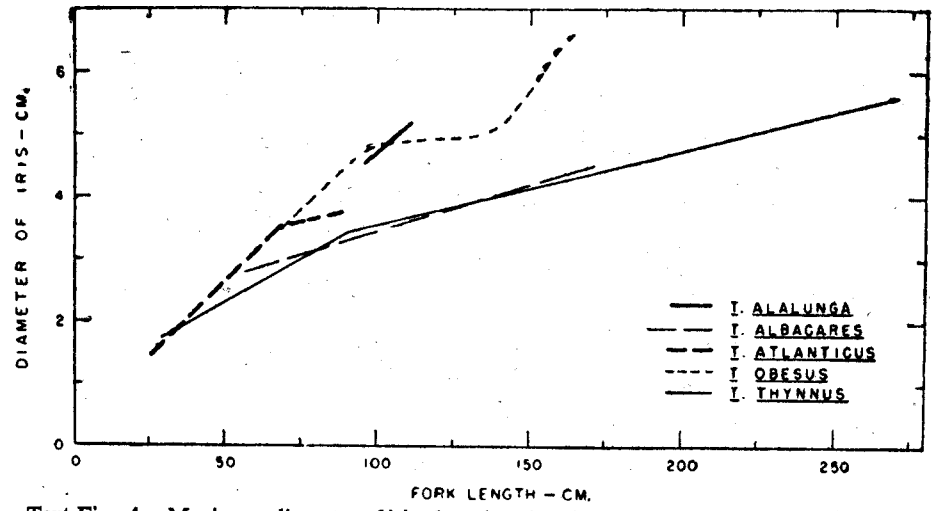
Text Fig. 2. Length of pectoral fin plotted against length of head for species of *Thunnus*.

pectoral of *T. alalunga* (Plate I) (over 1.20 of length of head for Atlantic specimens more than 60 cm. long) separates large albacore from all the remaining species. Likewise the short pectoral of *T. thynnus* (Plates II, III, IV) (less than 80 of head length) separates it from its congeners in most instances. Large *T. atlanticus* (Plate V) and *T. obesus* (Plate VIB) may rarely intergrade with *T. thynnus*. This is because, for all the species except *T. alalunga*, the pectoral attains its maximum relatives size in medium-sized individuals, and becomes relatively shorter as the tunas approach their maximum size. The relationship of the length of the pectoral to length of fish is shown in Fig. 3.



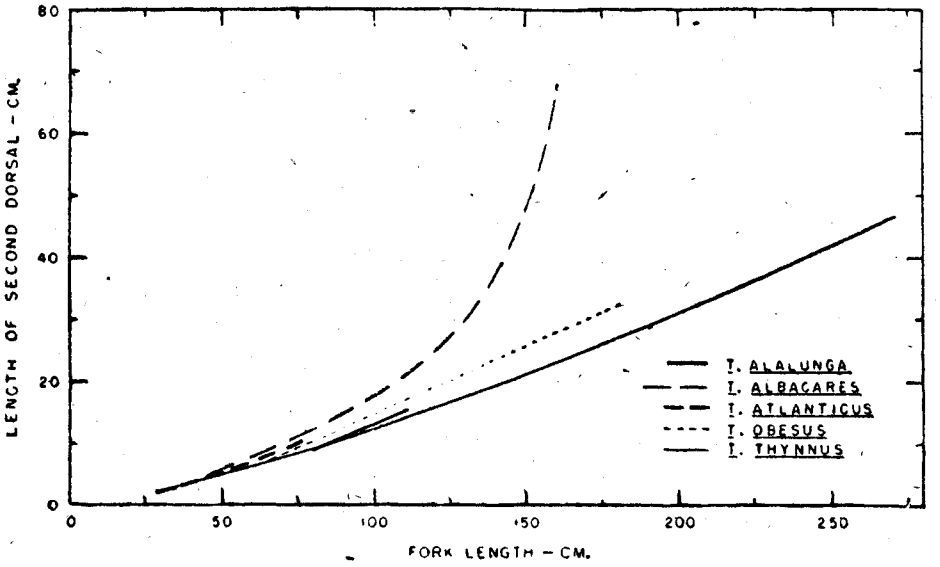
Text Fig. 3. Length of pectoral fin plotted against fork length for species of *Thunnus*.

Another important diagnostic character is the maximum diameter of the iris (Fig. 4). For individuals more than 65 cm. long, the irises of *T. alalunga*, *T. obesus*, and *T. atlanticus* were distinctly larger than those of *T. thynnus and T. albacares.* The irises of *T. albacares* less than 60 cm. long (Plate VIIA) tended to be larger than those of *T. thynnus* and to approach those of *T. atlanticus* in size, while in the 30-35 cm. range, those of *T. atlanticus* intergraded with those of *T. thynnus.*



Text Fig. 4. Maximum diameter of iris plotted against fork length for species of *Thunnus.*

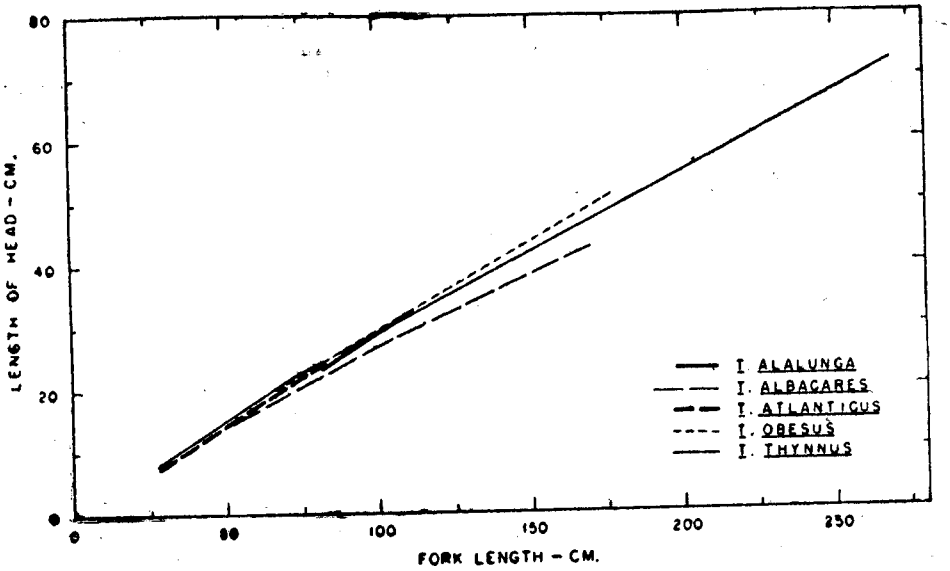
The allometric development of the second dorsal (Fig. 5) and anal fins with growth of fish is much more pronounced in *T. albacares* than in the other species. The extraordinary elongation of these fins of yellowfin over 125 cm. long (Plate VIA) makes them easily



Text Fig. 5. Length of second dorsal fin plotted against fork length for species of *Thunnus.*

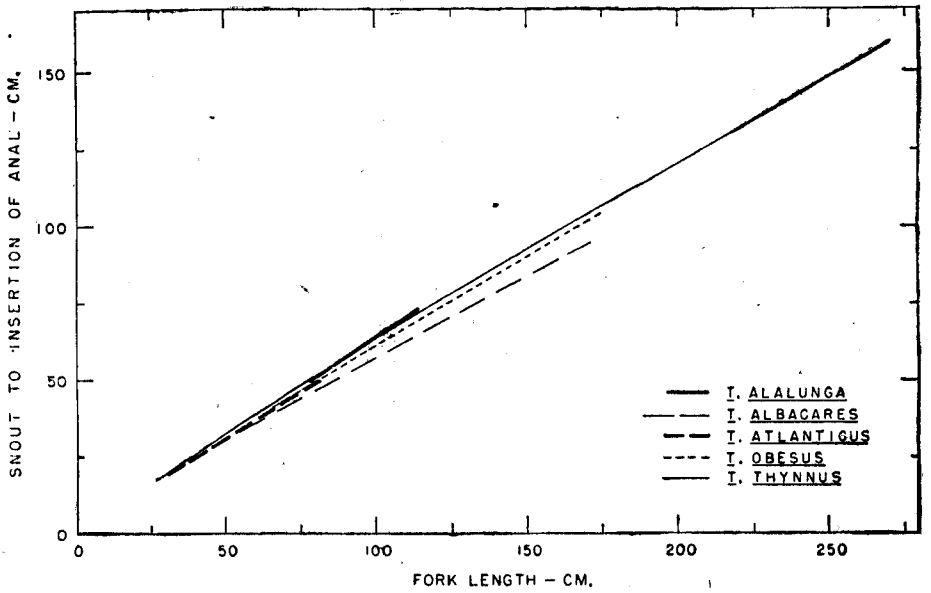
separable from their congeners, and their greater length is noticeable to the practiced observer even in individuals as small as 70 cm.

T. albacares also differs from the other species of *Thynnus* in having a shorter head (Fig. 6), and a longer caudal trunk as indicated by the shorter distance from snout to



Text Fig. 6. Length of head plotted against fork length for species of *Thunnus*.

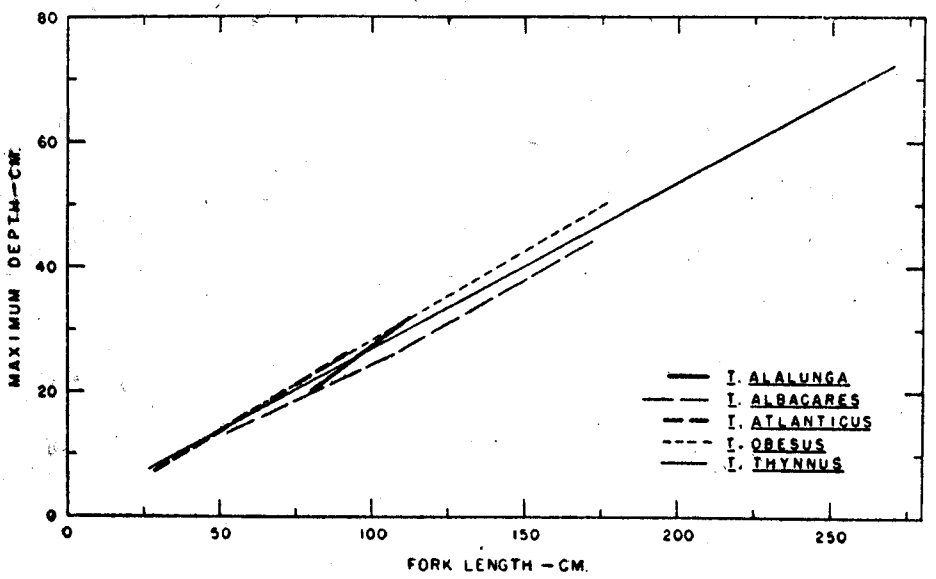
insertion of anal (Fig. 7). These characteristics, alone with its smaller depth, make the yellowfin much more slender and graceful in appearance than the other tunas.



Text Fig. 7. Distance from snout to insertion of anal fin plotted against fork length for species of *Thunnus*.

Although depth (Fig. 8) is quite variable even among tunas of the same species, and notable seasonal differences in the depth of *T. thynnus* over 150 cm. long have been observed, it is of some value in identification. *T. albacares*, as mentioned above, is usually more slender

than the others, while *T. obesus* is usually deeper. *T. thynnus* averages to be intermediate between these two, but intergrades with both. Large *T. atlanticus* and *T. alalunga* approach



Text Fig. 8. Maximum depth plotted against fork length for species of *Thunnus*.

T. obesus in depth, but smaller individuals are more similar to *T. thynnus* or even *T. albacares* in this respect. *T. alalunga* has an especially chunky appearance (Plate I) because it is much heavier posteriorly than the others and tapers abruptly to the caudal peduncle in a manner reminiscent of the oceanic bonito or skipjack, *Katsuwonus pelamis*.

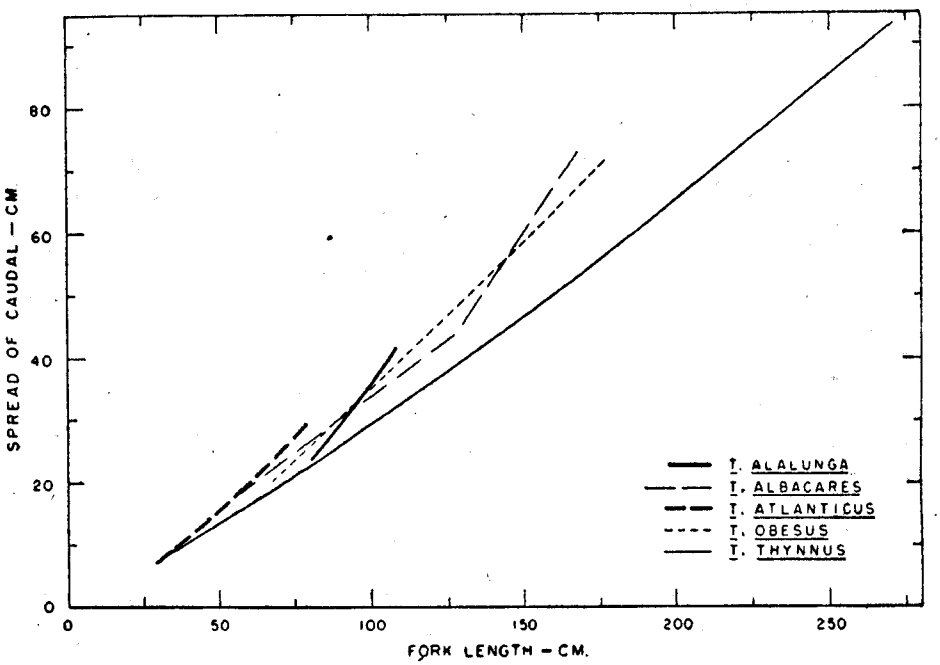
The spread of the caudal fin (Fig. 9) also shows marked allometric development, becoming larger in proportion to length of fish with increase of size for all species. The curves for the smaller tunas originate quite close to the one for *T. thynnus*, but as each species increases in size its curve trends sharply upward, departing from that of the bluefin, which is still far from its maximum size.

Color:

T. alalunga is comparatively dull colored, lacking the golden lateral band, and has a brownish cast laterally and ventrally on the body and head. This drab pattern is usually relieved by a narrow and irregular iridescent blue band between the dorsal and ventral colors. The dorsal finlets and often one or two of the largest anal ones have a central area of yellow ochre, but generally the finlets are darker than those of *T. albacares*, *T. thynnus*, and *T. obesus*. The specimens examined, all rather large ones, had no whitish spots or bars on the sides or underparts. The whitish trailing edges of all the fins except the first dorsal and the outer portions of the pectorals, and also of the finlets of *T. alalunga* are a conspicuous feature. The prominent white edge on the caudal clearly separates *T. alalunga* from all its congeners.

T. atlanticus is likewise a rather dull-colored tuna, but it does have a gold lateral band which is prominent in life. This species has small iridescent areas on the sides of the abdominal cavity with silvery and pearly reflections where scales are lacking or have been dislodged. In some individuals, this area is marked with vertical rows of whitish dots,

with more elongate spots between these rows (Plate VIIB). This pattern is not nearly as extensive or conspicuous as in small *T. albacares* and *T. thynnus*, and is not always present



Text Fig. 9. Spread of caudal fin plotted against fork length for species of *Thunnus*.

even in small individuals of *T. atlanticus*. In life the dorsal finlets are usually dusky with bronzy reflections, while the ventrals are usually gray with steely tints, although they may also show some brazen hues. The absence of yellow in the finlets separates *T. atlanticus* from all the other *Thunnus* we have observed, except a very few *T. thynnus* which had rather similar dull-colored finlets. This character must be used with reserve, however, because the finlets of *T. atlanticus* often fade to yellow after death.

T. obesus is generally somewhat duller in color than *T. albacares*, but we have observed a few individuals which were almost as brilliant as the latter. The finlets are yellow but usually have a more extensive dusky edging than those of *T. albacares* and *T. thynnus*. This edging sometimes extends along parts of base of the finlet as well as its leading and trailing edges. The anal finlets are tipped with white posteriorly. After death, the yellow often tends to darken or fade to brown. A 65 cm. individual examined after death had traces of light vertical bars along the sides, with possible remains of spots as well and a 62 cm. specimen from the eastern Atlantic had a distinct pattern of this type. Individuals over 112 cm. long lacked these markings, but sometimes had faint elongate white spots ventro-posteriorly. This species usually has a gold lateral band and often has brownish or olivaceous tints ventrally. There are extensive yellow areas near the edges and dips of the second dorsal and anal fins and smaller olivaceous yellow ones near the ends of the spines of the first dorsal.

T. thynnus, despite its name of bluefin, usually has bright yellow finlets with narrow black edging and also often has yellowish areas on the second dorsal and anal fins. Small individuals have a very conspicuous and extensive pattern of vertical bars or rows of closely

spaced spots with alternate rows of more widely spaced spots along the sides and underparts (Plate II). With increase in size, the posterior part of this pattern (from under the second dorsal fin nearly to the caudal keels) takes the form of whitish spots generally elongate in the direction of the longitudinal axis of the fish (Plate III). The background is considerably darker, creating a reticulated effect. The combination of vertical marking anteriorly and reticulations posteriorly is common in fish about 90-135 cm. long. The anterior vertical bars and spots are usually inconspicuous or lacking on bluefin 150 to 160 cm. but the reticulated pattern is prominent in fish of this size and often in considerably larger ones.

T. albacares is the most brilliantly colored member of the genus, with a brilliant gold lateral band, extensive yellow areas on the fins, and bright yellow finlets with very narrow dusky edges. This species usually has a whitish pattern of vertical bars or rows of closely spaced spots with less closely spaced spots between. This pattern is most extensive and conspicuous in small individuals, becoming less prominent in larger fish. These bars and rows of dots are approximately straight and vertical laterally as in *T. thynnus* but incline increasingly in a posterior direction as they approach the ventral profile. With increase in size of fish, the posterior portion of this pattern changes to elongate white spots, as in the bluefin, but the background is not as dark as in the latter and the reticulated effect is not as prominent. An individual 155 cm. long had vertical rows of spots, those in each row being alternately closely and more widely spaced, anteriorly, and elongated spots on the underparts ventrally. A 162 cm. fish was similarly marked posteriorly but had only a few spots on its sides anteriorly.

TENTATIVE KEY FOR FISHES MORE THAN 30 CM. LONG OF THE GENUS *THUNNUS* OF THE WESTERN NORTH ATLANTIC

1. Lower gill rakers on 1st arch 24-28 pectoral less than 4/5 of head length (less than 3/4 of head length in individuals less than 100 cm. long), usually extending as far as 8th to 12th dorsal spine. Weighs up to 1,000 lbs. or more..... .....Bluefin tuna, *T. thynnus*

   Lower gills rakers on 1st arch 15-23; pectoral more than 4/5 of head length, usually reaching almost to 2nd dorsal fin or beyond 2

2. Caudal distinctly edged with white posteriorly; pectoral in individuals over 60 cm. long more than 1 1/5 of head length, usually extending beyond anal fin. Weighs up to 75 lb. .....Albacore, *T. alalunga*

   Caudal not edged with white posteriorly less than 1 1/5 of head length, usually not reaching anal fin.....3

3. Total gill raker count on 1st arch 20-24 (usually 15-18 on lower limb); finlets not yellow in life. Weighs up to 35 lbs.....Blackfin tuna, *T. atlanticus*

   Total gill raker count on 1st arch 25-33 (usually 18-22 on lower limb) ; finlets predominantly yellow in life.....4

4. Eye large[1] ; body robust (girth usually more than .72 of length); 2nd dorsal and anal fins not greatly elongate 3. Weighs up to 400 lbs..... Bigeye tuna, *T. obesus*

   Eye small[2] ; body slender (girth usually less than .72 of length) ; 2nd dorsal and anal fins notably elongate in large individuals[3]. Weighs up to 300 lbs. or more.....Yellowfin tuna, *T. albacares*

Preliminary Notes on Comparisons of Bluefin Tuna and Albacore of the Western North Atlantic with those of other Regions

A biometric comparison of bluefin tuna, *Thunnus thynnus* from the Western North Atlantic with those of the western Atlantic and of the eastern Pacific is in progress. Available data include recent examinations by the author of fresh material in Spain and California, and those of Godsil and Holmberg (1950) and of Prof. L. R. Rivas (personal communication and unpublished in Rabins, 1957).

Meristic data of the various workers are in good agreement. Counts of second dorsal rays and dorsal finlets combined and of anal rays and finlets combined are similar for all regions, being typically 23 and 22, respectively. Pectoral ray counts are usually from 32 to 34 for the Atlantic regions and from 32 to 33 for the eastern Pacific. Gill raker counts (Table III), however, show distinct differences between Atlantic and eastern Pacific bluefin, and possible minor ones between those of the eastern and western Atlantic. The greatest difference is in the counts of lower gill raker.

Table III

Frequencies of gill raker counts for bluefin tuna by regions

Region	Upper Gill Raker Count						
	9	10	11	12	13	14	15
Eastern Atlantic ...		2	3	5	23	25	1
Western Atlantic ...	1	3	10	57	137	63	7
Eastern Pacific ...		1	2	22	13	2	1

[1]The dorsal finlets of *T. atlanticus* are a dusky bronze and the anals a dark steel-like gray in life, but both often fade to yellow after death.

[2]Approximate maximum diameter of iris in percentage of length of ventral fin :

Fork length in cm. ...	60	100	125	150
Percentage for *T. obesus* ...	.48	.41	.33	.32
Percentage for *T. albacares* ...	.39	.29	.26	.24

[3]Approximate length of 2nd dorsal lobe in percentage of maximum depth

Fork length in cm. ...	60	100	125	150
Percentage for *T. obesus* ...	.38	.53	.57	.61
Percentage for *T. albacares* ...	.52	.72	.88	1.25

Region	Lower Gill Raker Count							
	21	22	23	24	25	26	27	28
Eastern Atlantic ...				10	19	24	26	
Western Atlantic ...				25	83	104	52	13
Eastern Pacific ...	2	5	15	15	4			

Region	Total Gill Raker Count											
	32	33	34	35	36	37	38	39	40	41	42	43
Eastern Atlantic ...				1	4	7	13	13	15	3		
Western Atlantic ...			3	2	10	35	57	84	43	27	7	1
Eastern Pacific ...	2	2	2	13	8	11	2	2				

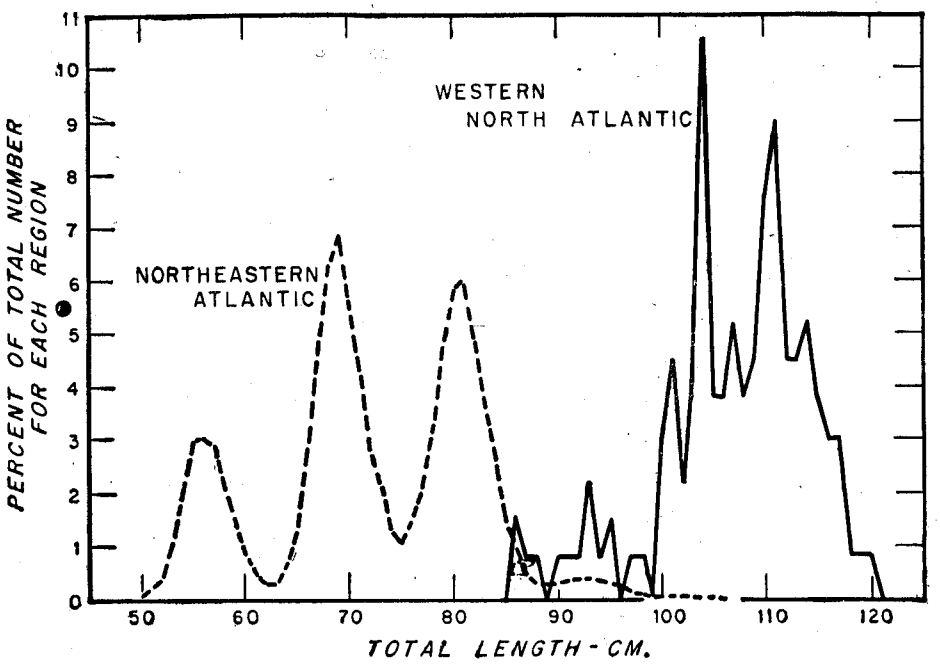
Sources : Eastern Atlantic : L. R. Rivas (Robins, 1957) — 7
F. J. Mather W 35 (including 3 from the Mediterranean)
Rodriguez-Roda (1960) — 17
Western Atlantic : L. R. Rivas (Robins, 1957) — 44
F. J. Mather et al. — 234
Eastern Pacific : Godsil and Holmberg (1950) — 27
F. J. Mather — 15

The morphometric data are more difficult to analyse, as there is almost as much variation between measurements taken by different workers on fish from the same area as there is between fish measured in different areas. Differences between western Atlantic and eastern Pacific bluefin appear to be important. The western Atlantic form is less deep than the Pacific one, and has longer pectoral fins, greater spread of the caudal fin, and larger diameter of the iris.

Pending more complete analysis, it seems that the bluefin tuna of the opposite sides of the Atlantic differ at the racial level at the most, but that those of the eastern Pacific may differ from them at the subspecific level.

Fourteen albacore, *T. alalunga* 60-77 cm. long from the Bay of Biscay were examined for comparison with western Atlantic materials. The gill raker counts of Letaconnoux (1951) were used to supplement the above data. There was virtually no difference between the fin ray counts for the two regions, nor between those of lower gill rakers. The counts of upper gill rakers were slightly higher for the eastern Atlantic albacore than for those of the western Atlantic. As the eastern Atlantic specimens were all smaller than any of the western Atlantic ones, a direct comparison of morphometric characters was not possible. When the respective measurements were plotted against fork length, however, straight lines or smooth curves could be fitted through the points from both areas for nearly all the characters. The major exception was the plot of depth. For the eastern Atlantic albacore, the depth averages about 25% of the fork length. The smallest western Atlantic fish are similar, but with increasing size the depth reaches 28.5% of the fork length. This may represent allometric development.

The sizes of a bacore taken on the respective sides of the north Atlantic suggest strongly that there is one population in that ocean, segregated according to size. In Fig. 10 we show length frequencies of 133 albacore taken in the western North Atlantic compared with those of over 16,000 taken in the northeastern Atlantic (Le Gall, 1949). Nearly all the



Text Fig. 10. Length frequencies of samples of albacore taken in the northeastern Atlantic (broken line) and in the western North Atlantic (solid line) by 1 cm. groups. The fork lengths of the western North Atlantic material were converted to total lengths by the formula : total length = fork length × 1.07 (Le Gall, 1949).

western catches were of fish larger than any of the eastern ones. A break-down of the western Atlantic data suggests further that there is also some size segregation within that area, as all the albacore taken in the vicinity of the Bahamas and the west Indies and in the Caribbean Sea were more than 100 cm. long (total length) whereas specimens down to 84 cm. long (total length) were taken in the northwestern Atlantic proper.

Notes on Literature

The literature of the genus was recently reviewed by Collete (1961, unpublished). With a few exceptions, his synonymies are in agreement with our identifications based on external characters. The author has examined the type of *Thynnus coretta* Cuvier *in* Cuvier and Valenciennes and agrees with Rivas (1961) that this is a blackfin tuna, *Thunnus atlanticus*, the gill raker count of 6-17 clearly separating it from all other Atlantic *Thunnus*. This specimen was listed as MNHN 2280 by Rivas, but the correct number is MNHN A5380 (Bauchot and Blanc, 1961, and personal communication from Dr. M. L. Bouchot). We also differ from Collette as to the actual identity of several species listed by Fernandez-Yepez and Santaella (1956). The specimen listed as *T. thynnus* (pp. 9-10; Fig. 2, plates 1 and 4) has all the characteristics and appearance of *T. obesus*, while the one listed as *Parathunnus obesus* (p. 19, Fig. 7, plate 9) appears actually to be *T. atlanticus*. The gill raker counts,

which would settle these questions conclusively, were unfortunately not listed by the authors. Finally, Fig. 4 and plate 6 show clearly that the specimen identified as *Germo balteatus* by Fernandez-yepez and Santaella and placed in the synonymy of *Thunnus atlanticus* by Collette is actually, as indicated by Rivas (1961), a young *T. albacares*. The markings shown in both the plate and the line drawing are typical of the yellowfin tuna but are never found on the blackfin.

The paper of Rivas (1961) raises the question of *Thynnus argentivittatus* Cuvier *in* Cuvier and Valenciennes. Specimen A5816, MNHN, Paris from the Malabar Coast, India was designated as the lectotype for the Indian Ocean yellowfin tuna, *Neothunnus argentivittatus*, by Schaefer and Walford (1950). Rivas (1961) showed that this number was incorrect, actually being A5814, and also that this specimen was not yellowfin tuna. He designated it as the lectotype of a species he considered valid, *Thunnus* (subgenus *Parathunnus*) *argentivittatus*. Actually, this specimen cannot be the lectotype for *Thynnus argentivittatus* Cuvier, as it was not so designated in the Museum nor was it cited by the author in listing his study materials, and the actual syntypes of *T. argentivittatus* Cuvier are MNHN specimens A5572, Atlantic, and A5567, "Sea of the Indies, below the Equator by 85° (E)" (Personal communication from Dr. M. L. Bauchot). The author has examined all three specimens, externally. Although the syntypes are poor stuffed specimens, he has little doubt but that they are yellowfin tuna. Specimen A5814, on the other hand resembles completely in its external characteristics a *Thunnns tonggol* (Plate VIII) of nearly the same size collected in Japan and identified and sent to us by Dr. H. Nakamura, and also a larger specimen of this species collected in the Red Sea, as well as the description of *Neothunnus rarus* Kishinouye, since synonymized with *Kishinoella tonggol* (Serventy. 1942). The external characteristics of specimen A5814 certainly differ from Rivas' proposed subgenus *Neothunnus* in the direction of *Thunnus* (*Kishinoella*) *tonggol* rather than in the direction of *T. atlanticus* and *T. obesus*, the other species included in Rivas' subgenus *Parathunnus*. Specimen A5814 is more slender, with a shorter head and anterior portion of the body, and a longer posterior portion, as indicated by a shorter preanal length, and a smaller eye than *T. albacares*, the only species included by Rivas in his subgenus *Neothunnus*, whereas *T. atlanticus* and *T. obesus* are both stouter than *T. albacares*, with longer heads and anterior portions of the body, and shorter posterior portions and larger eyes. Only in the gill raker count (8+17) it is closer to *Parathunnus* than to *Neothunnus* (after Rivas).

Therefore *Thynnus argentivittatus* (Cuvier, specimen A5572 and A5567, MNHN, Paris) should be placed in the synonymy of *Thunnus albacares* (Bonnaterre), while *Neothunnus argentivittatus* (Schaefer and Walford, 1950) and *Thunnus argentivittatus* (Rivas, 1961) (both based on specimen A5814, MNHN) belong in the synonymy of *Thunnus tonngol* (Bleeker) as far as can be determined from external characters. This is mentioned in support of the more conclusive internal evidence on the status of specimen A5814 included in Part I of this paper (Watson, in press).

Summary

Morphometric and meristic data and color notes were obtained for numerous specimens comprising graded series covering the range of sizes available for each of the five species of *Thunnus* occurring in the western North Atlantic. These are the bluefin tuna, *T. thynnus*, the yellowfin tuna, *T. albacares*, the albacore *T. alalunga*, the blackfin tuna, *T. atlanticus*, and the bigeye tuna, *T. obesus*. Proportions, counts, and color descriptions are presented for the

genus as a whole. The respective species are compared with emphasis on allometric development. Characters important for identification include the count of gill rakers, the lengths of the pectoral fins, the head, and the second dorsal lobe, the maximum depth, and the diameter of the iris.

The head and anterior portion of the body become relatively shorter with growth, whereas the posterior portion of the body and the second dorsal, anal and caudal fins become relatively longer. The first dorsal and ventral fins remain relatively unchanged, and the pectoral; except in *T. alalunga*, is at its maximum relative size in medium sized individuals of the respective species. Color characters important for identification include the white posterior edge of the caudal fin of *T. alalunga*, and the absence of yellow in the finlets of live *T. atlanticus*. A key for the identification of *Thunnus* species of the western North Atlantic based on external characters is presented. A preliminary comparison indicates that bluefin tuna of the eastern and western Atlantic differ from each other at the racial level at the most, and from those of the eastern Pacific at the subspecific level. Examinations of albacore from opposite sides of the Atlantic reveal no distinct morphological differences. Length frequencies of samples from the two regions indicate a distinct size segregation, with large individuals to the west and small ones to the east, possibly all belonging to one population.

Acknowledgement

The authors are indebted to Howard A. Schuck, formerly of the U.S. Fish and Wildlife Service, and Donald M. Allen and many others of that organization, to Dr. Robert H. Gibbs, Jr., of Boston University, and also to Prof. Luis R. Rivas and others of the University of Miami for much of the data used here. Harvey R. Bullis, Jr., James L. Squire, Jr., and Warren F. Rathjen of the U. S. Fish and Wildlife Service have made possible cruise participation and the loan of fishing equipment resulting in the opportunity to examine a great many specimens obtained beyond the range of ordinary fishing activity. The Associates of the Woods Hole Oceanographic Institution and the Louis E. Marron Fund have financed field trips which otherwise would have been impossible, and Mr. Marron's loan and subsequent gift of his fine cruise EUGENIE VIII further augmented our collections. In 1961, a grant from the Sport Fishing Institute, Washington, D.C., contributed to the collection of specimens and data and to biometric analyses. The fine facilities of the Lerner Marine Laboratory greatly assisted our work in the Bahamas.

A great many sport and commercial fishermen have permitted us to examine their catches and even donated specimens. Numerous members of the ships' companies and scientific parties aboard vessels of the Woods Hole Oceanographic Institution have collected specimens as a voluntary extra activity, notably Carl Speight, formerly of R. V. ATLANTIS, Martin R. Bartlett, formerly of R. V. CRAWFORD, and John Valois of the Marine Biological Laboratory, Woods Hole, Mossachusetts. The author wishes to extend his sincere appreciation to these and to the many others who have contributed support and material to this study, and also to the National Science Foundation for the principal financial support of this study.

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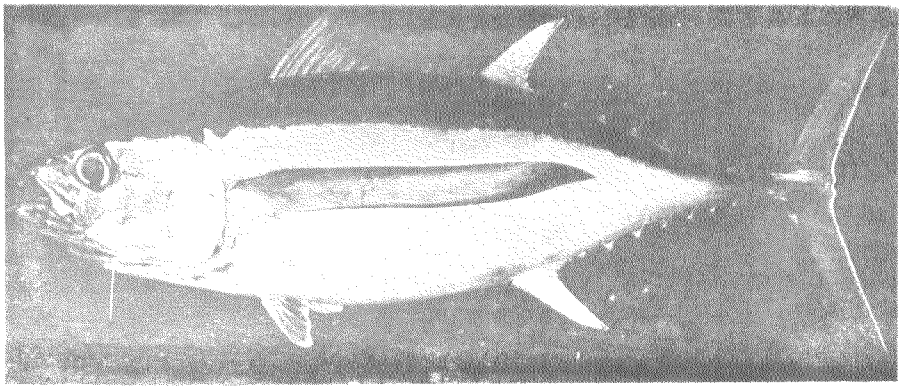
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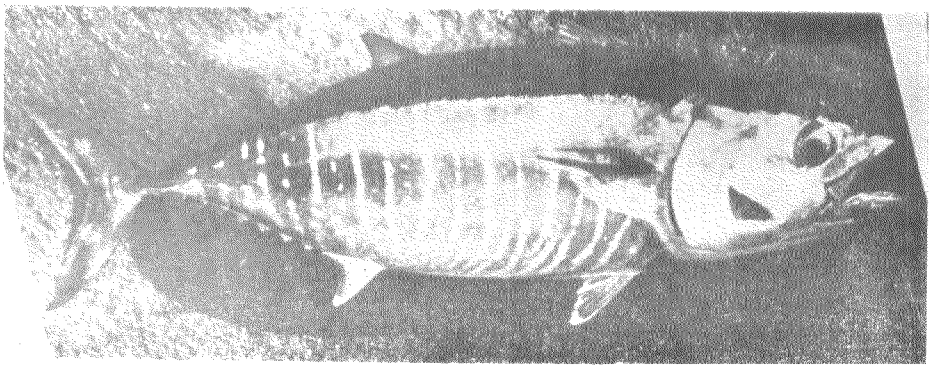
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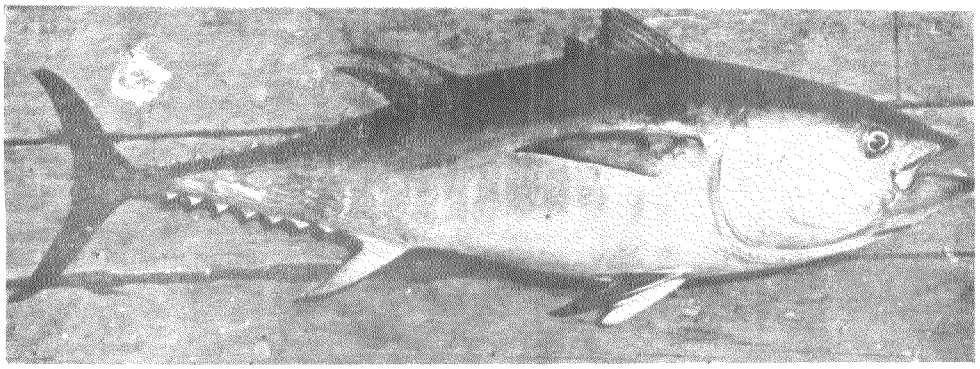
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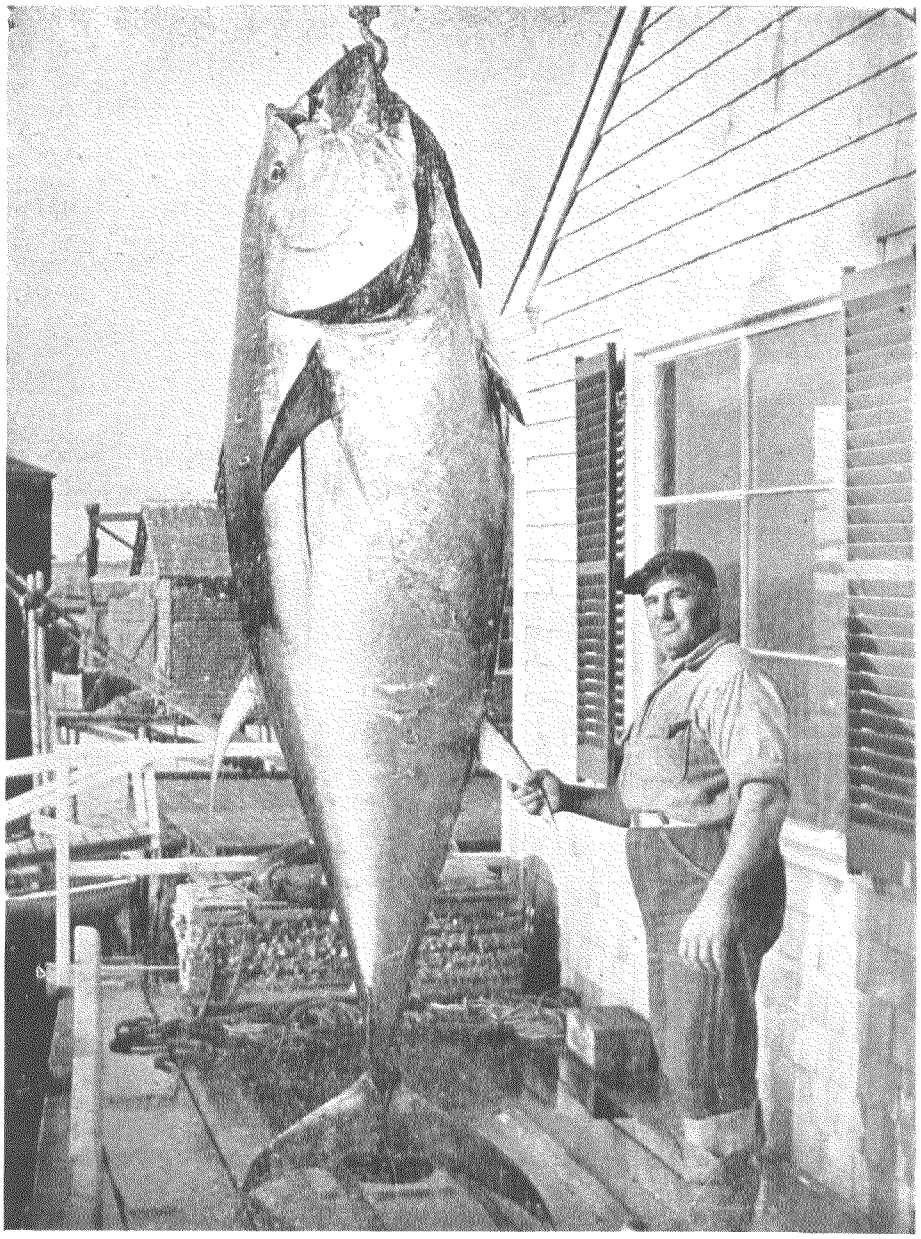
Albacore, *Thunnus alalunga*, about 100 cm. in fork length, taken in late May, 1959, in the vicinity of 38° 30′ N — 68° 30′ W. Note white posterior edging of caudal fin which separates *T. alalunga* from all other species of *Thunnus*.



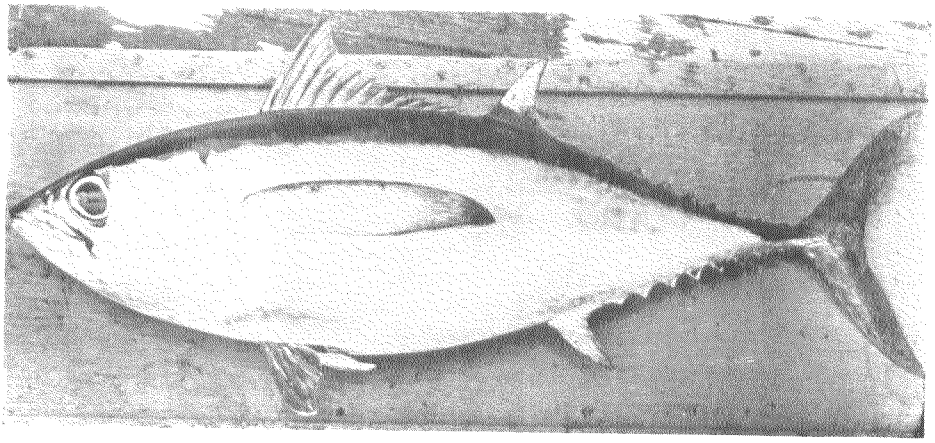
Bluefin tuna, *Thunnus thynnus*, 46 cm. in fork length, taken off Cape Hatteras, North Carolina, on 27 January, 1959. Note extensive and prominent light markings, which break up into spots and become less extensive and conspicuous with growth of fish.



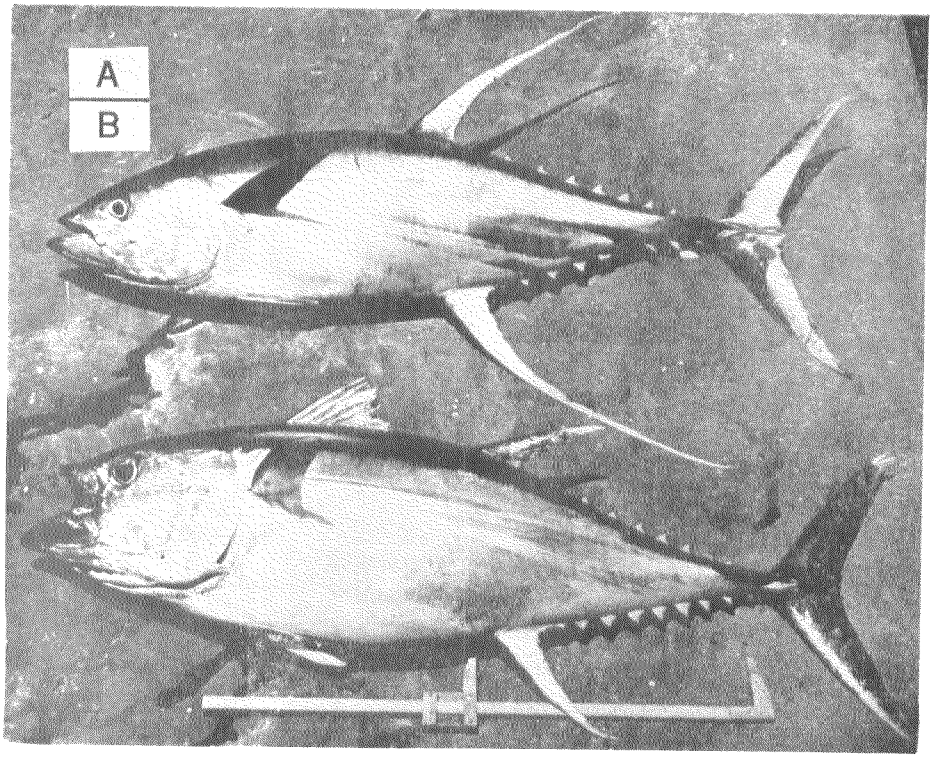
Medium-sized bluefin tuna, *Thunnus thynnus*, about 165 cm. long caught late in May, 1959, in the vicinity of 38° 30′ N — 68° 30′ W. Note reticulated pattern ventrally between anal and caudal fins and reduction in anterior lateral and ventral markings compared with Plate II.



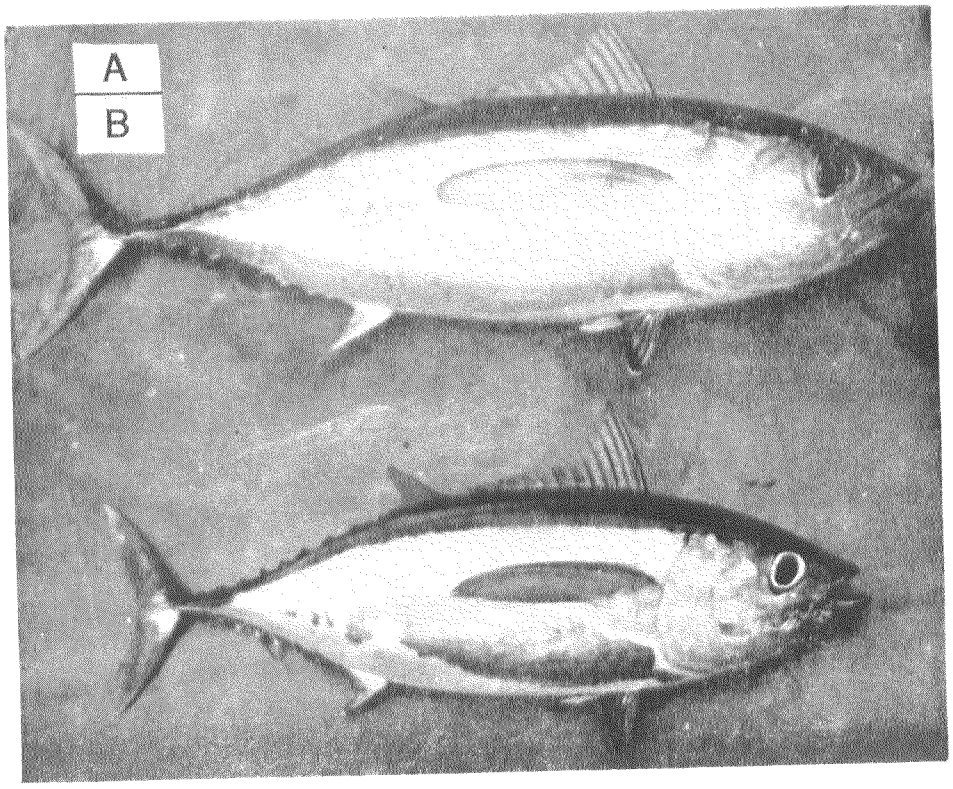
Bluefin tuna, *Thunnus thynnus*, 270 cm. long and weighing 428 kg. taken off Barnstable, Cape Cod, Massachusetts, on 2 October, 1950. Note absence of lateral and ventral markings. The fat condition of this fish is typical of those taken at the end of the summer feeding season.



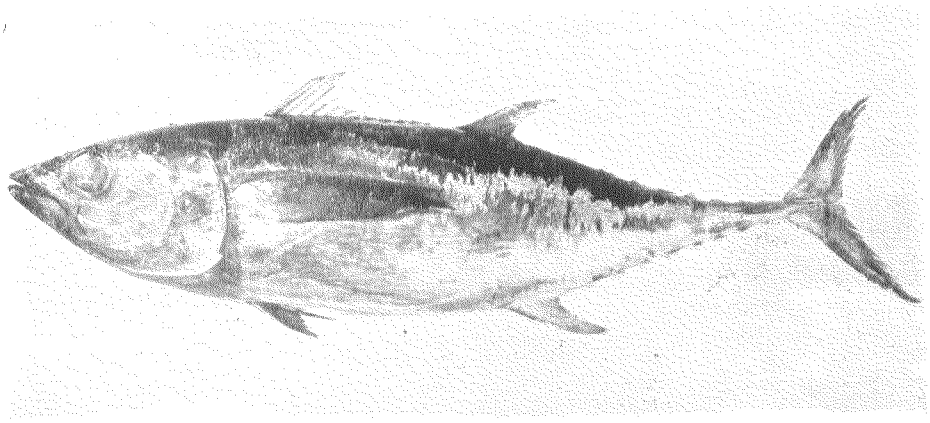
Blackfin tuna, *Thunnus atlanticus*, 59 cm. long, taken off Cozumel Island, Mexico, (Yucatan Channel) on 23 February, 1950. This specimen lacks white markings on side of body.



Yellowfin tuna, *Thunnus albacares* (A) and a bigeye tuna, *Thunnus obesus* (B), both about 150 cm. long, taken off Beata Point, Dominican Republic, 17°50 N—72°00′ W, on 21 April, 1955 by M.V. OREGON at Station 1291. The two bigeye tuna caught at this station were the first recorded from the western Atlantic (Bullis & Mather, 1956).



Small yellowfin tuna, *Thunnus albacares* (A) 54 cm. long and blackfin tuna, *T. atlanticus* (B) 44 cm. long, both collected off Cayo Confites, Cuba (Old Bahama Channel) on 24 May, 1958. The white markings usually conspicuous in yellowfin tuna of this size have faded, but those on the blackfin tuna may be seen below the pectoral fin.



Thunnus tonggol (*Kishinoella tonggol*, *Neothunnus rarus*) ripe female, 44.7 cm. in fork length, caught by trolling on 7 June, 1958 at 4°13′ N W 106, 11.E by YACHIYO-MARU No. 6. Received from Dr. H. Nakamura, Director of the Nankai Regional Fisheries Laboratory, Japan.

TUNAS (GENUS *THUNNUS*) OF THE WESTERN NORTH ATLANTIC*

PART III. Distribution and behavior of *Thunnus* species

BY

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INTRODUCTION

Although tunas of the genus *Thunnus* are widely distributed over the western North Atlantic, remarkably little was known about their occurrences in this region until recently. Commercial and sport fishermen have long been familiar with the summer occurrence of *T. thynnus* in coastal waters from New Jersey to Nova Scotia. In the 1930's the sport fishermen also discovered the northward run of large bluefin tuna off the northwestern Bahamas in spring. Gradually scientists and fishermen began to recognize the other species of *Thunnus*, chiefly in southern waters. Increased research and fishing has, in recent years, rapidly expanded our knowledge of tunas in the region.

We searched the statistics and the press of sport and commercial fisheries, as well as scientific literature, for information on distribution. The senior author and several of his colleagues have fished extensively in sport and research vessels from Nova Scotia to the West Indies and have examined sport and commercial landings in most of the tuna fishing centres in this region. In addition, a great deal of information has been obtained through interviews and correspondence with fishermen, scientists and other persons who knew about the occurrences of these fishes. Every effort was made to obtain as accurate data as possible on species, sizes, and numbers of fish, and dates, locations and circumstances of capture. Although some allowance must be made for possible errors in identification, a great deal of valuable data was obtained on tunas in the inshore waters (usually less than 30 miles from land) fished by the sport and small-scale commercial fisheries. Exploratory fishing by the U. S. Bureau of Commercial Fisheries (Murray, 1952, 1953, 1954) and occasional catches by commercial trawlers provided considerable information on tuna distribution further offshore in the Gulf of Maine and on the banks and the continental shelf off New England, Long Island, and New Jersey.

The chief source of information for waters beyond the 100-fathom curve has been exploratory long-line fishing. The Exploratory Fishing and Gear Research Laboratories of the Bureau of Commercial Fisheries (U. S. Fish and Wildlife Service) at Pascagoula, Mississippi, and Gloucester, Massachusetts, have conducted major long-line programs with M. V. OREGON in the Gulf of Mexico and the Caribbean Sea (Wathne, 1959) and with M. V. DELAWARE in the northwestern Atlantic (Squire, in press). More recently, cruises of R. V. CRAWFORD (Mather and Bartlett, 1962, and unpublished data) of the Woods Hole Oceanographic Institution have supplemented these efforts, as have small-scale cooperative ventures of various sport fishermen and scientists (Erdman and Maytag, 1957, unpublished), and data at the Woods Hole Oceanographic Institution. The long-line fishing

* Contribution No. 1258 from the Woods Hole Oceanographic Institution.

technique has generally followed that described by Bullis and Captiva (1955). The results of cruises of the OREGON, the DELAWARE, and of other vessels of the U. S. Bureau of Commercial Fisheries have been published in "Commercial Fisheries Review" in addition to the summarizing papers cited above. Japanese vessels have also explored the Caribbean Sea and the western North Atlantic, and have been fishing commercially for several years in the Equatorial Current area (Anonymous, 1958 and 1960, Nagai and Nakagome, 1957). Records of trolling catches and sightings contained in cruise reports of vessels of the U. S. Bureau of Commercial Fisheries, and also those resulting from an informal volunteer program on our vessels engaged in other projects, have provided additional data on offshore occurrences of tunas (Schuck and Mather, 1951 ; Mather and Schuck, 1952 ; Mather and Day, 1954 ; and Mather and Gibbs, 1957).

General Distribution

Three species, *Thunnus albacares, T. obesus and T. alalunga,* are cosmopolitan in southern warm waters. Seasonally they move northward and into the waters of the continental slopes and occasionally those of the shelves as they become warmer. The northernmost western Atlantic record for yellowfin and bigeye tunas is 42°18'N, 64°02'W, on 11 September, 1957 (M.V. DELAWARE Cruise of 57-8, Sta. 1). That for the albacore is from Banquereau (about 44 °N, 58°30'W, Goode and Bean, 1879). *T. atlanticus,* the blackfin tuna, is more restricted in its range, being found mainly near land or relatively shoal water (less than 100 fathoms). Its range changes little seasonally, and the northernmost record for it is 40°04' N 70°42'W (Mather and Schuck, 1952). This is the only species of *Thunnus* which, as far as we know, occurs in the western Atlantic only. *T. thynnus* has a much more dramatic and complicated migratory pattern than the others, drastically changing its habitat both seasonally and at various stages in its life cycle. Important changes in its distribution and habits appear to occur approximately (at the following sizes and ages: 2.5 kg. (1 year), 30 kg. (4 years), and 120 kg. (9 or 10 years) (ages from Mather and Schuck, 1960). In describing the distribution and behavior of bluefin tuna, therefore, we shall refer to individuals weighing less than 2.5 kg. as "very small", those from 2.5 to 30 kg. as "small" those from 30 to 120 kg. as "medium-sized", and those over 120 kg. as "large" or "giant", a popular term in the eastern United States.

Vertical Distribution

The vertical distribution of tunas in the western North Atlantic varies with species and with season. *T. obesus* and *T. alalunga* are taken almost entirely at depths of from 15 to 100 fathoms. *T. albacares* is caught at these depths throughout the year, but it is also taken by trolling and is often seen feeding in schools on the surface in the tropics and, seasonally, as far north as Maryland and Bermuda. *T. thynnus,* except for very small individuals, appears to be at depths of from 15 to 100 fathoms in the winter. In the spring large individuals appear to school travelling near the surface off the northwestern Bahamas, and many schools may be found feeding or travelling on the surface in area from Cape Hatteras to Newfoundland in the summer, but there is evidence that they also feed on the bottom in the latter period. *T. atlanticus* is usually caught by surface fishing and is frequently seen feeding in schools on the surface. Catches by deep (long-line) fishing are negligible and it seems likely that it is not a very deep-swimming species. Mowbray (1956, unpublished) cited evidence that it was often found 13 to 15 fathoms below the surface in water from 26 to 50 fathoms deep off Bermuda.

Behavior and Associations

Tunas are noted as schooling fishes. Schools on the surface can be observed visually and species and sizes confirmed by catching the fish. Subsurface schools may be observed on depth recorders or similar equipment and sometimes can be chummed to the surface (lured by throwing quantities of bait overboard) or raised by trolled lures. Most of our information on subsurface schooling, however, is derived from the distribution of catches on long-lines. Tunas are usually caught in clusters, with groups of several fish on relatively short lengths of line separated by much longer lengths with very few fish or none. The following comments are based on our own and others' observations.

Tunas tend to school according to size. In schools of mixed sizes the larger fish are frequently below the smaller ones. Tunas of different species but similar sizes may school together. In northern waters skipjack, *Katsuwonus pelamis*, are sometimes taken in the same schools as small bluefin *Thunnus thynnus*, while in southern waters, they are often found schooling with *T. atlanticus*. Long-line catches have indicated that *T. obesus* may school with *T. albacares* of the same size (Bullis and Mather, 1956).

There is a tendency for the number of tuna in schools to vary inversely with the size of the individuals. The schools of large bluefin tuna observed off the Bahamas usually number from 6 to 20 fish each, although they sometimes include 50 to more than 100. The composition of schools of large *T. thynnus* off New England seems to be similar, except that smaller individuals may be mixed with the larger ones. Schools of medium-sized bluefin may number 1,000 or more fish, while schools of smaller individuals may include several thousands. Schools of medium-sized and small bluefin often consist of many layers of fish and may extend over a much greater area than is indicated at the surface.

Schools of bluefin tuna in the New England area have three typical patterns of behavior. One is "pushing"—travelling at speeds of from 3 to 8 knots in a dense group, with upper layer of fish very close to the surface, often showing their upper caudal lobes and second dorsal fins. The fish all travel in the same direction, pushing a wave of water before them and causing a wave like that of a small motor boat. A second pattern is called "milling." In this case, the school is more or less stationary, but individual fish are moving in circles or in random directions, rippling the water over the school. The third pattern, called "smashing," occurs when the fish are feeding viciously, compressing and driving schools of bait, making large splashes and whirls on the surface, and often leaping clear of the water. These flurries usually last for 30 seconds or less, and the school may reappear 100 yards or more away in a few minutes.

The large migratory bluefin passing the Cat Cay area in the Bahamas behave quite differently, usually, travelling northward in loose schools which may be seen just below the surface, and rarely feeding, leaping or pushing a noticeable wave. Smashing has been observed, however, off Walker Cay on the northern edge of the Bahamas.

Sharks' attacks on hooked tunas in northern inshore waters are comparatively rare, but in tropical waters large numbers of sharks, notably *Eulamia obscura*, *E. falciformis* and *Pterolamiops longimanus*, often accompany schools of blackfin and yellowfin tuna and frequently mutilate hooked fish. An interesting association is the frequent presence of a whale shark, *Rhincodon typus*, often in a vertical position with its head at the surface, in schools of *T. atlanticus* (Commercial Fisheries, U.S. Bureau of, 1951). Blue marlin (*Makaira*

nigricans) are also often found near these schools, as the blackfin tuna is a frequent item in their diet (Erdman, 1951, unpublished).

Large bluefin tuna are subject to predation by cetaceans called "blackfish", but whose exact identity is uncertain, in the Straits of Florida (personal communication, Captain Walter Clay) and by killer whales (*Orcinus orca*) in Newfoundland waters (Wulff, 1943, unpublished). On the other hand, the presence of finback whales (*Balaenoptera* sp.) and blackfish (*Globicephala melaena*) is regarded as a favorable indication for the presence of bluefin tuna in Cape Cod waters (personal communications Capt. Charles Mayo).

The wakes of boats and other disturbances in the water apparently offer a strong attraction to small bluefin tuna. It is notable when these fish are schooling that lures trolled close to the stern usually catch more fish than those trolled at a distance from it, and that fast trolling speeds and turbulent wakes produce the best results. On one occasion when a fisherman was having difficulty in approaching small *T. thynnus* to harpoon them in the usual manner, he got into a small boat which was being towed behind his motorboat and harpooned several bluefin which rose in its wake, although no lures were being trolled (personal communication, Capt. Stanley Poole).

Distribution by Species

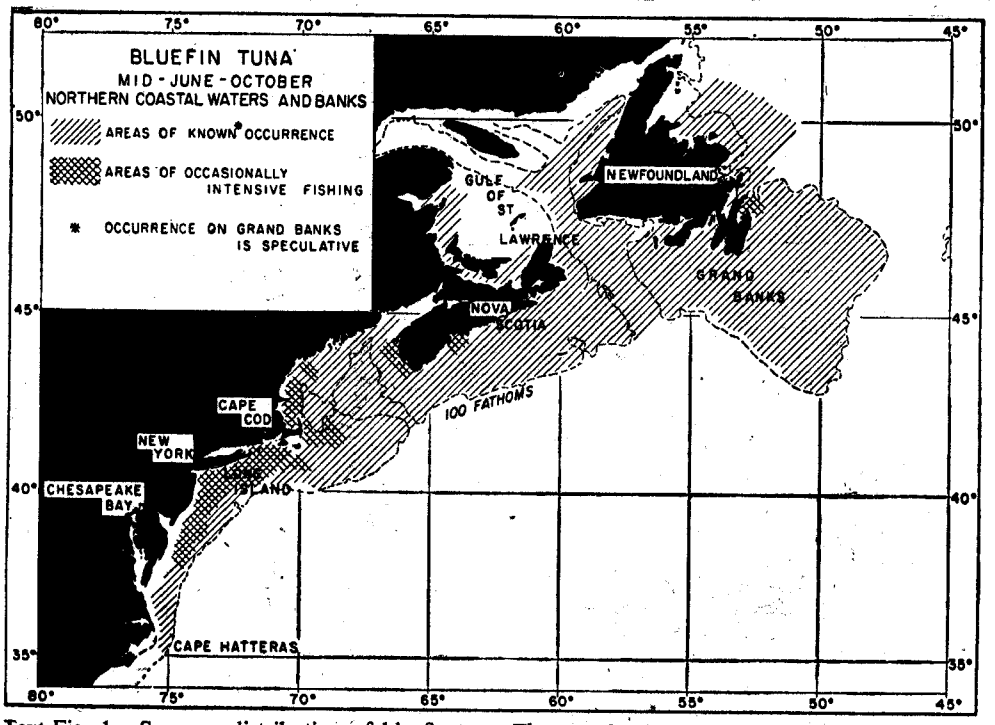
Bluefin tuna :

Thunnus thynnus, the bluefin tuna, is scattered over a wide range at birth, owing to the vast extent of its spawning grounds, Juvenile *T. thynnus* tend to concentrate in northwestern Atlantic coastal waters during their first year of life. Their range is at its minimum during their second summer after which it again increases.

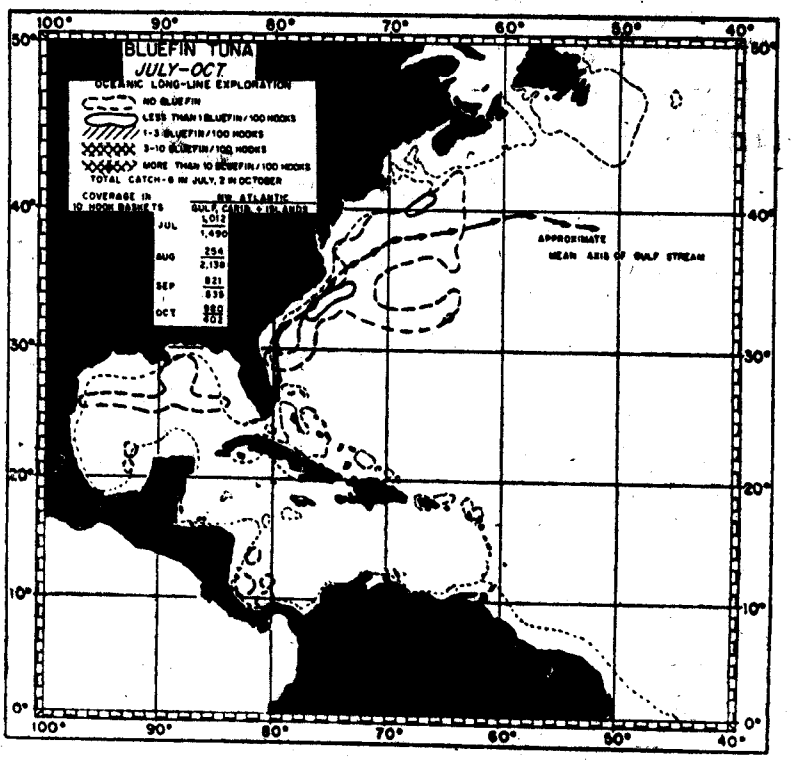
During the season of maximum water temperature in the inshore waters, from July through October, the bluefin tuna of the western North Atlantic are apparently almost all on or near the continental shelf between Cape Hatteras and Newfoundland, including the outer shoals and banks (Figure 1) (Bigelow and Schroeder, 1953). Longline fishing in this period (Figure 2) indicates the almost complete absence of the species from the deep oceanic waters. Occurrences of *T. thynnus* in its summering area are erratic and unpredictable, depending on the availability of food and probably also on other factors which are not yet known. Shifts in the localities of concentrations of bluefin sometimes occur from year to year and sometimes after periods of two or three years or longer. It is sometimes difficult to determine whether changes in the landings at a given locality are due to non-availability of fish or to lack of fishing effort, since there has been very little organized and continuous commercial tuna fishing in the area.

In general, most of the small bluefin tuna are found from Cape Cod to the southwestward, and on the outer shoals and banks. The medium-sized and larger *T. thynnus* generally occur from eastern Long Island to the northeastward, although they were formerly abundant off northern New Jersey and western Long Island and still occasionally gather there. The smaller individuals seem to favor the warmer waters of the region in the summer, while the larger ones frequent colder waters as well.

The first bluefin to arrive in northern waters usually are large individuals, taken late in May or in the first half of June off Cape Cod or Gloucester. Next are the small *T. thynnus* which may appear anywhere from the Chesapeake Capes to Cape Cod from mid-June to early July. The medium-sized fishes usually are the last, sometimes occurring off eastern Long



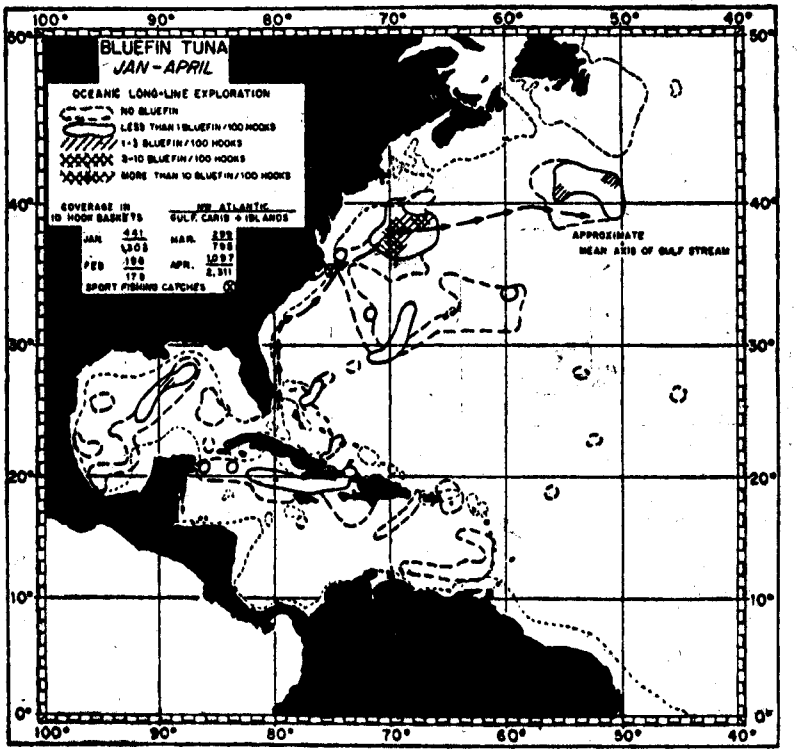
Text Fig. 1. Summer distribution of bluefin tuna *Thunnus thynnus* on the continental shelf from Cape Hatteras to Newfoundland.



Text Fig. 2. Oceanic longline exploration for July-October, showing areas and rates of bluefin tuna catches. The negligible catches indicate the virtually complete absence of the species from the oceanic waters in this period.

Island in July, but rarely arriving in numbers off Cape Cod, where they are more frequently found, before August, or in Nova Scotia before September. *T. thynnus* of this size also are usually the last to leave the northern areas, having been recorded in Cape Cod Bay in November and off Nova Scotia in October, after the larger and smaller fish have departed.

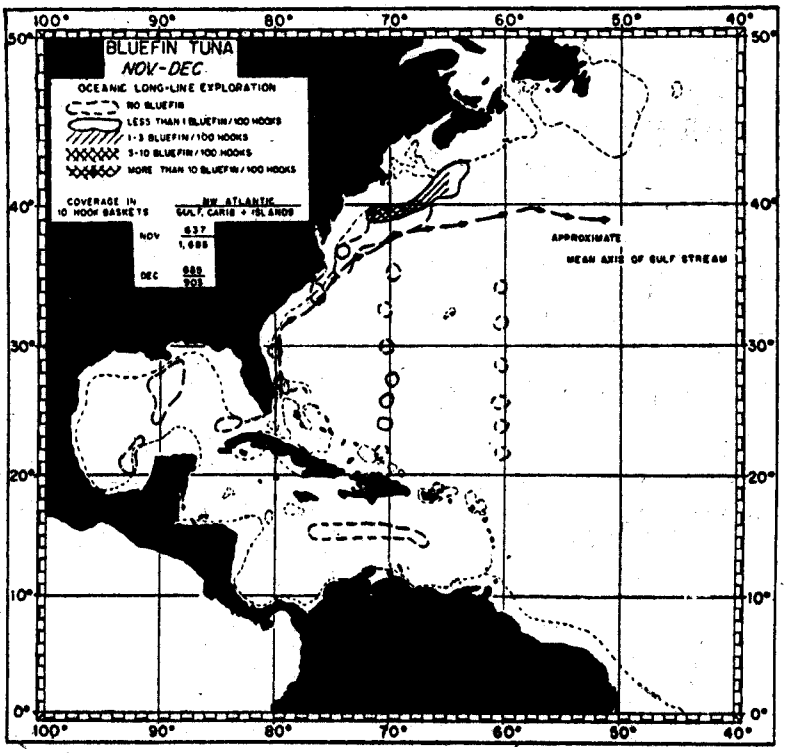
During the late fall, *T. thynnus* moves from its summer feeding grounds to its wintering areas, which are much more extensive. Figure 3 shows longline catches in November and



Text Fig. 3. Oceanic longline exploration for November-December, showing areas and rates of bluefin tuna catches. Medium-sized and small bluefin were concentrated along the 1,000 fathom curve off Cape Cod and Long Island in November, and the catches east of the Bahamas occurred in December.

December. During November 1960, a dense concentration of bluefin tuna was found by longline fishing along the 1,000 fathoms curve off southern New England, Long Island, and New Jersey (Mather and Bartlett, in press). Most of those taken were of medium size, but a few were smaller. As extensive fishing south of this area and one at station inshore from it produced no bluefin, it seems probable that these fish were schooling up and perhaps feeding in preparation for their migration to their wintering area.

The distribution of bluefin tuna in the period of minimum water temperatures (January–April) has been determined mainly by long-line fishing (Figure 4). The area occupied by the species in this season is vast and its limits have not been completely defined. Size segregation is more distinct in this season than in the summer. Although large individuals may be found over practically all of the wintering area, the medium-sized and small ones (with the exception of juveniles weighing less than 2.5 kg.) have rarely been taken south of 36°N in off shore waters or south of Cape Hatteras along the coast.

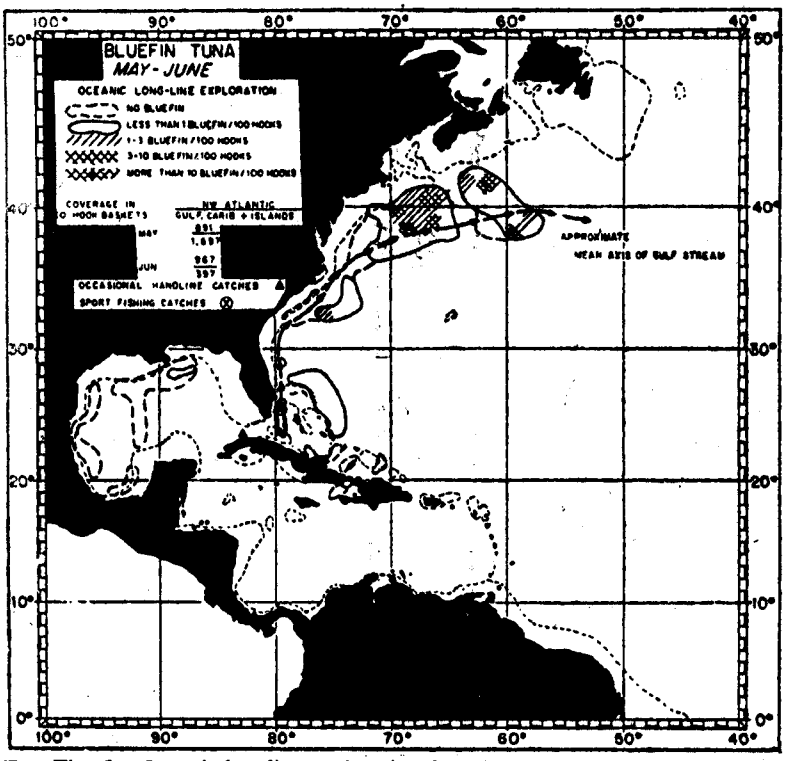


Text Fig. 4. Oceanic longline exploration for January-April, showing areas and rates of bluefin tuna catches. Large individuals were taken throughout the areas of the catches, but medium-sized and small ones were rarely caught south of 36° N.

There is little knowledge of the distribution of small bluefin tuna in winter. The few longline catches recorded have been in the vicinity of the Gulf Stream between 66°W and 72°W. Trolling catches are limited to a few in the Cape Hatteras area. Therefore the winter whereabouts of this immensely numerous group of *T. thynnus* remains virtually unknown.

The run of giant bluefin along the edge of the shelf off Cat Cay and Bimini in the northwestern Bahamas from early May until mid-June is the most dramatic evidence of the general spring migration of the species. Great numbers of these fish regularly appear in schools just below the surface when a southerly wind is blowing, travelling northward at speeds estimated to average 3.5 knots (Rivas, 1955). The oceanic longline catches for May and June, shown in Figure 5, suggest that most of these large individuals remain east of the Gulf Stream until they are well beyond Cape Hatteras.

Medium-sized *T. thynnus* have been taken in good numbers over a wide area between 37°N, 58°W, and the edge of the continental shelf. Catch rates for these fish outside the 1,000 fathoms curve have been higher in spring than in any period, especially during M.V. DELAWARE Cruise 59-6, May 1959, when the rates for 6 stations just north of the Gulf Stream in the vicinity of 38°30'N, 63°30'W averaged 15.6 fish per 100 hooks. These results suggest a schooling up of medium-sized bluefin tuna on the northern edge of the Gulf Stream prior to their inshore movement, corresponding to the concentration along the 1,000 fathoms curve north to northwest of this area in November prior to their offshore movement.



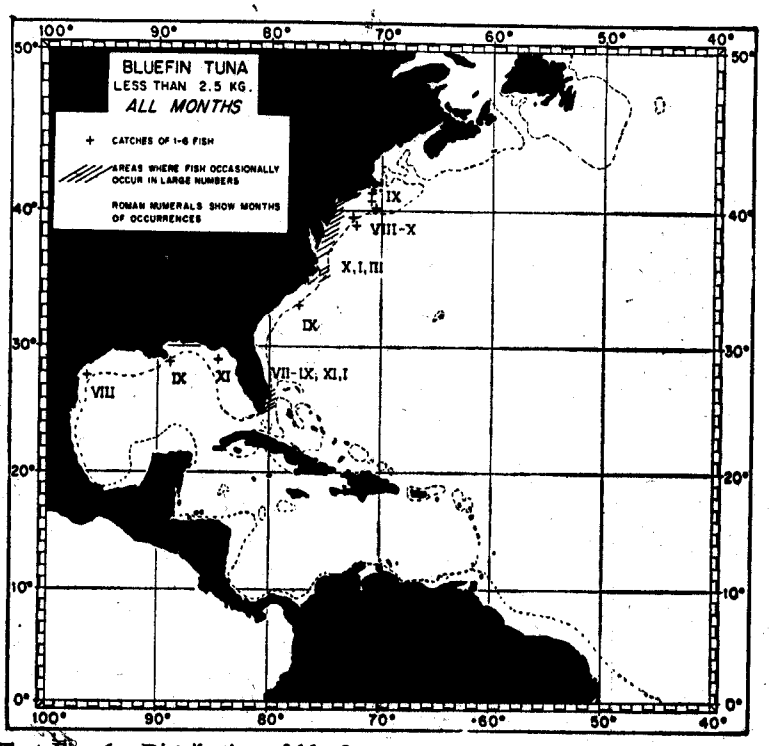
Text Fig. 5. Oceanic longline exploration for May-June, showing the areas and rates of bluefin tuna catches. Catches south of 36°N consisted of large individuals. Further north, medium-sized ones predominated in May but many large bluefin were taken in June.

Many of the bluefin caught from the DELAWARE in May were tagged, and one was recaptured in Cape Cod Bay in August, 1959 (Mather, 1960).

Again, little is known of the whereabouts of small *T. thynnus* in spring. A few have been caught by longline fishing, some near the edge of Georges Bank and others further eastward. Frequent trolling catches have been reported off Cape Hatteras in May (Aycock Brown, personal communication), and in the last half of June runs of them have occurred off many localities, as mentioned above, from the Chesapeake Capes to Cape Cod.

In the above discussion we have not considered the very small (less than 2.5 kg.) bluefin tuna, which are believed to be less than 1 year old. Considering the enormous numbers of these fish which must exist, few are taken and little is known about their distribution (Figure 6).

The annual distributional cycle described above suggests that there is a resident population of bluefin tuna in the western North Atlantic. The pattern for the eastern Atlantic *T. thynnus* is generally similar, but differs somewhat in dates and in the sizes of fish landed in certain parts of the cycle, suggesting that these fish also form a resident population. Morphometric and meristic comparisons between samples from the two areas have failed to show significant differences or complete similarity [see Part II, Mather, in press; also Ginsburg (1953); Rivas (1954, unpublished); Robins (1957, unpublished)]. The cooperative tagging program of the Woods Hole Oceanographic Institution, in addition, to showing the inshore

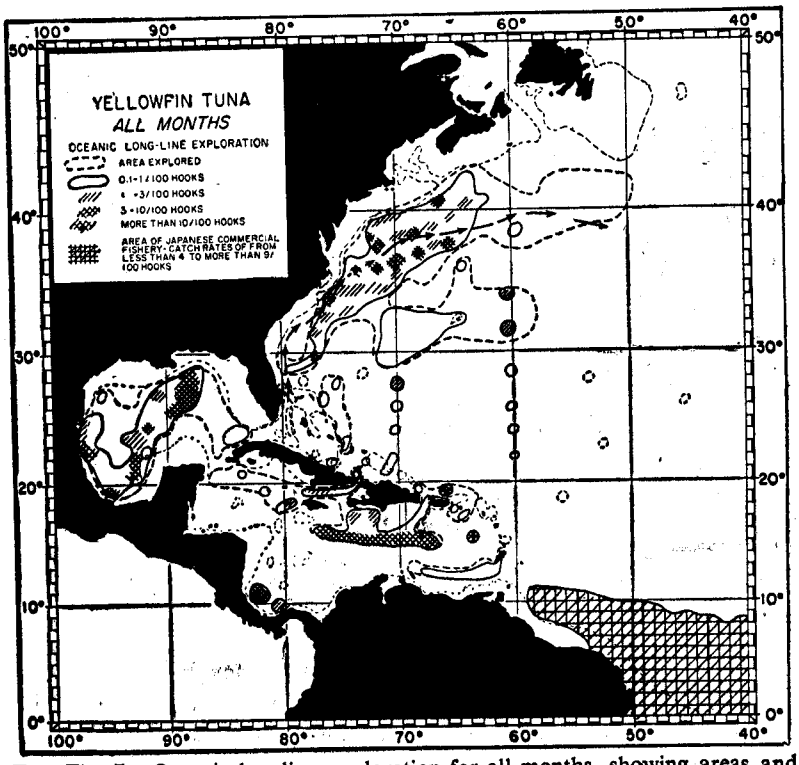


Text Fig. 6. Distribution of bluefin tuna weighing less than 2.5 kg., based on trolling catches.

migration mentioned above and some movements along the New England coast, has demonstrated transatlantic migrations of both small and large Western Atlantic bluefin tuna (Mather, 1960 and Mather, MS.). More tagging and related studies are needed to establish the importance of these migrations.

Yellowfin tuna:

Thunnus albacares, the yellowfin tuna, is cosmopolitan in the warm seas, being taken by deep fishing and also, in many areas, on the surface. Its distribution (Figure 7) appears to be controlled to a large extent by water temperature, as we have no records of its capture in waters of less than 18.3° C, and most of its occurrences have been in much warmer waters. The available data indicate that it is ubiquitous in the Gulf Stream and North Equatorial Current systems, the western Sargasso Sea, the Caribbean Sea, and the southern Gulf of Mexico. In the late spring it advances into the northwestern Atlantic slope water and is present there from late June until early October, leaving as the water cools. During Cruise 59-6 of M. V. DELAWARE, May 20-26, 1959, the sensitivity of the species to temperature was dramatically demonstrated. At six longline stations from 10 to 40 miles north of the Gulf Stream, with surface temperatures ranging from 10.6°C to 17.5°C, no yellowfin tuna were taken, although 450 bluefin were caught. A set just south of these, in 22.8°C water, produced 13 *T. albacares*. In June, some yellowfin have been caught about halfway between the Gulf Stream and the edge of the continental shelf off southern New England and Georges Bank, where the species has been taken from July into early October. During some summers, this tuna is taken in numbers by sport fishermen in localities between Cape Hatteras and Delaware Bay. The disappearance of the species from the northwestern



Text Fig. 7. Oceanic longline exploration for all months, showing areas and rates of albacore catches. Some trolling catches are also indicated.

Atlantic slope in November was indicated by Cruise 56 of R.V. CRAWFORD, when an extensive longline coverage of the area produced no *T. albacares* north of the Gulf Stream (Mather and Bartlett, in press).

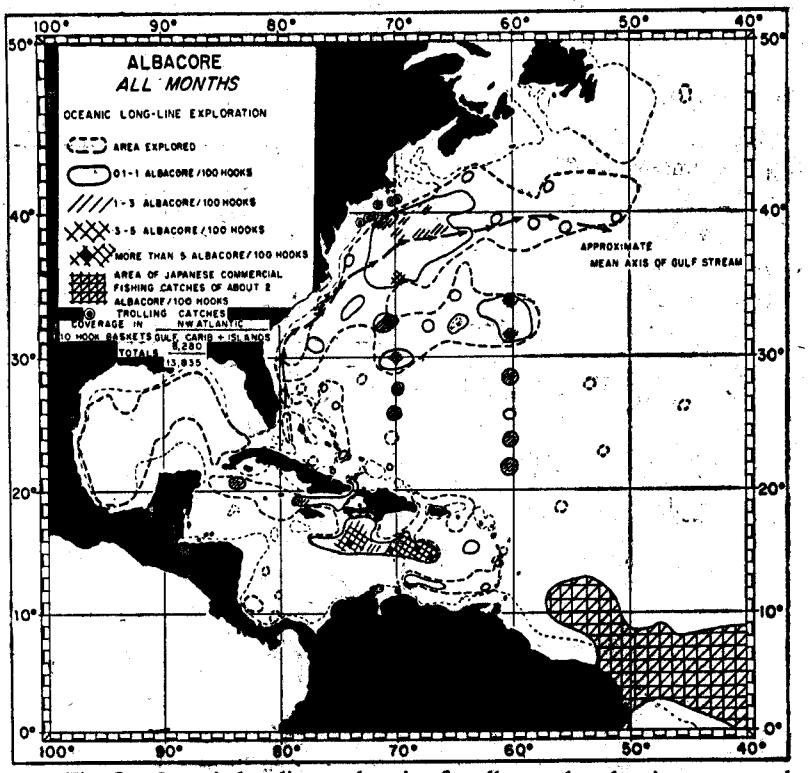
The occurrence of yellowfin tuna in the Gulf of Mexico has been described in detail by Wathne (1959), from extensive exploratory fishing by M. V. OREGON and records of commercial longline fishermen. While yellowfin tuna are present throughout the year, during the period January-June catch rates of more than 6 fish per 100 hooks are confined entirely to the southwest (Gulf of Campeche). During the period July–December, while the fishing in the Gulf of Campeche continues to be good, similar high catch rates occur over a large area in the north central Gulf of Mexico. Apparently the fish move into the northern Gulf in quantity about the same time as they enter the northwestern Atlantic slope water, but, probably owing to the higher winter temperature in the northern Gulf, they retreat from this area later and do not abandon it completely.

The Caribbean has been much less thoroughly explored, but the species has been found in that Sea in every season in which exploratory fishing was carried out.

Albacore :

Thunnus alalunga, the albacore, is widely but thinly distributed over the western North Atlantic (Figure 8). It is typically a deep-swimming resident of the oceanic waters, being taken almost exclusively by longline fishing. The waters between 30°N, 60°E and the continental shelf have been explored fairly thoroughly in most seasons, and albacore have been

taken over a great deal of this area in each season. The best fishing has been in November and December and the poorest in May and June. They are quite tolerant of



Text Fig. 8. Oceanic longline exploration for all months, showing areas and rates of yellowfin tuna catches. Catches north of the Gulf Stream and the larger ones in the northern Gulf of Mexico occurred in the warm months only.

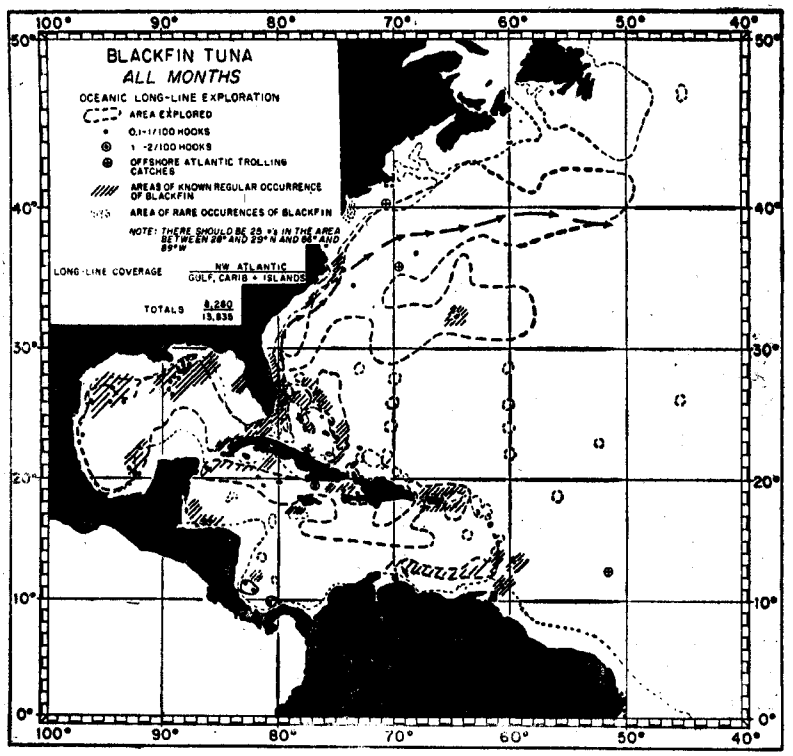
low temperatures, having been taken in waters whose surface temperature was below 60°F. including one catch near the edge of Georges Bank in February. We know of less than a dozen trolling catches for the species, and these are all from offshore waters between Cape Cod and New Jersey, during the summer and early fall (Mather and Gibbs, 1957; personal communications from Al Pflueger, Luis R. Rivas and L. R. Dixon).

Consistent catches of the species in the Windward Passage-Great Inagua-Crooked Island Passage area in the spring suggest a migration through these passages, or at least a connection between the Atlantic and Caribbean populations. Despite extensive exploratory and commercial tuna fishing in the Gulf of Mexico, this species has not been recorded from there. Nor has it been taken in the Straits of Florida, where little longline fishing has been done but where the sport fishery is probably the most intensive in the world.

T. alalunga are cosmopolitan in the Atlantic, being taken in the Equatorial Current region, around the Azores, Madeira, and the Canary Islands and in the northeastern Atlantic. The biometric studies in Part II (Mather, in press) suggest that there is a single albacore population in the North Atlantic, with a tendency toward size segregation of smaller fish in its eastern areas and larger ones in its western region.

Blackfin tuna :

Thunnus atlanticus, the blackfin tuna, is a warm-water species and one which is most commonly found near land or relatively shoal (less than 100 fathoms) water. Mather and Day (1954) described the broad outline of its distribution in the western Atlantic from off southern New England to the vicinity of Rio de Janeiro, Brazil. Areas where we have positive knowledge of its occurrence in the western North Atlantic are shown in Figure 9, but it may



Text Fig. 9. Distribution of blackfin tuna, based on literary references, personal observations, inquiries and longline catch records.

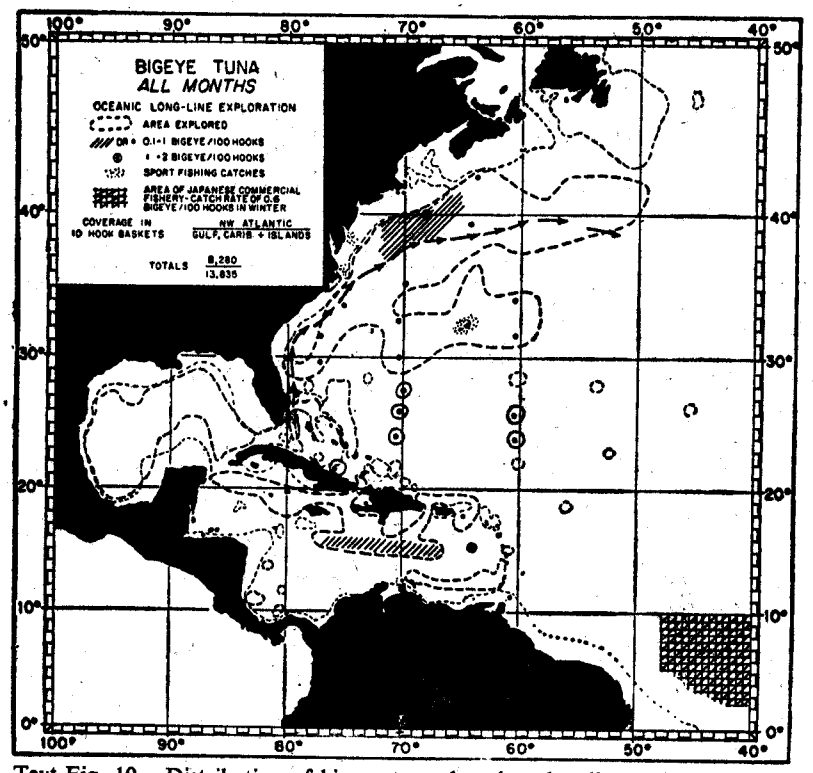
be assumed that this ubiquitous species will be found anywhere in tropical and warm subtropical waters where suitable conditions exist. It is the only tuna whose habitat is restricted to the western Atlantic, and although it extends its range into higher latitudes with the summer warming of the water, it does so less than the other tunas.

In tropical waters, schools of blackfin tuna often are seen feeding on the surface, sometimes mixed with skipjack (*Katsuwonus pelamis*) and other tunas. Offshore records of the species are more frequent for the Gulf of Mexico and the Caribbean Sea than for the Atlantic proper (Wathne, 1959, longline catches ; Bullis and Captiva, 1955, Bullis and Mather, 1956 and Commercial Fisheries, U. S. Bureau of, 1951, sightings and trolling catches).

Bigeye tuna :

Thunnus obesus, the bigeye tuna, is widely but thinly distributed over the northwestern Atlantic and the southern Caribbean (Figure 10). It appears to be a typically deep-swimming inhabitant of the waters beyond the edges of the continental shelves. Most of our records

are from oceanic longline fishing, and those of its capture by surface trolling are limited to a very few from the Straits of Florida and from the Cape Hatteras area, and of occasionally more numerous catches off Ocean City, Maryland (Mather and Gibbs, 1958).



Text Fig. 10. Distribution of bigeye tuna, based on longline and sport fishing catches.

The data are inadequate for analysis of seasonal movements, except that the catches along or near the edge of the continental shelf from Hudson Canyon to the Nova Scotia Banks have been confined to the summer and fall, and those off Ocean City, Maryland, have occurred in the summer only. The inshore-offshore movement is probably in response to seasonal warming and cooling of the water, as the minimum surface temperature for which we have records of the species is 13.9° C.

The bigeye tuna taken in the western north Atlantic are nearly all of a rather large size, ranging from 110 to 175 cm. in length. The only reports we have received of numerous smaller individuals have been based on sport fishing catches at Ocean City, Maryland, where the senior author examined an individual 66 cm. long, the smallest of which we have knowledge taken in the western north Atlantic.

It is also of interest that, while *T. obesus* is regarded as a tropical species in the eastern Atlantic and usually reported in associatoin with *T. albacares* (Frade, 1929), in the northwestern Atlantic it moves into the temperate zones seasonally and is often found with *T. thynnus* and *T. alalunga*. The species is cosmopolitan in the Atlantic and catches in the Equatorial Current system and the Azores and other islands indicate a transatlantic distribution.

SUMMARY

Three cosmopolitan species of *Thunnus*, the yellowfin tuna, *T. albacares* the albacore, *T. alalunga*, and the bigeye tuna, *T. obesus*, are found over most of the warmer waters of the western North Atlantic. All three species are taken by longline fishing in oceanic waters at depths of from 15 to 100 fathoms throughout the year. During the warm months, they expand their range northward and into the waters of the continental slopes and shelves, retreating to the deeper waters in the late fall. *T. albacares* is the most sensitive to cold water, not being found north of the Gulf Stream except in the warmest period. Unlike the albacore and the bigeye tuna, it is frequently found at the surface. *T. obesus* and *T. alalunga* have not been recorded from the Gulf of Mexico, nor has the latter been taken in the Straits of Florida. The blackfin tuna, *T. atlanticus*, is apparently a local species restricted to the warmer waters of the western Atlantic, and except in the Gulf of Mexico and the Caribbean Sea, is rarely taken by deep fishing. Its range expands but little in the warm months, rarely extending north of Cape Hatteras and Bermuda. The bluefin tuna, *T. thynnus*, is the most migratory species of the genus. Apparently nearly all the western North Atlantic population spends the warm months on the continental shelf from Cape Hatteras to Newfoundland, with the smaller individuals mainly to the southwest and the larger ones to the northeast. During the winter the species leaves the continental shelf and disperses widely over the subsurface waters of the Atlantic. Few of those weighing less than 120 kg., excepting small juveniles, have been taken south of 36°N, but the larger individuals range all the way to the Greater Antilles, the Gulf of Mexico, and the northwestern Caribbean Sea. Many schools of large *T. thynnus* regularly migrate northward through the Straits of Florida by the northwestern Bahamas in May and early June. Despite indications of a resident western north Atlantic population, both large and small bluefin tuna tagged in these waters have been recaptured off the coasts of Europe.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of a great many fishermen, scientists, and other individuals, in gathering information on the distribution and behavior of tunas. Among the most complete catch records were those obtained for the Cape Cod Bay trap fishery with the assistance of Frank Riley of the U. S. fish and Wildlife Service and Charles A. Mayo III, and the cooperation of Joseph Francis, Stuart Joseph, Anthony R. Silva, Max A. Finkel and John A. Worthington of the Province town area and Captains John E. Vetorino, Adam Rupkus, Mike Goulart and Nathaniel Wixon of Barnstable. Good statistics for sport fishing catches in Nova Scotia were received from the Nova Scotia Provincial Bureau of Information and from J. Israel Pothier, while those for catches off the northwestern Bahamas were provided through the courtesy of the Cat Key Club. Our own work in that area was greatly assisted by the excellent facilities of the Lerner Marine Laboratory. Much data for the Caribbean area have been furnished by Donald S. Erdman and many others.

Information on the previously unknown distribution of tunas in oceanic waters was obtained initially through cruise reports, participation in longline cruises, and personal communications provided or made possible by members of the U. S. Fish and Wildlife Service, notably Stewart Springer, Harvey R. Bullis, Jr., James L. Squire, Jr., John. J. Murray and Warren F. Rathjen. Additional longline explorations were carried out in R. V. CRAWFORD and smaller vessels whose part-time use was donated by L. V. Worthington, William E. Schevill, Dr. William S. Richardson and Dr. Richard H. Backus, all of the Woods Hole Oceanographic Institution. In addition, much exploratory fishing has been done in the

cruiser EUGENIE VIII, donated by Louis E. Marron, and some in June 1950 in sport fishing boats loaned by members of the Hatteras Marlin Club. Often valuable extra-curricular collecting was carried out by Martin R. Bartlett, Carl Speight, John Valois and others on research vessels engaged in other programs. A great many big game anglers, captains and mates of sport fishing boats, and commercial fishermen have furnished us with records and their knowledge and observations of the habits of tunas, and even more have participated in our cooperative game fish tagging program, which has also received fine organized support from several fishing clubs. Members of the fishing press have also contributed much information. We deeply regret that it is impossible to thank these persons and organizations individually. Among our colleagues who have contributed much to this study are Howard A. Schuck, formerly of the U. S. Fish and Wildlife Service, Donald M. Allen of that organization, Dr. Robert H. Gibbs, Jr., Bruce B. Collette, Bruce A. Rogers and Richard L. Haedrich of the Woods Hole Oceanographic Institution, and presently Martin R. Bartlett, M. Dorothy Rogers and John D. Bell. Financial support has been obtained from the Louis E. Marron Fund, the Associates of the Woods Hole Oceanographic Institution, the sport Fishing Institution, the Charles W. Brown, Jr., Memorial Foundation, and miscellaneous contributions, as well as the main sustaining grants from the National Science Foundation. We are most sincerely appreciative of the valued assistance of these many individuals and organization who have made this study possible.

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KEY TO THE ATLANTIC OCEAN TUNA FISHES OF THE GENUS *THUNNUS*[1]

BY

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The following key is based on preserved museum material, and on fresh caught specimens examined in the field. Subgenera are characterized mainly on the basis of internal characters. Markedly allometric proportional characters have been largely avoided in order to allow identification regardless of size. The geographical distribution and the most widely used common names are given for each species; following the diagnostic key characters.

With the exception of young yellowfin tuna (*Thunnus albacares*), the Atlantic species of *Thunnus* are not difficult to identify. Yellowfin tuna less than about four feet in fork length are very similar to the bigeye tuna (*T. obesus*). These two species differ in the average number of gill rakers on the lower limb of the first arch but there is overlap in the range of variation for this character. In the bigeye tuna, the number is usually 19, whereas in the yellowfin, the number is usually 20 to 22. Positive identification can be obtained however, by examination of the liver. In the bigeye tuna, the ventral surface of the liver is marginally striated and capillary plexuses are present on the dorsal side. In the yellowfin, the ventral surface of the liver is entirely smooth and there are no capillary plexuses on the dorsal side. In yellowfin tuna longer than about four feet in fork length, the second dorsal and the anal fin are very long and may extend to or beyond the caudal fin in large specimens. This markedly possitive allometric character serves to distinguish large yellowfin tuna from all the other members of the genus. In the largest specimens of bigeye tuna, the dorsal and anal fin, when depressed, never reach beyond the fifth finlet. In the bluefin tuna, albacore and blackfin tuna, the second dorsal and anal fin, when depressed, never reach beyond the third finlet.

1*a*.—Pectoral fin short, not reaching to vertical from origin of second dorsal fin or very long, reaching well beyond vertical from origin of anal fin. Cutaneous arteries originating ventral to the fifth vertebra. Coeliac-mesenteric artery with only two main branches. Posterior cardinal vein absent. Ventral surface of liver radially striated with fine venules. First completely enclosed hæmal arch occurring on the tenth vertebra. (Subgenus *Thunnus*).

2*a*.—Pectoral fin short, much shorter than head, not reaching to vertical from origin of anal fin. Gill rakers 24 to 28 on lower limb of first arch. Western Atlantic, from Newfoundland southward throughout the Gulf of Mexico and Caribbean Sea to Venezuela. Eastern Atlantic, from Norway

[1]Contribution No. 40 from the Ichthyological Laboratory and Museum, Department of Zoology, University of Miami.

southward throughout the Mediterranean and Black Sea and west coast of Africa to the Gulf of Guinea. (Bluefin tuna ; tunny ; thon rouge ; atun).

1. *Thunnus thynnus* (Linnaeus)

2*b*.—Pectoral fin long, much longer than head, reaching well beyond vertical from origin of anal fin. Gill rakers 19 to 22 on lower limb of first arch. Western Atlantic, from off New England southward throughout the Gulf of Mexico? and Caribbean Sea to Venezuela. Eastern Atlantic from the North Sea southward throughout the Mediterranean. (Albacore ; albacora ; germon.)

2. *Thunnus alalunga* (Gmelin)

1*b*.—Pectoral fin of medium length, reaching to or beyond vertical from origin of second dorsal fin but not beyond vertical from origin of anal fin. Cutaneous arteries originating ventral to the seventh or eighth vertebrae. Coeliac-mesenteric artery with three main branches. Posterior cardinal vein present. Ventral surface of liver smooth or only marginally striated with fine venules. First completely enclosed haemal arch occurring on the eleventh vertebra.

3*a*.—Second dorsal and anal fin shorter than head at all sizes. Gill rakers 15 to 20, usually 16 to 19 on lower limb of first arch. Efferent branchial arteries not connected with the cutaneous arteries. Dorsal and ventral branch of cutaneous artery not forming a posterior commissure. Capillary plexuses dorsal to the liver present. Ventral surface of liver marginally striated with fine venules. (Subgenus *Parathunnus*).

4*a*.—Gill rakers 4 to 6 on upper limb and 15 to 19 on lower limb of first arch. Finlets dusky, without yellow, not margined with black. Western Atlantic, from Cape Cod southward throughout the Gulf of Mexico and Caribbean Sea to southern Brazil and Trinidad Island. (Blackfin tuna).

3. *Thunnus atlanticus* (Lesson)

4*b*.—Gill rakers 8 or 9 on upper limb and 18 to 20 on lower limb of first arch. Finlets yellow, narrowly margined with black. Western Atlantic, from Browns Bank southward to Venezuela. Eastern Atlantic, from the Azores southward to South Africa. (Atlantic bigeye tuna; atum patudo).

4. *Thunnus obesus* (Lowe)

3*b*.—Second dorsal and anal fin about equal to or longer than head at about four feet in fork length or longer. Gill rakers 19 to 23, usually 20 to 22 on lower limb of first arch. Efferent branchial arteries connected with the cutaneous arteries on each side by a large vessel paralleling the dorsal aorta. Dorsal and ventral branch of cutaneous artery meeting posteriorly and forming a commissure. Capillary plexuses dorsal to the liver absent. Ventral surface of liver smooth. (Subgenus *Neothunnus*). Western Atlantic, from Florida and Bermuda southward throughout the Gulf of Mexico and Caribbean Sea to Brazil. Eastern Atlantic, from the Azores southward to South Africa. (Yellowfin tuna ; Allison tuna).

5. *Thunnus albacares* (Bonnaterre)

MARLINS, SAILFISH AND SPEARFISH OF THE INDIAN OCEAN

BY

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INTRODUCTION

The Indian Ocean is blessed with the presence of most of the known species of Istiophoridae, the family of the marlins, sailfish and spearfishes. Of the seven species that are recognized today, no less than four are known to occur in the Indian Ocean, and it seems probable that a fifth also is present. These species are the black marlin, *Istiompax indicus* (Cuvier) ; the blue marlin, *Makaira nigricans* Lacépède ; the striped marlin, *Tetrapturus audax* (Philippi) ; and the sailfish, *Istiophorus gladius* (Bloch). The probable fifth species is the short nosed spearfish, *Tetrapturus angustirostris* Tanaka. This last has not, to the best of my knowledge, been recorded from Indian waters, but it would be surprising if it is not present in the Indian Ocean.

All the members of this group are good food fishes, and are also highly regarded by those who fish for sport. The black marlin and the blue marlin, because of the excellent quality of their flesh, their sporting characteristics, and the enormous size they achieve, are without doubt the most highly esteemed. Closely following these two are the striped marlin, also of excellent food and sporting qualities, but of much smaller size, and the sailfish, which is a first class sport fish, although the meat is often tough. The spearfish is rather rare in all parts of its range, and is generally considered inferior to the others in its eating qualities.

The members of the family Istiophoridae may easily be distinguished from all other groups by the presence of the elongate, more or less cylindrical snout, which is much longer than the lower jaw in all except the adults of *T. angustirostris* ; the presence of ventral fins which are, from external appearance, reduced to a single ray (actually three elements, closely appressed) ; and the presence of two keels on each side of the caudal peduncle.

All members of the group are carnivores. Judging by the few food studies that have been done on this group, they are primarily piscivorous, but will eat whatever is available. Thus, Morrow (1952) found that striped marlin in New Zealand waters had fed most extensively on the local saury ; Hubbs and Wisner (1953) found similar conditions in striped marlin off California ; and Wallace and Wallace (1942), dealing with a strictly Atlantic species off the east coast of North America, found that the dominant food item was the local round herring. All these forage fishes are abundant, and all are of a size which may be conveniently eaten by the marlins. But that they will eat almost anything is also shown by these and other workers. Hubbs and Wisner recorded six additional species of fishes, Morrow nine, as well as cephalopods, while LaMonte (1955) reported " only squid in the stomachs " of striped marlin taken off Peru and Chile.

*The field work on which this paper is based was done while the author was on the staff of the Bingham Oceanographic Laboratory, Yale University, New Haven, Conn.

Most of the istiophorids apparently spawn during the summer months, roughly May through September. Sailfish and black marlin examined by me at Kaohsiung, Taiwan, in July 1957 were running roe and milt. Nakamura (1949) and Royce (1957) state that the spawning period of the striped marlin in the South China Sea, near the Ogasawara Islands, and in the Central Pacific may extend from February through June. By contrast, striped marlin examined by me in northern New Zealand in February and March 1948 were far from being in breeding condition. Blue marlin, black marlin and sailfish examined by me at Ceylon and the Maldive Islands in August and September 1957, at the Seychelles Islands in October and November of the same year, and off the East African coast in January—March 1950 and November 1957—January 1958 were not in breeding condition. Honma and Kamimura (1958) state that striped marlin of the South Pacific are reported by Japanese long liners to breed in the late fall—that is, November and December. It is quite possible that these fishes may spawn more or less all year round, with, perhaps, peak periods of breeding activity in May—July and November—December, which may very well be influenced by the seasonal changes associated with geography.

Egg measurements made by me on striped marlin from New Zealand waters and on sailfish from Taiwan suggest that in both these species about 1,000,000 eggs are present in each ovary, for a total of approximately 2,000,000 eggs per female. The eggs average about 0.85 mm. in diameter. No data are available for the other species, but the size of the ovaries makes it certain that they, too, must produce several million eggs per female.

The phylogeny of the Istiophoridae is not yet entirely clear, despite the recent excellent summary by Robins and deSylva (1960). Nearly every worker familiar with the group has slightly different ideas. All, however, agree that the sailfish is more closely related to the spear fish group (Atlantic and Pacific spear fishes, striped marlin, and white marlin) than to the marlins *sensu stricto* (blue marlin and black marlin); and that these latter forms are closer to each other than to the rest of the family. My own ideas are summarized in Figure 1, and in the last section of this article. A discussion of each of the species found or to be expected in the Indian Ocean, taken more or less in phylogenetic order, is now appropriate.

Tetrapturus angustirostris Tanaka

Shortnosed Spearfish, Furaikajiki

The spearfish apparently has not been recorded from the Indian Ocean, although it probably occurs here, for it is well known from the Pacific and certainly reaches as far east as the Indo-Australian Archipelago. Nowhere abundant, it does not achieve large size. Its flesh is not as desirable as that of most of the other istiophorids, hence it is not particularly sought after by commercial fishermen. Nakamura (1938) reports that in Taiwan this species is treated the same, market-wise, as the sailfish.

Distinguishing Characters : The most notable characteristic of the shortnosed spearfish is the relatively short upper jaw, which is scarcely longer than the lower in adults. Recent studies by Robins and de Sylva (1960) on the Atlantic spearfish (*Tetrapturus belone* Rafinesque) have shown that in that species the upper jaw is much longer than the lower in young specimens, but becomes relatively shorter with increased size of the individual. In addition to the character of relative length of the upper and lower jaws,

the shortnosed spearfish may also be distinguished by its long, moderately high dorsal fin. The greatest height of the dorsal fin is greater than the greatest depth of the body, and the fin maintains this height (or nearly so) in its posterior portion. The anus of the shortnosed spearfish is anterior to the origin of the anal fin by a distance nearly equal to the length of the anal fin base. In all other Indian Ocean istiophorids, the anus is almost immediately before the anal fin. The lateral line is single and prominent.

Color : The shortnosed spearfish is a dark greenish or brilliant metallic blue dorsally, fading through silver grey to white or silvery on the ventral side. A few hours after death, the dorsal colors fade to a dark slatey blue-grey. The fins are all dark, and there are no spots or bars on the body.

Size : As already noted, *T. angustirostris* does not achieve large size. Nakamura (1938) states that specimens over 20 kg. are rare. Royce's (1957) largest specimen (1857 mm. fork length) weighed 50 pounds, and the largest seen by me was somewhat smaller.

Habits : The species is so uncommon that almost nothing is known about its habits. Presumably it, like other istiophorids, is piscivorous, devouring anything of suitable size, it is known to occur occasionally in concentrations off Taiwan, and Nakamura (1938) Ireports that it spawns in the fall of the year (October to December). This statement appears to have been based on the record of one fish taken November 22, 1936 by the *Shonan Maru* at 21° 46′ 30″ N, 124° 22′ 30″ E, which, when brought on board, " released eggs all over the deck ".

Relation to Man : *T. angustirostris* is not particularly important in the fisheries of the orient, due to its scarcity and its small size.

Range : The shortnosed spearfish is known from the Pacific Ocean, ranging from the Central Pacific in the region of Hawaii and the Line Islands, westward to the Celebes-Philippine Islands area, and northward to Taiwan and Japan. Although it has not yet been definitely recorded from the Indian Ocean, it would be surprising if it does not occur in that ocean also.

Tetrapturus audax (Philippi)

Striped marlin, Makajiki

The striped marlin, largest member of the genus *Tetrapturus*, is perhaps the most abundant of the istiophorids of the Indian Ocean. Often weighing as much as 300 pounds, sometimes more, its flesh is of high quality and it is much sought after by commercial fisheries.

Distinguishing Characters : The striped marlin may be distinguished from its relatives by the height of the dorsal fin, which is about equal to or (more often) higher than the greatest depth of the body, falcate anteriorly, with a long, low posterior portion. Occasional large specimens may have dorsal heights less than the body depth, while in young specimens up to about 40 or 50 pounds weight, the posterior part of the dorsal fin is relatively high. The older individuals thus may be confused with the blue marlin, but are distinguished from that species by the more uniform taper of the body of the striped marlin. The dorsal fin of

the young resembles that of the shortnosed spearfish, but these specimens of striped marlin are short and chunky whereas the spearfish of the same weight is long and slender. The sides of the body are rather flat, and are marked with a variable number of pale, vertical bars. The lateral line is single and is not prominent.

Color: The striped marlin is typically dark steely blue dorsally and on the snout, fading to white on the ventral side. The sides of the body are marked with a variable number of prominent, pale bluish or whitish vertical stripes. The fins are dark, except for the first dorsal and anal, which in life are a bright cobalt blue. The eye, like that of all istiophorids, is brown in life, but blue after death. The whole fish slowly assumes a dull dark blue-grey color as the skin dries after death.

Size: The largest specimen on record, taken off Chile, weighed 483 pounds, but the average seems to be less than 300 pounds. The striped marlin is thus one of the "middle-sized" members of the family. Royce (1957) notes that striped marlin from the North Pacific seem to run smaller than those from the South Pacific, and suggest that the maximum weight is probably around 500 pounds.

Habits: The striped marlin has probably been studied in as great detail as any member of the family, yet surprisingly little is really known about it. Like its relatives, it is primarily piscivorous, though it also feeds readily on such items as squid when these are available. Morrow (1952) noted that the saury, *Scomberesox saurus*, constituted about 75% of the items taken by striped marlin in New Zealand, with cephalopods making up only about 5.5% of the total. Hubbs and Wisner (1953) found that striped marlin off California had also fed heavily on sauries (75.5% of the identifiable fish food items), with only a few squid present in the stomachs. On the other hand, La Monte (1955) reported that, "In *M. mitsukurii* examined in Peru and Chile, we found only squid in the stomachs." Thus, it appears that the striped marlin is a feeder of opportunity, and probably eats anything suitable that is available.

Spawning seems to occur chiefly in the summer months, roughly June through September. Specimens examined by me in December through March in various parts of the world, particularly New Zealand and the south-western parts of the Indian Ocean, were not in breeding condition, but several seen in Kaohsiung, Taiwan, in July 1957 appeared close to spawning. Nakamura (1949) reported the major spawning period off Taiwan to be in April and May, but Honma and Kamimura (1958) note that the spawning season in the South Pacific is October and November. They deduced from this and other evidence that the populations of the North and South Pacific do not mix. It is also possible that this species spawns more or less the year around, with several peaks of spawning activity.

The several local populations of striped marlin in various parts of the world appear to undertake north-south coastwise movements according to the seasons, moving pole-wards in the warmer weather and towards the equator in the winter season. This has been observed in such varied localities as the Gulf of California, off Taiwan and Japan (Nakamura, 1938, and others), in the Coral Sea (Nomura, 1955), and in the South Pacific (Honma and Kamimura, 1958). What the situation may be in the Indian Ocean is not yet known.

Relation to Man: The striped marlin is considered the most valuable of the istiophorids by the Chinese and Japanese commercial fisheries. This is primarily due to the high quality

of its flesh, which is extraordinarily fine food. It also appears to be the most abundant of the istiophorids in the Indo-Pacific region, which further contributes to its value. Commercial landings run into millions of pounds annually. Sport fishermen carry the striped marlin in rather high regard, for although it cannot compare in size with the black marlin or blue marlin, it takes a bait readily and fights spectacularly.

Range : The striped marlin is widely distributed throughout the warmer waters of the Indian and Pacific Oceans. It has been recorded all the way from the west coasts of the Americas to the east coast of Africa, and from Japan in the north to Australia and New Zealand in the South. Royce (1957) notes that the areas of concentration suggest that it prefers the more temperate to the really tropical waters. In the Indian Ocean, the striped marlin is taken commercially by long line vessels in several areas west of the Maldive Islands, south towards Madagascar, and in other locations, and it has been recorded from such diverse localities as the northern parts of the Arabian Sea and from Mauritius.

Istiophorus gladius (Bloch)

Sailfish, Bashokajiki

The species of sailfish of the world—whether this form represents one species of world-wide distribution, or several species of more circumscribed areas—still present a moot question, one which is not yet solved. For the present, the Indian Ocean form will be treated as a separate species, with the reservation that this opinion may have to be changed at any moment.

Distinguishing Characters : The sailfish may easily be distinguished from the adults of all other Indian Ocean forms by the long and high dorsal fin, which is, in this species, much higher than the greatest depth of the body. This height is maintained for almost the full length of the fin. The body is slender and compressed, and the ventral fins are much longer than in the spearfishes and marlins. The lateral line is prominent, composed of a single row of pores.

Color : The sailfish is generally dark steel blue dorsally, fading to white or silvery on the ventral side. The vertical fins are bright cobalt blue in life, and the posterior part of the dorsal fin is more or less liberally sprinkled with round or oval black spots. A varying number of paler vertical bars, sometimes made up of rows of pale spots, may be present on the sides and may or may not persist after death. Indian Ocean fish are often a deep bronze color when brought to the boat, but this color does not persist more than a few minutes after death.

Size: The maximum size attained by the Indian Ocean sailfish is not known. The largest seen by me weighed 135 pounds, but the average of 67 specimens was only 73.6 pounds. The sailfish of the Atlantic coast of North America seldom reach 100 pounds but those of the Pacific coast average much larger. The largest known from that area weighed over 200 pounds.

Habits : Little is known of the habits of the Indian Ocean sailfish. By analogy with the sailfish of other areas, which tends to be confirmed by observations along the east coast of Africa, these fish probably undertake coastwise movements from time to time, but at present neither the timing nor the cause are understood.

The food of the sailfish includes almost anything in the sea which is of suitable size. Primarily piscivorous, they also feed on squid when these are available.

Relation to Man : The sailfish is sought both for sport and food. In those parts of the world where deepsea angling is popular, the sailfish is considered a great prize. Although it attains no tremendous size, it jumps and fights hard and spectacularly when hooked. In many parts of the world, too, the sailfish is regarded as a good food fish, although in this respect it is generally considered inferior to the marlins. Many thousands of pounds of sailfish are landed annually by Japanese and Taiwanese long line vessels. At the present time, utilization of the Indian Ocean stocks is at a very low level.

Range : The Indian Ocean sailfish, if considered as distinct from the sailfish of other oceans, is limited in its range to that part of the sea bounded by Africa, Arabia, India and the Indo-Australian Archipelago. The southerly limit of its range has not been established, but it certainly reaches Durban on the South African coast, and Mauritius. If this fish is considered conspecific with the sailfishes of other areas, then its range is worldwide in tropical and warm temperate seas.

Makaira nigricans Lacépède

Blue marlin, Kurokajiki

The blue marlin is probably the largest of the istiophorids, although it is closely approached in this respect by the black marlin. Japanese longline fishermen have told me that the blue marlin may exceed 2,000 pounds in weight. The rod and reel record for this species is currently held by a specimen of 1,002 pounds, taken off Hawaii. Although not generally considered quite such a fine food fish as the striped marlin and black marlin, the blue is still excellent food, with pale colored flesh that is especially good smoked.

Distinguishing Characters : The blue marlin is set apart from other members of the family by its relatively low dorsal fin ; relatively high first anal fin, which averages about 86% of the height of the dorsal ; the round, rather than flat, sides ; and the nearly cylindrical form of the anterior part of the body before the first anal fin. The lateral line is complex, with a chain-like pattern covering the whole body, and is seldom visible on the external surface of the skin.

Color : In general, the blue marlin is colored like the striped marlin, that is, dark steely blue on the dorsal areas, fading to silvery white on the ventral side. The sides of the body are usually marked with a series of lighter bars, but these are never as prominent as in the striped marlin. Sometimes a blue marlin will turn a beautiful bronze color when it dies, which fades in a few minutes to hours, leaving the skin generally a nearly uniform dark slate blue. After the skin has dried, the color is usually a uniform dark blue to almost black. Sometimes the stripes remain visible for sometime.

Size : As already mentioned, the blue marlin is reputed to be the largest member of the family. Individuals weighing over 1,000 pounds are not uncommon in the Japanese and Hawaiian fisheries of the Central Pacific, and even larger ones are caught occasionally. These giants appear, however, to be largely creatures of the high seas, for despite the intensity of angling closer to shore in various parts of the world, the 1,002 pound fish from Hawaii is far

larger than the previous rod and reel record. This suggests that the very large blue marlin are probably not common in areas accessible to sport fishermen. The average weight in the commercial catch, however, is much below the record, and seems to be on the order of 200 pounds or even a bit less.

Habits : The blue marlin is primarily piscivorous, according to my observations, with squids also a popular food item. These notes agree with reports of other workers in various parts of the world, such as Nakamura (1942) for the eastern Philippine Sea and Royce (1957) for the Central Pacific. Royce in particular noted that the commonest fishes in the blue marlin stomachs were tuna-like forms, with *Katsuwonus* prominent in the diet of the larger individuals.

The seasonal movements of the blue marlin are not at all well understood, but Royce (1957) cites evidence and authority to show that such movements do occur. He neatly summarizes the state of knowledge of movements in the Pacific, "...north of the equatorial area the seasonal occurrence suggests a summer movement...northward followed by a return south in the late autumn." This type of movement corresponds with that which has been observed on the East Coast of North America in the same species, and in other places for other species.

The time of spawning is uncertain. LaMonte (1944) reported ripe blue marlin from Cuba in July. Many specimens examined by me along the coast of North Carolina in June of 1959 and 1960 were not yet in breeding condition, but suggesting that late summer might be the spawning period. Other blue marlin examined by me in the Indian Ocean in August and December 1957 were definitely not even close to breeding. On the other hand, Royce (1957) found males running milt from February through October in the Central Pacific. It would appear, therefor, that the blue marlin, as a species, probably breeds more or less all year long, but that local populations may have more limited spawning periods.

Relation to Man : *Makaira nigricans* is one of the more important components of the marlin catch in Japan, Taiwan and Hawaii. A tremendous poundage of this species is landed annually at such ports as Misaki, Tokyo, Kaohsiung and Honolulu. In the Atlantic, along the east coast of the United States, and around the Hawaiian Islands in the Pacific, sport fisheries of considerable magnitude are based at least in part on this species. In the Indian Ocean, so little is known of its abundance and distribution that only further and more intensive exploration will tell whether the species can become important in this area as well.

Range : The blue marlin is of worldwide occurrence in warm seas. It is well-known through the warmer parts of the Atlantic, from approximately Cape Cod in the north-west to Capetown in the south-east. In the Pacific, I have recorded the species from Peru (Morrow, 1957), and it is well-known from such localities as Australia, Hawaii, Celebes Sea, off the Philippines, Taiwan, Japan, etc. Records for the Indian Ocean are more sparse, but it is surely present around Ceylon (1 specimen seen), in the area of 4° – 5° N, 67° – 71° E (numerous specimens from a commercial catch), off the east coast of Africa, and around Mauritius (several specimens and records from each place). It is thus quite certain that the blue marlin ranges pretty well throughout the Indian Ocean.

Istiompax indicus (Cuvier)

Black marlin, Shirokajiki

The black marlin vies with the blue in reaching large size. As already noted under the latter species, Japanese longline fishermen believe that the blue is the larger, but the largest fish taken on rod and reel was a black marlin weighing 1,560 pounds. The black marlin is one of the finest of food fishes, being delicious raw or cooked. It is also highly esteemed in Japan as a component of "fish sausage", and at present something over 1,000,000 pounds per year of black marlin meet this fate.

Distinguishing Characters : *Istiompax indicus* is at once set apart from all other istiophorids by its pectoral fins, which are set quite rigidly, extending at right angles from the sides of the body, and cannot be folded flat without breaking the joint. In addition, the dorsal fin is the lowest of any of the marlins, averaging about 60% of the greatest depth of the body ; the body is deep and slab-sided, and the color is different. The lateral line is a double row of small pores, generally invisible in adults.

Color : The color of the black marlin varies a great deal. Most specimens are dark slate blue above, changing rather abruptly to white or silvery just below the lateral line. As the skin dries, after the fish has been caught, it usually turns a uniform dull blue-black. However, in this species, the skin often appears to have a milky white overwash, whence stems the Japanese name, shirokajiki, or white marlin. I have occasionally seen specimens which were an almost uniform bronze color. Occasionally vertical pale blue stripes may be present, but these always disappear immediately when the fish is boated.

Size : As noted previously, *Istiompax indicus* is one of the two largest species of marlins. The rod and reel record is 1,560 pounds, but Japanese fishermen have assured me that the species may reach 2,000 pounds. Thus the black marlin closely rivals the blue in its maximum size. Off the coast of Peru, specimens of 1,000 pounds or more are not uncommon, but in other areas, such as northern New Zealand, or the east coast of Africa, a fish half that weight is an unusually large one. Judging from the reports of commercial fishing captains, the largest individuals are to be found in the tropical Central Pacific.

Habits : The black marlin, like the rest of the family, is primarily piscivorous. There do not appear to be any specific studies of its food, but casual observations indicate that it feeds chiefly on fish and squid. In addition LaMonte, (1955) quotes a report of *I. indicus* feeding upon *Physalia*. June (1951) and Royce (1957) both mention the size of the fishes eaten by these marlins, tunas of 158 and 157 pounds, respectively. Royce also notes finding a 94 cm, 40 lb. *Germo*, and the remains of ocean sunfish (*Mola*) in the stomachs of black marlin.

The spawning season seems to be in the summer, or at least the warmer months of the year. Nakamura (1949) deduced that spawning probably occurred from August to October off Taiwan. In the latter part of July 1957, many of the specimens examined by me at Kaohsiung, Taiwan, which had been taken north of western New Guinea, in the Celebes Sea, and near Taiwan, were running roe or milt. Specimens examined in northern New Zealand (February-March, 1948), Peru (January-May, 1953 and January, 1955), east coast of Africa and Mauritius (taken October-December, 1957) were not in breeding condition. All this suggests that the spawning period probably begins as early as June, and may extend well into the fall of the year.

Nothing is known of the movements (if any) of the black marlin. Nakamura (1938) indicated that the fishing season for this species is October through April in Taiwan. In northern New Zealand, the season is the southern summer, but whether or not this represents the time of greatest abundance of fish or merely the time when most people are able to go fishing has not been established. Off Cabo Blanco, Peru, sport fishermen have taken this species in every month of the year.

Relation to Man : The black marlin is an important part of the oriental longline fisheries, for its white flesh is appealing both to the eye and to the palate. It is said to be the most abundant marlin off Taiwan (Nakamura 1942), and certainly made up the larger part of the landings at Kaohsiung in July of 1957. In addition, the black marlin is much sought after by sport fishermen because of its great size and fine sporting qualities. All in all, it is an extremely valuable fish in areas where it occurs in numbers.

Range : *Istiompax indicus* occurs in greater or lesser numbers throughout the warmer parts of the Pacific and Indian Oceans. In certain areas, such as the coast of Peru, off New Zealand and Australia, north of New Guinea, and adjacent waters to the west and north, there appear to be concentrations of this species. It is quite commonly found close to shore, particularly in areas where the sea bottom drops steeply from the beach. Although Gregory and Conrad (1939) suggested, mainly on the basis of seasonal occurrence off Australia and New Zealand and the pattern of oceanic circulation in the South Pacific, that the black marlin might move in a great circular route around the ocean, this theory is no longer tenable. Royce (1957), Nakamura (1949) and others have shown that more or less isolated local groups can be distinguished from various parts of the Pacific, indicating some restriction on the mingling of populations from New Zealand—Australia, Hawaii and the Central Pacific.

The following key to the Indian Ocean istiophorids is for identification only, and does not purport to represent relationships within the family. Further, it is based entirely upon adult characters and will not necessarily serve to identify juveniles. The young stages of the istiophorids are not at all well-known, hence construction of a key for their identification does not seem feasible at present.

KEY TO THE ADULT ISTIOPHORIDAE OF THE INDIAN OCEAN

1A. Dorsal fin high and sail-like, its height much greater than greatest body depth, middle rays longest.

Istiophorus gladius (Bloch)

Sailfish, Bashokajiki

1B. Dorsal fin not sail-like, middle rays about equal to or shorter than anterior ones, greatest height of fin not much greater than body depth, often less.

2A. Pectoral fins rigid, not capable of being folded flat against body without breaking joint.

Istiompax indicus (Cuvier)

Black marlin, Shirokajiki

2B. Pectoral fins normally flexible, easily folded flat against sides of body.

3A. Snout short, scarcely longer than lower jaw. Posterior part of dorsal fin about as high as anterior lobe.

Tetrapturus angustirostris Tanaka

Shortnosed spearfish, Furaikajiki

3B. Snout notably longer than lower jaw. Posterior part of dorsal fin much lower than anterior lobe except in young specimens.

4A. Height of dorsal fin about equal to or greater than greatest body depth. Sides of body more or less flat, marked with prominent, light colored vertical bars.

Tetrapturus audax (Philippi)

Striped marlin, Makajiki

4B. Height of dorsal fin less than greatest body depth. Sides of body well rounded, stripes generally not particularly prominent.

Makaira nigricans Lacepede

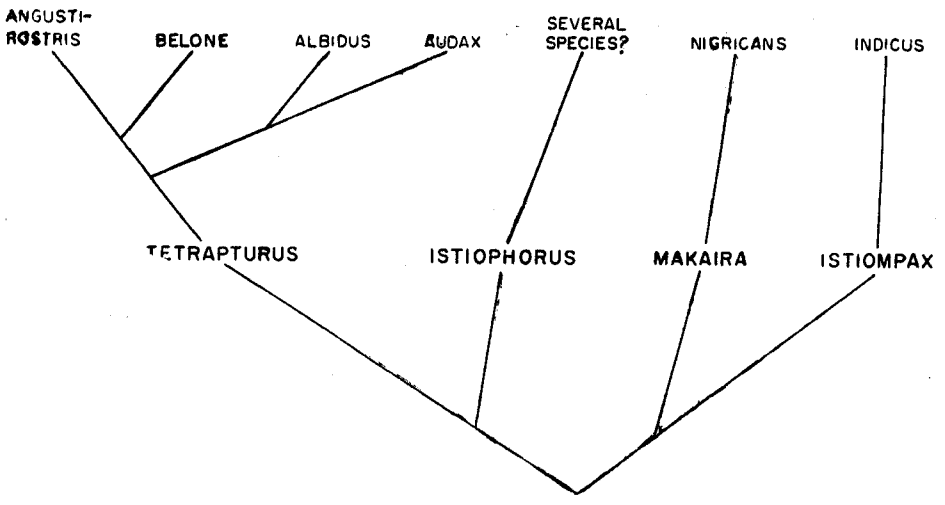
Blue marlin, Kurokajiki

REMARKS ON THE NOMENCLATURE

Except for the sailfish and shortnosed spearfish, the specific names of the istiophorids are firmly established. With the two forms mentioned, there is some doubt as to whether or not they are distinct from similar fishes in other parts of the world. Until conclusive studies have been made, however, we propose to maintain them, at least temporarily, as separate entities. Under these conditions, then, the shortnosed spearfish is clearly to be called *T. angustirostris*. The situation is not, however, so neat with respect to the sailfish. There exist many descriptions and names for sailfishes from various parts of the world. The oldest which is eligible for consideration is that of Bloch (1793). This description has, however, been criticised on the grounds that it does not represent the description of an actual species or specimen, but is a composite of the works of earlier authors, involving fish from many diverse areas which may or may not represent a single species. However, even though the discussion on pages 83 and 84 of Bloch's description shows that he considered his fish the same as those described by a number of earlier authors—indeed, he did not distinguish between his fish and that of Banks, which later I have shown (Morrow, 1959) to be the black marlin and not a sailfish at all—he also points out that several authors had copied earlier works (page 85). This seems to suggest that Bloch's description was not a copy of an earlier one. Furthermore, Bloch gives, in his description, a number of particular characteristics. Among these is the count of the anal spines, nine. I have examined sailfish from many parts of the world—the Atlantic Ocean off the south eastern coast of the United States, the Pacific coast of South America, New Zealand, the Central Pacific Ocean, the coast of Taiwan and the Philippine-Celebes area, India and Ceylon, the Seychelles Islands, Mauritius, and the east coast of Africa from Mombasa to Durban. In all these areas, except the East African, the lowest anal count was 11, but in the East African samples, counts as low as eight are not uncommon. Mrs. Jane Bailey, of Malindi, Kenya, and Mr. Frank Williams, of the East African Marine Fisheries Research Organization, Zanzibar, have kindly supplied additional data which confirm the presence of these low anal counts in sailfish from that area. This suggests that Bloch had either a specimen or the data from a specimen from this particular population. All in all, even though the evidence is not in great quantity, it appears to point distinctly to the conclusion that Bloch had a particular fish in mind when he wrote his description and named that fish, from the Indian Ocean, *Scomber gladius*. I am of the opinion, then, that the specific name, *gladius*, should be applied to the sailfish of the Indian Ocean. If it should be shown that there is but one species of sailfish in the world, then this name, according to the rule of priority, should take precedence over all others.

In contrast to the reasonably well stabilized situation of the specific names, the generic divisions of the istiophorids are still in a state of flux. A genus is at best a somewhat subjective category, open to the interpretations of the individual systematist. This does not always provide relief from confusion. With respect to the Istiophoridae, the various species fall naturally into several quite clear-cut groups. These may be interpreted as the genera of a family, or as the sub-genera of a genus. The longnosed spearfish of the Atlantic, the short-nosed spearfish of the Indo-Pacific, the striped marlin of the Indo-Pacific and the white marlin of the Atlantic all form a closely knit group, clearly more closely related to each other than to the remaining forms. The sailfish is closer to this group than to the marlins *sensu stricto*, but diverges from both chiefly in the extraordinary development of the dorsal fin, as well as in some less obvious features. The two marlins are set apart from the sailfish and spearfish groups in that the former have 11 pre-caudal and 13 caudal vertebrae while both the latter groups have 12 and 12. The two marlins diverge from each other in several important respects. The blue marlin, *Makaira nigricans*, has normally flexible pectoral fins; a complex, chain-like lateral line; an air bladder composed of a single layer of chambers; and the two sides of the pelvic girdle separated by a space. By contrast, in the black marlin, *Istiompax indicus*, the pectoral fins are rigid; the lateral line is simple, composed of a double row of pores; the air bladder is composed of two layers of chambers; and the two sides of the pelvic girdle are fused together. These differences are certainly as great and as basic as those which separate the sailfish from the spearfishes, indicating that the two marlins should be placed in separate groups.

Although there are arguments for lumping all these forms into a single genus on the basis of their overall similarities, it seems to me that such a procedure obscures the relationships within the family, even if sub-genera are created. Both the relationships and the differences are, I think, emphasized in this family if it is split into four genera, as has been done here. *Tetrapturus*, the most primitive genus, includes the two spearfishes, the striped marlin and the Atlantic white marlin. *Istiophorus* is the genus of sailfishes, closely related to but separated from *Tetrapturus* chiefly in the high degree of development of the dorsal fin. And set further apart from these, as indicated above, are the two marlins, *Makaira* and *Istiompax* (see Fig. 1).



ACKNOWLEDGEMENTS

It is a great pleasure to acknowledge the generous support received from Messrs Thomas Shevlin, Alfred C. Glassell Jr., John K. Howard, and the late Wendell Anderson, as well as from the Society of the Sigma Xi, the Sport Fishing Institute and the American Academy of Arts and Sciences. My former colleagues at the Bingham Oceanographic Laboratory, in particular Mr. Walter Weed and Mr. John Howrath, have assisted in numerous ways. In addition, I have benefited greatly from discussing marlins and other matters with Miss Francesca LaMonte, Col. John K. Howard, Dr. C. R. Robins, Dr. William Hassler and others in the United States, as well as a host of people in almost every part of the world where istiophorid fishes are found.

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THE BEAKED LARGE SCOMBROIDS OF CEYLON

BY

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The beaked Scombroids of Ceylon comprise the Istiophoridae with three genera, and the Xiphidae represented by a single monotypic genus which occurs in all the oceans. The least specialised of these is the Genus *Tetrapturus* Rafinesque, which for many years had been confused with the Genus *Makaira* Lacepede. The type species of the former is *T. belone* from the Mediterranean. Cuvier (1828) described an allied species *T. indicus*. The type specimen was captured off Sumatra. Both these species possess short beaks.

For many years the British Museum had a mounted long beaked specimen labelled as *Makaira indica*. This specimen was named *Tetrapturus tenuirostratus* (Deraniyagala, 1933) and is the same species that Day (1899) had erroneously assigned to *Histiophorus brevisrostris* Playfair, this name being a synonym for the short beaked *T. indicus* Cuvier. *Tetrapturus tenuirostratus* possesses an elongate slender beak, very different from the short one of *T. indicus* which character is appropriately described by Playfair's name of *brevisrostris*, which unfortunately is a synonym.

There are undoubtedly two species of *Tetrapturus* in the Indian Ocean, *T. indicus*, in which the beak is short and stout, and *T. tenuirostratus* with the beak long and thin.

The next genus, *Makaira* possesses three species. The largest is *Makaira nigricans* Lacepede, which possesses pliable pectoral fins that fold against the body. The other *Makaira xantholineata* Deraniyagala (1956) is a somewhat more slender fish in which the pectoral fins are fixed and cannot be folded back against the body. The third species *Makaira mitsukurii* (Jordan et Snyder) is even more slenderly built and the body is marked with 15 to 17 light cross bars.

The third genus is *Istiophorus* Lacepede and is represented in the Indian Ocean by a single species *Istiophorus gladius* (Broussonnet).

The first record of the young of any of these fishes was the capture of a *Makaira* 127 mm. long on April 5th, 1934. This specimen was deposited in the British Museum.

The last and most specialised of these beaked fishes is *Xiphias gladius* Linne. Copley writing from East Africa in 1935 drew attention to its absence from African waters and Dr. L. F. de Beaufort had not recorded it from the East Indian Archipelago. The first record of this species from the Indian Ocean was from the south of Ceylon (Deraniyagala, 1936). Other specimens have subsequently been secured, but the fish is by no means common.

All these species appear to be migrants and do not remain in Ceylon waters for more than a couple of months annually. These large fishes are not only important as items

of food, but are of the greatest scientific interest as being some of the swiftest and most highly evolved of bony fishes.

The velocity with which a *Makaira* had swum was such that it had driven its rostrum completely through a $1\frac{3}{4}$ inch thick teak plank which formed the otter board of a Ceylon mine-sweeper that was moving away from the fish at six knots per hour. The weight of the fish as estimated from the broken fragment of the rostrum was about $2\frac{1}{2}$ cwts. and it was probably travelling at about 18 knots or more per hour when it struck the board.

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LES *SCOMBROIDEI* (POISSONS TELEOSTEENS PERCIFORMES) DU MUSEUM NATIONAL D'HISTOIRE NATURELLE DE PARIS

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Les collections du Museum National d'Histoire Naturelle de la Chaire de Zoologie, Reptiles et Poissons (Directeur : Pr. J. GUIBE) sont relativement riches en types du sous-ordre des Scombroidei. Cinquante trois spécimens représentant vingt neuf types d'espèces ont pu être dénombrés. Nous en donnons la liste par famille et par genre. Nous ne considérons comme types que les spécimens décrits, figurés ou cités par les auteurs mêmes des éspéces nouvelles.

Nous adjoignons ā ces types de nombreux exemplaires que nous désignons sous le nom " d'exemplaires historiques ". Il s'agit de spécimens étudiés et cités par les auteurs anciens (Cuvier et Valenciennes en particulier dans l'Histoire Naturelle des Poissons) qui s'attribuaient a tort des espèces déja connues sous les mêmes noms spécifiques.

Nous donnons également une liste des espèces nouvelles décrites d'aprēs des figures ou relations de voyageurs naturalistes et pour lesquelles il n'existe évidemment pas de type. Aucun exemplaire de nos collections ne leur ayant été identifié nous ne pouvons désigner de néotypes. (Ceci a l'usage des ichthyologistes qui demandent ā consulter les types de ces espēces figurant souvent dans des listes synonymiques).

Pour chaque spécimen, nous indiquons la longueur standard (LS) et la longueur totale (LT) qui est généralement la seule indiquée — en pouce — dans les descriptions originales. Etant donné l'ancienneté des types, et l'état défectueux de plusieurs d'entre eux (caudales abimées), ces données manquent parfois de précision.

Famille des SCOMBRIDAE

Genre Cybium Cuvier 1829, Rēgne animal, 2e edit., t. II., p. 199.

—*Cybium acervum* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 186.

=*Scomberomorus regalis* (Bl.)

A. 5781—Syntypes

Saint-Domingue.

Ricord

3 spécimens, alcool, assez bon état.

LS : 117, 121 et 123 mm.

LT : 143, 146 et 154 mm.

(Fig. 1.)

A. 5782—Syntype
Martinique
Achard
1 specimen, alcool, assez bon etat.
LS : 102 mm.
LT : 125 mm.
(Fig. 1.)

—*Cybium altipinne* (Guichenot) Dumeril, 1858, Arch. Mus. Hist. Nat. Paris, t. X. p. 262.
=*Scomberomorus tritor* (C. V.)

A. 5797—Holotype.
Sénégal.
Heudelot.
1 spécimen, alcool, trēs bon état.
LS : 374 mm.
LT : 472 mm.
(Fig. 2.)

—*Cybium clupeoidum* (Broussonet MS) Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t VIII, p. 178.
=*Scomberomorus caballa* (C. V.)

A. 5784—Holotype.
Ile de Norfolk (Australie).
Collection Broussonet (don de la Faculté de Montpellier).
1 spécimen. alcool, assez bon état.
LS : 278 mm.
LT : 338 mm.
(Fig. 3.)

—*Cybium commersonii* Cuvier Valenciennes, 1831. Hist. Nat, Poiss., t. VIII, p. 165.
(nomen nudum in Cuvier 1829, Régne animal, 2e edit., p. 200, pour *Scomber Commerson* Lacépēde, 1800, Hist. Nat. Poiss., t. II, p. 600. d'aprēs figure de Commerson).
Espēce redécrite par Cuvier-Valenciennes, 1831, d'aprēs les manuscrits de Commerson, Les exemplaires de Commerson ont été perdus sans que Cuvier et Valenciennes puissent les observer.
=*Scomberomorus commerson* (Lac.)

A. 788—Néosyntype.
Pondichéry.
Leschenault.
1 spécimen, sec. assez bon état.
LS : 805 mm.
LT : 945 mm.
(Fig. 4.)

A. 5609—Néosyntype.
Malabar.
Dussumier.
1 spécimen, sec, assez bon état.
LS : 855 mm.
LT : 955 mm.
(Fig. 5.)

A. 587—Néosyntype.
Ile de France (I. Maurice).
Quoy et Gaimard.
1 spécimen, alcool, mauvais état.
LS : 475 mm. environ.
LT : 555 mm. environ.
(Fig. 6.)

83-835—Néosyntype.
Mer des Indes.
Dussumier.
1 spécimen, sec, assez bon état.
LS : 1,000 mm.
LT : 1,150 mm.
(Fig. 7.)

—*Cybium caballa* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 187. (nomen nudum in Cuvier 1829, Règne animal, 2e edit., t. II, p. 200, *C.cavalla* ou Guarapuca Margrave).

=*Scomberomorus caballa* (C. V.)

A. 5521—Syntype.
Antilles.
Plée.
1 spécimen, sec, assez mauvais état.
LS : 330 mm.
LT : 405 mm.
(Fig. 8.)

A. 5567—Syntype.
Bahia.
Prince Maximilien de Neuwied.
1 spécimen, sec, assez bon état.
LS : 510 mm.
LT : 605 mm.
(Fig. 10.)

A. 5575—Syntype.

Bresil,
Delalande.
1 spécimen, sec, assez bon é'at.
LS : 510 mm.
LT : 590 mm.
(Fig. 9.)

A. 5610—Syntype.

Porto—Rico.
Plée.
1 spécimen, sec, assez bon état.
LS : 765 mm.
LT : 890 mm.
(Fig. 11.)

—*Cybium immaculatum* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII p. 191.
=*Scomberomorus caballa* (C.V.)

Le texte de Cuvier et Valenciennes ne précise ni l'origine ni les donateurs des exemplaires décrits. Les registres ont permis d'identifier :

A. 5720—Syntypes.

Martinique.
Plée.
2 spécimens, alcool, mauvais état.
LS : 137 et 145 mm.
LT : 153 et 174 mm.
(Fig. 12)

A. 5780—Syntype.

Martinique.
Plée.
1 spécimen, alcool, mauvais état.
LS : 153 mm.
LT : 180 mm.
(Fig. 12.)

—*Cybium interruptum* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 172.
=*Scomberomorus lineolatus* (C.V.)

A. 5522—Holotype.
Pondichéry.
Leschenault.
1 spécimen, sec, assez bon état.
LS : 353 mm.
LT : 432 mm.
(Fig. 13.)

—*Cybium kuhlii* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 178.
=*Scomberomorus kuhli* (C.V.)

A. 5771—Holotype.
Java.
Kuhl et Van Hasselt.
1 spécimen, alcool, bon état.
LS : 100 mm.
LT : 122 mm.
(Fig. 14.)

A. 5715—Paratype.
Bombay.
Dussumier.
1 spécimen, alcool, bon état.
LS : 104 mm.
LT : 131 mm.
(Fig. 14.)

—*Cybium lineolatum* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII. p. 170.
=*Scomberomorus lineolatus* (C.V.)

A. 6866—Holotype.
Malabar.
Dussumier.
1 specimen, alcool, bon etat.
LS : 650 mm.
LT : 770 mm.
(Fig. 15.)

A. 6357—Paratype.
Mahé.
Belenger.
1 spécimen, alcool, très mauvais état (tête et caudale restent seules).
(Fig. 16.)

—*Cybium regale* Cuvier et Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 184.
(nomen nudum in Cuvier 1829, Règne animal, 2e edition, p. 200).
Néosyntypes (1) de *Scomber regalis* Bloch 1793, Naturg Ausl. Fische, t. X p. 31, pl. 333.
=*Scomberomorus regalis* (Bl.)

A. 5801—Néosyntype.
Saint-Domingue.
Ricord
1 sp., alcool, bon état.
LS : 415 mm.
LT : 520 mm.
(Fig. 17.)

A. 5577—Néosyntype.
Saint-Domingue.
Ricord.
1 sp., sec., bon étet.
LS : 450 mm.
LT : 530 mm.
(Fig. 18.)

—*Cybium tritor* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 176, pl. 218.
=*Scomberomorus tritor* (C.V.)

A. 6871—Holotype.
Gorée.
Rang.
1 spécimen, alcool, bonétat.
LS : 610 mm.
LT : 735 mm.
(Fig. 18.)

A. 6868—Paratype.
Gorée.
Rang.
1 spécimen, alcool, assez bon état.
LS : 471 mm.
LT : 590 mm.

—Outre ces spécimens qui ont donné lieu ã la création de quatre espéces nouvelles, les collections du Museum renferment un certain nombre d' " exemplaires historiques " que

(1) Le type de *Scomber regalis* Bloch, déposé au Musée de l'Université Humboldt de Berlin, a été detruit pendant la guerre.

Cuvier et Valenciennes, dans leur Histoire Naturelle des Poissons, ont étudiés et décrits en les rapportant a des espèces déjà connues. Ce sont :

6 exemplaires de *Cybium guttatum* Cuvier-Valenciennes, 1831, Hist Nat. Poiss., t. VIII, p. 173, pour *Scomber guttatus* Bl. Schn.

A. 584 (2 spécimens, alcool) et A. 585 (1 spécimen, alcool), Malabar—Dussumier.

A. 5783 (1 spécimen, alcool), Bombay—Dussumier.

A. 5452 (1 spécimen, sec), Pondichéry—Sonnerat.

A. 5802 (1 spécimen, alcool), Mer des Indes.

—Les exemplaires décrits par Cuvier et Valenciennes, 1831, t. VIII, p. 191. sous le nom de *Cybium maculatum*=*Scomber maculatus* Mitchill, n'ont pas été retrouvés.

—Cuvier et Valenciennes ont decrit quatre espèces nouvelles de *Cybium* d'apres des figures rapportées par des voyageurs naturalistes. Il n'existe dans les collections aucun poisson étiqueté sous ces noms, permettant de désigner des néotypes.

Ce sont : *Cybium mertensii* C.V., 1831, t. VIII, p. 179.

Cybium chinense C.V., 1831 t. VIII, p. 180, pour Scombre chinois Lacépède—*Scomber sinensis*, 1802, t. III, p. 23.

Cybium niphonium C.V., 1831, t. VIII, p. 180.

Cybium solandri C.V., 1831, t. VIII, p. 192.

Genre *Pelamys*, Klein, 1775, Neuer Schauplatz der der Natur. t. I, p. 176.

—*Pelamys chiliensis* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 163.
=*Sarda chilensis* (C.V.)

A. 5608—Holotype.
Valparaiso.
d'Orbigny.
1 spécimen, sec, bon état.
LS : 625 mm.
LT : 715 mm.
(Fig. 21.)

—" Exemplaires historiques ", non types, étudiés et décrits par Cuvier et Valenciennes.
10 exemplaires de *Pelamys sarda* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 149, pl. 217.
pour *Scomber sarda* Bloch 1793.
=*Sarda sarda* (Bl.)

La description de Cuvier et Valenciennes est faite d'aprēs de nombreux exemplaires dont l'origine et le donateur ne sont pas toujours précisés. Les registres ont permis d'identifier :

A. 5573 (1 spécimen. sec), Brésil—Delalande.

A. 5581 (1 spécimen, sec) et 6495 (1 spécimen, alcool), Ivica (Baléares)—De La Roche.

A. 5584 (1 spécimen, sec), Ile du Cap Vert—Duc de Rivoli.

A. 5807 (2 spécimens, alcool), Nice—Laurillard.

A. 5719 (1 spécimen, alcool), Naples—Savigny.

A. 5717 (1 spécimen, alcool), Alexandrie—Geoffroy Saint—Hilaire.

A. 5236 (1 spécimen, sec) et A. 5803 (1 spécimen, alcool), Méditerranée.

Genre Scomber Linné, 1758, Syst. Nat., 10e edit., p. 297.

—*Scomber antarcticus* F. de Castelnau, 1872, Proc. Zool. Accl. Soc. Victoria, t. 1, p. 106.

=*Scomber japonicus* Houttuyn.

B. 2125—Holotype.

Marché de Melbourne.

F. de Castelnau.

1 spécimen, sec, en herbier, mauvais état.

LS : 283 mm.

LT : 315 mm. (caudale abimée).

(Fig. 22.)

—*Scomber australasicus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 49.

=*Scomber japonicus* Houttuyn.

A. 5312—Holotype.

Port du Roi Georges (Australie S.W.)

Quoy et Gaimard (1) (1829 Voy. " Astrolabe ").

1 spécimen, alcool, mauvais état.

LS : 170 mm.

LT : 196 mm.

(Fig. 23)

—*Scomber brasiliensis* Quoy et Gaimard, 1824, Voy. " Uranie " p. 360.

Le spécimen, long de 3 pieds et provenant de Rio de Janeiro, n'a pas été conservé. Bien que Quoy et Gaimard écrivent qu'il " pourrait être placé dans le sous-genre thon ", nous pensons qu'il ne faut pas l'identifier au *Thynnus brasiliensis* décrit par Cuvier et Valenciennes en 1831.

—*Scomber capensis* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 56.

L'espèce nouvelle établie d'après un squelette préparé par Delalande, et originaire du Cap de Bonne Esperance, n'a pas été retrouvé dans nos collections. Dans son Mémoire sur les poissons de l'Afrique australe, 1861, F. de Castelnau, qui n'a pas retrouvé cette espèce, pense qu'il s'agit d'une variété d'âge du *Scomber grex* Mitchill.

—*Scomber kanagurta* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 49.

(nomen nudum in Cuvier 1817, Règne animal, t. II, p. 313, d'après une figure de Russell 1803 in Poissons de Coromandel, t. II, pl. 136).

=*Rastrelliger kanagurta* (C.V.)

(1) Dans la description originale, Cuvier et Valenciennes ecrivent : " MM. Quoy et Garnot nous en ont envoyé un du port du Roi Georges ". Il s'agit surement d'une erreur et il faut lire MM. Quoy et Gaimard, comme il est d'ailleurs mentionné dans les registres.

A. 5291—Syntype.
Pondichéry.
Leschenault.
1 spécimen, alcool, très mauvais état.
LS : 160 mm. environ.
LT : 185 mm. environ.
(Fig. 24.)

A. 5292—Syntype.
Côte de Malabar.
Dussumier.
2 spécimens, alcool, bon état.
LS : 170 et 180 mm
LT : 207 et 229 mm.
(Fig. 24.)

A. 5296—Syntype.
Mer Rouge.
Ehrenberg.
1 spécimen, alcool, bon état.
LS : 195 mm.
LT : 231 mm.
(Fig. 24.)

A. 5455—Syntype.
Pondichery.
Sonnerat.
1 spécimen, sec, tres mauvais état.
LS : 190 mm. environ.
LT : 228 mm. environ.
(Fig. 25.)

A. 5519—Syntype.
Pondichery.
Leschenault.
1 spécimen, sec. assez mauvais état.
LS : 200 mm. environ.
LT : 231 mm. environ.
(Fig. 26.)

—*Scomber loo* Lesson 1829, Dict. class. d'hist. nat., t. 15, p. 277, et 1830, " Voyage de la Coquille ", t. II, lere p., p. 166, pl. 33.

=*Rastrelliger loo* (Lesson)

2910—Holotype.
Port Praslin—I. Nouvelle—Irlande (Mélanésie).
Lesson et Garnot (Voy. " La Coquille ", 1822-25).
1 spécimen, alcool, tres mauvais état.
LS : 213 mm.
LT : 250 mm.
(Fig. 27.)

—*Scomber pneumatophorus* de Laroche 1809, Ann. Mus. Hist. Nat., t. XIII, p. 335.
=*Scomber japonicus* Houttuyn.

A. 5284—Holotype.
Ivica (I. Baléares).
de Laroche.
1 spécimen, alcool, bon état.
LS : 166 mm.
LT : 195 mm.
(Fig. 28.)

Cuvier et Valenciennes ont également décrit une espēce nouvelle *Scomber Sloanei* 1831, t. VIII, p. 148, d'apres une figure grossiēre de l'albacore de Sloane, Hist. nat. Jamaica, t. I, pl. 1, fig. 1.

Ces memes auteurs (p. 146) ont redécrit *Scomber taso* Lac. 1802, t. III, p. 9, d'aprēs les notes manuscrites de Commerson. L'unique exemplaire de Commerson, long de 18 pouces, a été mangé aprēs sa capture. Aucum exemplaire étiqueté sous ce nom n'existe dans nos collections ; il est donc impossible de désigner un néotype de l'espēce.

" Exemplaires historiques ", non types, étudiés et décrits par Cuvier et Valenciennes.

15 exemplaires de *Scomber scombrus* L. 1758, in Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 6 et suivantes. La longue description de Cuvier et Valenciennes est faite d'aprēs de trēs nombreux exemplaires dont l'origine et le donateur ne sont pas toujours précisés. Les registres ont permis d'identifier :

A. 5272 (1 spécimen, alcool) et A. 5279 (2 spécimens, alcool), Marseille—Roux.

A. 5274 (2 spécimens, alcool) et A. 5281 (1 spécimen, alcool), Ancienne collection Cabinet du Roi.

6.332 (1 spécimen, alcool) et A. 5273 (4 spécimens, alcool), Abbeville—Baillon.

A. 5275 (1 spécimen, alcool), Naples—Savigny.

A. 5280 (2 spécimens, alcool), Sicile—Bibron.

A. 5276 (1 spécimen, alcool) Marche de Paris.

7 exemplaires de *Scomber colias* L. Gmel, 1788 in Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 39, pl. 209,

A. 5282 (1 spécimen, alcool), A. 5304 (1 spécimen, alcool) et A. 5306 (1 spécimen, alcool), Marseille—Roux.

A. 5286 (1 spécimen, alcool) et A. 5307 (1 spécimen, alcool), Naples—Savigny.

A. 5285 (1 spécimen, alcool), Nice—Savigny.

A. 5239 (1 spécimen, sec), Méditerranée.

9 exemplaires de *Scomber grex* Mitchill 1815 in Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 45.

A. 5310 (2 spécimens, alcool), Sainte-Hélène—Quoy et Gaimard.

A. 5309 (1 spécimen, alcool), Sainte-Hélène—Lesson et Garnot.

A. 5318 (1 spécimen, alcool), New-York—Millert.

A. 5319 (4 spécimens, alcool), Le Cap—Quoy et Gaimard.

A. 5283 (1 spécimen, alcool), Canada—Bert.

2 exemplaires de *Scomber vernalis* Mitchill 1815 in Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 48.

A. 805 (1 spécimen, sec) et A. 5568 (1 spécimen, sec), New-York—Milbert.

3 exemplaires de *Scomber loo* in Cuvier-Valenciennes. 1831, Hist. Nat. Poiss., t. VIII, p. 52. (Cuvier et Valenciennes s'attribuent à tort cette espèce de Lesson).

A. 5311 (1 spécimen, alcool), A. 5288 (1 spécimen, alcool) et A. 5289 (1 spécimen, alcool), Havre-Dorey (Nouvelle-Guinée)—Quoy et Gaimard 1829 (Voy. " Astrolabe ").

Famille des THUNNIDAE

Genre *Auxis* Cuvier 1829, Règne animal, 2e Edit., t. II, p. 199.

Bien qu'inscrits dans nos registres, aucun des types d'*Auxis* signalés ci-dessous n'a été retrouvé dans nos collections en dépit de longues recherches.

—*Auxis ramsezi* Castelnau 1879, Proc. Linn. Soc. South-Wales, t. 3, pt. 4, p. 382.

A. 1241—Holotype.

acheté au marché de Sydney le 6 avril 1878.

et rentré dans nos collections en 1879.

De Castelnau.

1 spécimen.

—*Auxis vulgaris* Cuvier-Valenciennes 1831, Hist. Nat. Poiss., t. VIII, p. 139.

(=*Scomber bisus* Rafinesque 1810, *Scomber rochei* Risso 1810, *Scomber rocheanus* Risso 1826).

=*Auxis thazard* (Lac.)

A. 5808—Nice.

Laurillard.

A. 5815—Morée.

Bory St. Vincent.

A. 5792—Martinique.

Plée.

Genre *Thynnus* Cuvier 1817, Règne animal, t. II, p. 313.

—*Thynnus argentivittatus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 134.

A. 5567—Syntype.

Mer des Indes.
Dussumier.
1 spécimen, sec, mauvais état.
LS : 435 mm.
LT : 510 mm.
(Fig. 30.)

A. 5572—Syntype.

Quoy et Gaimard.
Atlantique.
1 spécimen, sec, mauvais état.
LS : 580 mm.
LT : 685 mm.
(Fig. 29.)

A la suite de renseignements erronés ou mal intêrpretés que leur avait fournis le Professeur Léon Bertin, Schaefer et Walford en 1950 ont désigné comme lectotype de l'espēce un spécimen originaire de la Côte de Malabar et envoyé par Dussumier. Ce spécimen est enregistré dans nos Catalogues sous le no. A. 5814 (et non pas A. 5168 comme il est indiqué dans le travail de Schaefer et Walford). Dans la description originale de l'espēce (p. 134 ā 136), Cuvier et Valenciennes ne mentionnent nullement cet exemplaire. Leur description est faite d'aprēs les deux seuls individus désignés ci-dessus (A. 5567 et 5572), avec toutes les précisions nécessaires (origine, donateurs, longueur). La designation d'un lectotype choisi parmi des exemplaires non mentionnés par les auteurs de l'espēce est une inexactitude.

—*Thynnus brachypterus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 98, pl. 211.

(nomen nudum in Cuvier 1829, Rēgne animal, 2e edit., t. II, p. 198, figure Duhamel, Sect. VII, pl. VII, fig. 5).

Dans la description de Cuvier et Valenciennes, l'origine et les donateurs des exemplaires étudiés ne sont pas trēs précis ; les registres des collections ont permis d'identifier les types suivants :

=*Thunnus thynnus* (L.)

A. 5299—Syntypes.

Naples.
Savigny.
2 spécimens, alcool. assez bon état.
LS : 119 mm. et 114 mm.
LT : 139 mm. caudale abimée.
(Fig. 32.)

A. 5316—Syntype.

Nice.
Savigny.
1 spécimen, alcool, bon état.
LS : 125 mm.
LT : 142 mm.
(Fig. 32.)

A. 5377—Syntype.

Nice.
Laurillard.
1 spécimen, alcool, trēs bon état.
LS : 430 mm.
LT : 503 mm.
(Fig. 31.)

A. 5791—Syntype.

Naples.
Savigny.
1 spécimen, alcool, assez bon état.
LS : 245 mm.
LT : 280 mm.
(Fig. 33.)

—*Thynnus brasiliensis* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 110.
=*Euthynnus alleteratus* (Raf.)

A. 5571—Holotype.

Brésil.
Delalande.
1 spécimen, sec, assez bon état.
LS : 650 mm.
LT : 745 mm.
(Fig. 34.)

—*Thynnus brevipinnis* Cuvier-Valenciennes, 1837, Hist. Nat. Poiss., t. VIII. p. 112, pl. 216.
=*Euthynnus alleteratus* (Raf.)

La description de Cuvier-Valenciennes ne précise pas le donateur, et n'indique comme origine que " Méditerranée ". Les registres ont permis d'identifier cet holotype.

A. 5810—Holotype.
Naples.
Savigny.
1 spécimen, alcool, assez bon état.
LS : 300 mm.
LT : 340 mm.

—*Thynnus coretta* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss.. t. VIII, p. 102.
(nomen nudum in Cuvier 1829, Règne animal, 2e edit., t. II, p. 198, figuré in Sloane, Jamaica, t. II, pl. III, fig. 1.)
=*Thunnus thynnus* (L.)

A. 5380—Holotype.
Martinique.
Plée.
1 spécimen, alcool, bon état.
LS : 245 mm.
LT : 291 mm.
(Fig. 36.)

—*Thynnus pacificus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss.. t. VIII, p. 133 (d'après Commerson MS. et un exemplaire de Dussumier).
=*Germo alalunga* (L. Gmelin.)

A. 6862—Holotype.
Mer des Indes, " sous l'Equateur ".
Dussumier.
1 spécimen, alcool, assez bon état.
LS : 478 mm.
LT : 568 mm.
(Fig. 37.)

—*Thynnus thunnina* Cuvier- Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 104, pl. 212.
(nomen nudum in Cuvier 1829, Règne animal, 2e edit., t. II, pl. 198, figuré in Adrovande, p. 315, Description de l'Egypte, pl. 24, fig. 5).
=*Euthynnus alleteratus* (Raf.)

A. 5605—Holotype.
Méditerranée.
Delalande.
1 spécimen, sec, assez bon état.
LS : 750 mm.
LT : 820 mm.
(Fig. 38.)

—Le type de l'espèce nouvelle *Thynnus maccozi* Castelnau, 1872, Proc. Zool. Accl. Soc. Victoria, vol. I, p. 104, rentré dans nos collections en 1877 sous le n°. 515, n'a pas été retrouvé.

—Aux espèces nouvelles précédentes, il faut ajouter le *Thynnus balteatus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 136, créé d'apres un dessin fait par Lesson, d'um individu de 28 pouces, originaire de la Trinité, par 20° de latitude australe, et non rapporté. Aucun exemplaire, étiqueté sous ce nom, n'existe dans nos collections.

—" Exemplaires historiques ", non types, étudiés et décrits par Cuvier et Valenciennes.

3 exemplaires de *Thynnus pelamys* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 113, et suivantes, pl. 214, pour *Scomber pelamis* L. edit. Gmel. 1788.

=*Euthynnus pelamis* (L.)

B. 2124 (1 spécimen, sec), Rio de Janeiro—Duc de Rivoli.

A. 5607 (1 spécimen, sec), Mer des Indes—Dussumier.

A. 796 (1 spécimen, sec), " entre la côte d'Afrique et les Maldives, par les 85° de longitude orientale "—Dussumier.

1 exemplaire de *Thynnus alalunga* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 120 et suivantes, pl. 215, pour *Scomber alalunga* L. ed. Gmel. 1788.

=*Germo alalunga* (L. Gmelin.)

A. 798 (1 spécimen sec), La Rochelle—d'Orbigny.

Famille des ISTIOPHORIDAE

Genre Istiophorus Lacépède 1802, Hist. Nat. Poiss., t. III, p. 374.

—*Histiophorus ancipiti-rostris* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 307–309.

Dans leur description, Cuvier et Valenciennes ne mentionnent ni l'origine, ni le donateur.

=*Istiophorus gladius* (Broussonet)

A. 9464—Holotype.

" Museau "—lg. : 635 mm.

(Fig. 39.)

—*Histiophorus gracili-rostris* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 307–308.

Istiophorus gladius (Broussonet)

L'holotype (A. 9462) décrit par Cuvier-Valenciennes (p. 308)est perdu ; nous possédons seulement l'individu rapporté par Cuvier et Valenciennes eux-mêmes à la mème espèce.

A. 9461—Paratype.

Iles Seychelles.

Lamarre-Piquot.

1 tête (Longueur du bec : 610 mm.).

(Fig. 40.)

—*Histiophorus indicus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 293, pl. 229.

=*Istiophorus gladius* (Broussonet)

La description de Cuvier et Valenciennes a été faite d'aprēs l'individu de Broussonet *Scomber gladius* (1786) étudié a Londres, et l'individu rapporté de la Mer Rouge par Ehrenberg, et étudié ā Berlin.

Cuvier et Valenciennes mentionnent aussi l'existence dans les collections du Cabinet du Roi d'une tête osseuse rapportée des Seychelles par M. Dussumier et de deux fragments de bec de voilier, donnés par M. de Jussieu et que l'on avait " retirés de la quille d'un navire en réparation ā l'Isle de France ".

Il ne reste dans nos collections que l'un de ces fragments de bec.

A. 5514—Syntype.
Isle de France.
de Jussieu.

Aux espēces nouvelles précédentes, il faut ajouter :

—*Histiophorus americanus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 303.
décrit d'aprēs une figure de Margrave.

—*Histiophorus pulchellus* Cuvier-Valenciennes, 1831, Nat. Poiss., t. VIII, p. 305, pl. 230.
décrit d'apres un specimen long de 4 pouces, rapporté par M. Reynaud, en janvier 1829, " en revenant du Cap en France ".

Cet holotype, inscrit dans nos catalogues sous le numero A. 6801, n'a pas été retrouvé.

Genre *Tetrapturus* Rafinesque 1810, Caratt. Nuov. An. Sicil, p. 54.

—L'espece *Tetrapturus indicus* Cuvier-Valenciennes, 1831, Hist. Nat. Poiss., t. VIII, p. 286, fut décrite d'aprēs la figure d'un poisson long de neuf pieds, capturé dans les parages de Sumatra, et que Sir Joseph Banks avait communiquée ā Broussonet. Il n'en existe aucun exemplaire dans nos collections.

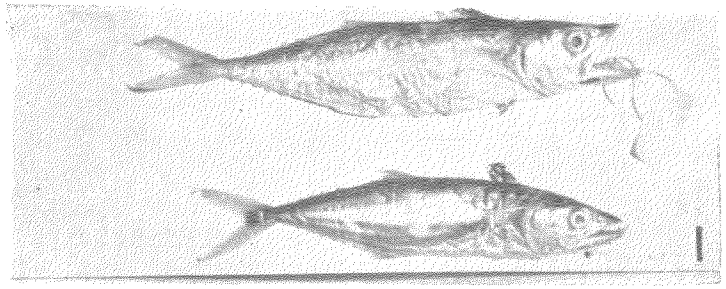
Famille des XIPHIIDAE

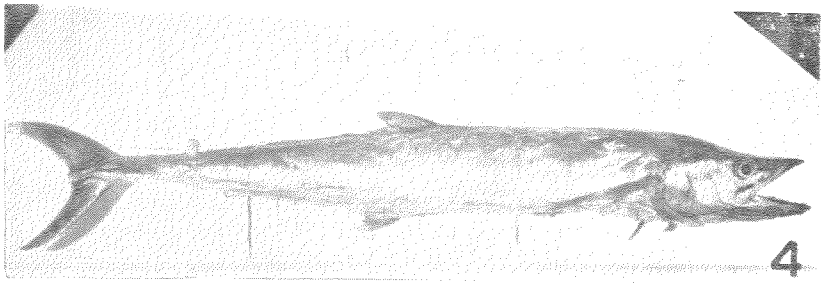
Genre Xiphias Linné 1758, Syst. Nat., 10e edit., p. 248.

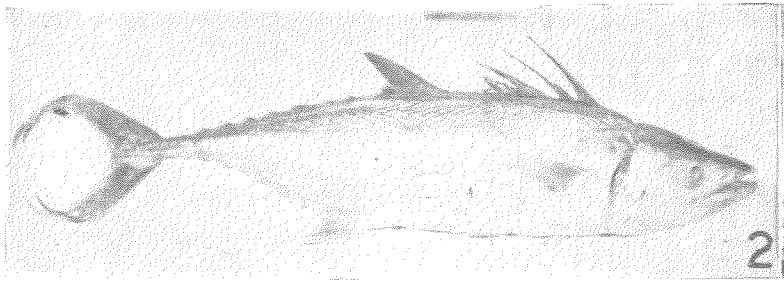
—*Xiphias ensis* Lacépēde 1800, Hist. Nat. Poiss., t. II, p. 296, redécrit in Cuvier-Valenciennes 1831, Hist. Nat. Poiss , t. VIII, p. 307.
=*Istiophorus gladius* (Broussonet) (Famille des Istiophoridae)

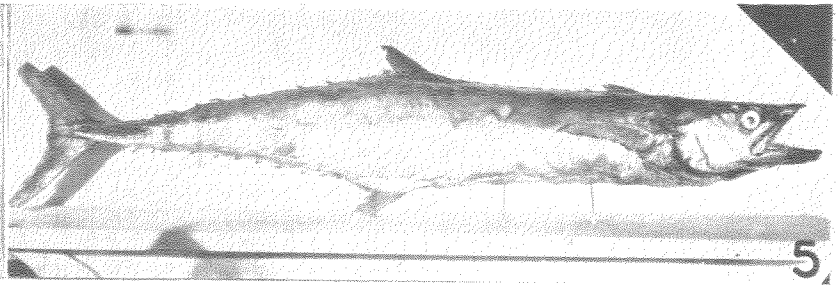
A. 9460—Holotype.
Cabinet du Roi.
" Museau "—lg. : 470 mm.
(Fig. 4.)

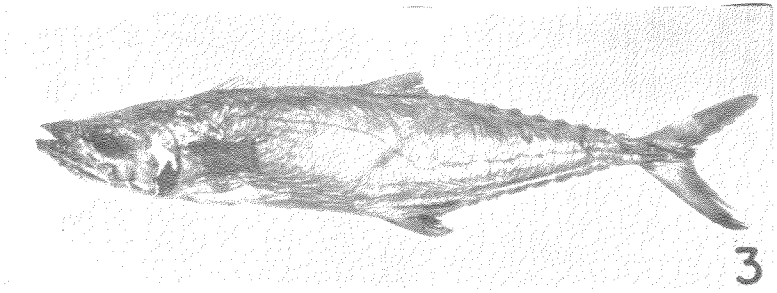
—" Exemplaires historiques ", non types, étudies et décrits par Cuvier et Valenciennes
1 exemplaire de *Xiphias gladius* L. 1758.
A. 6684 (1 spécimen, alcool), Naples—Savigny.

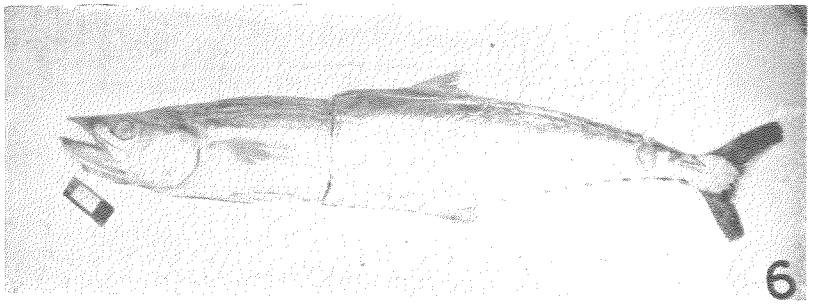

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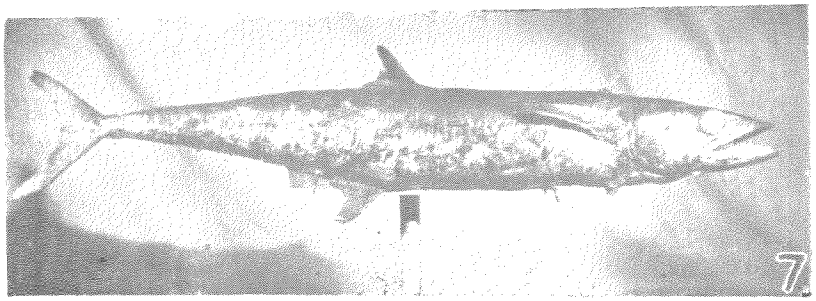

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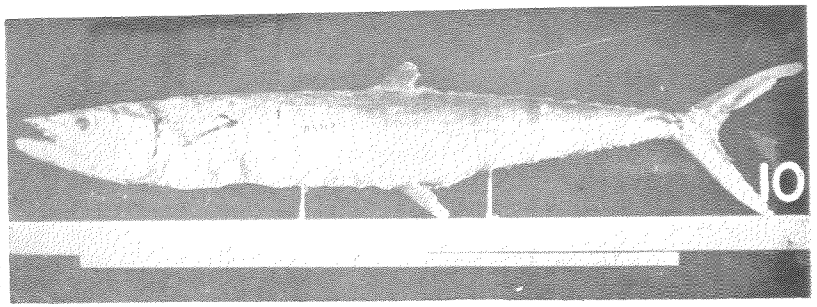

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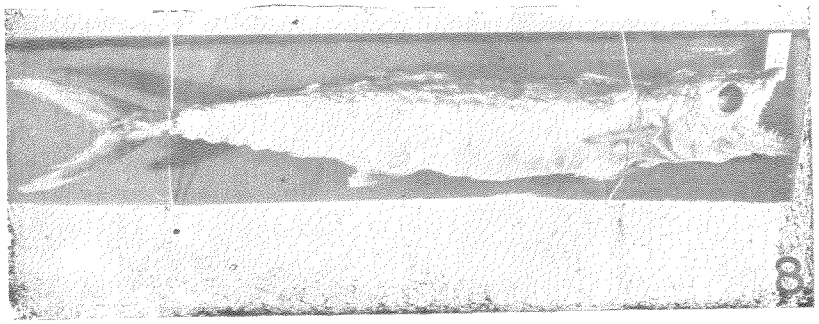

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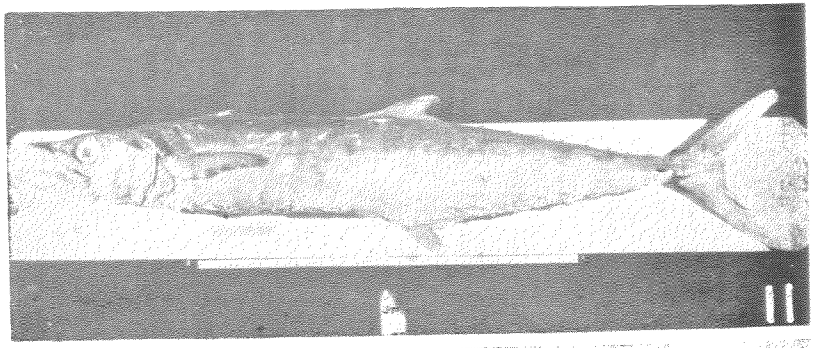

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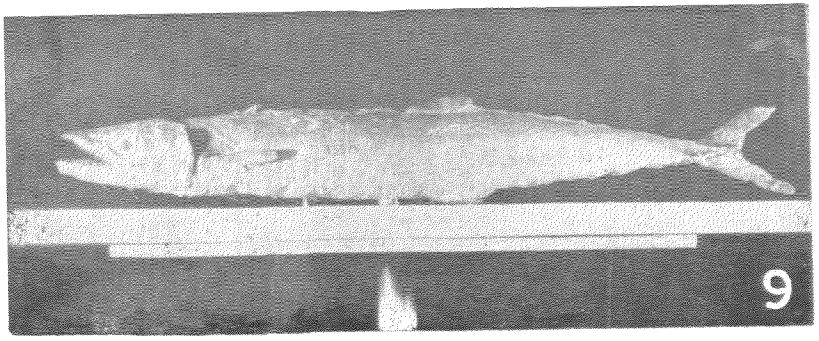

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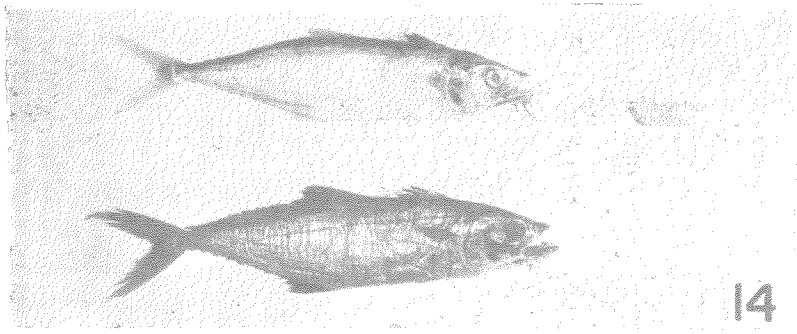

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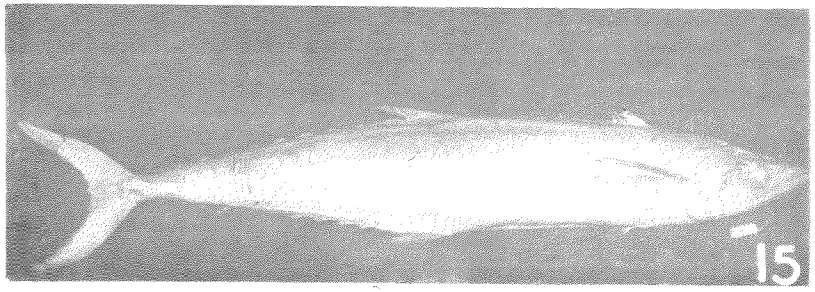

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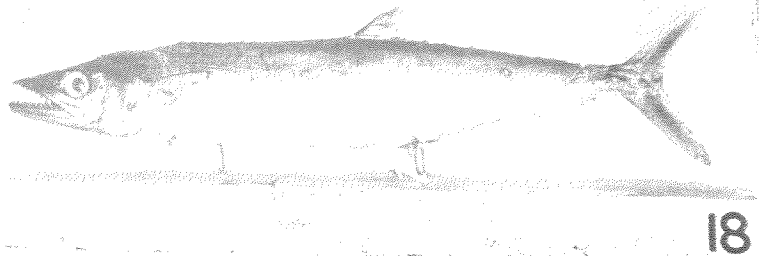

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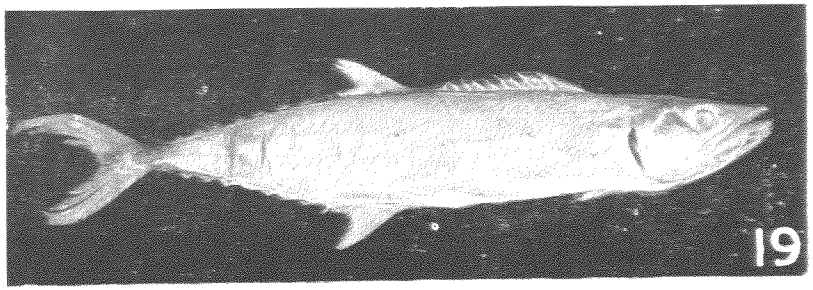

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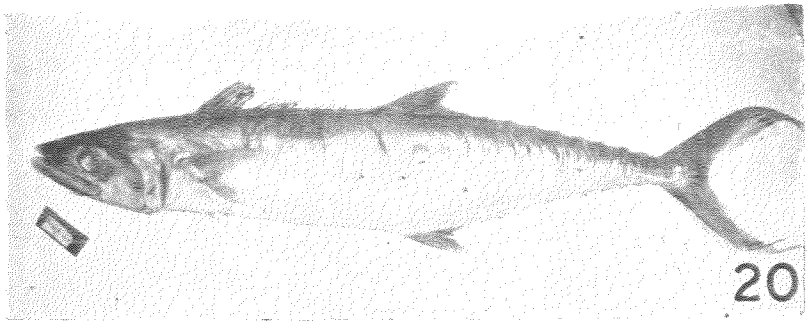

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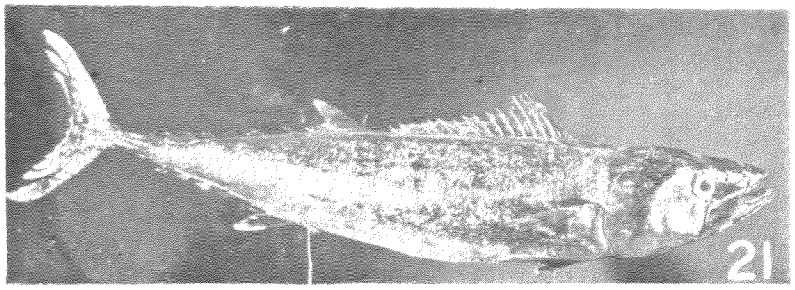

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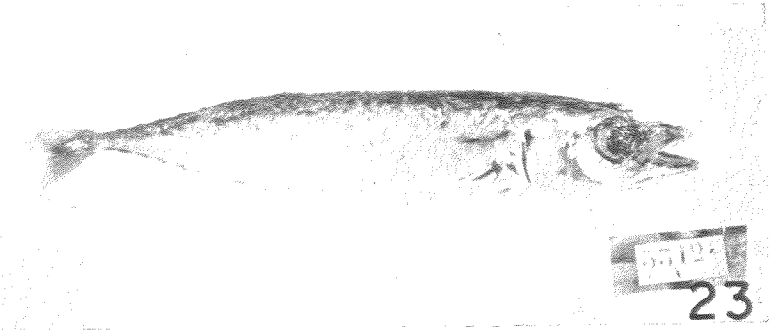

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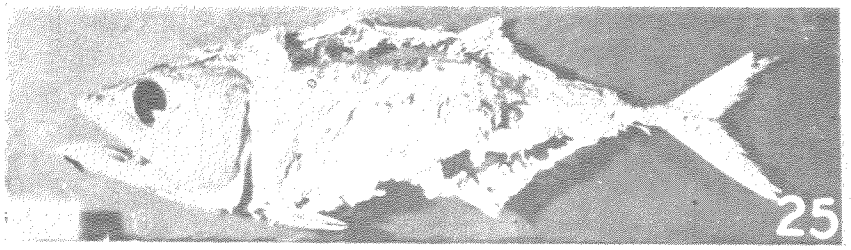

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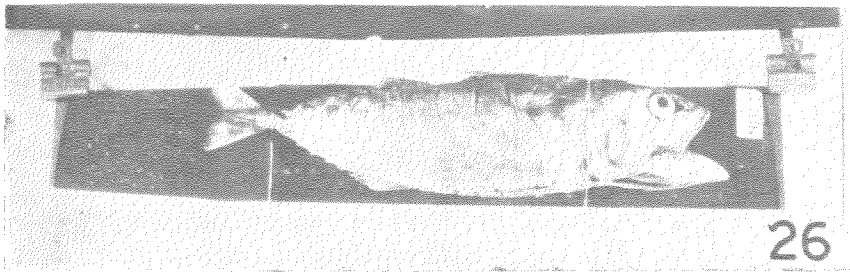

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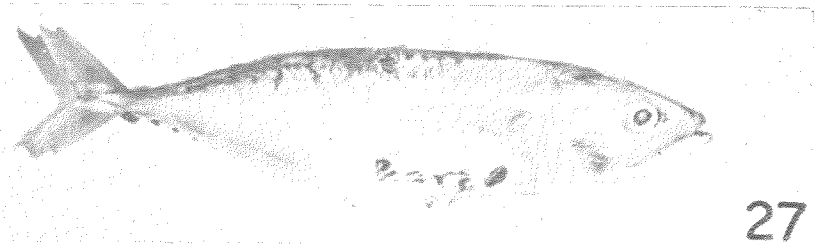

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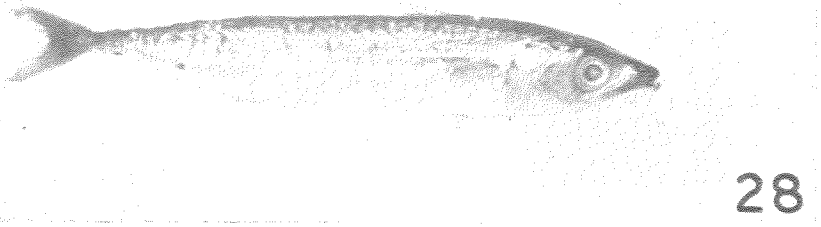

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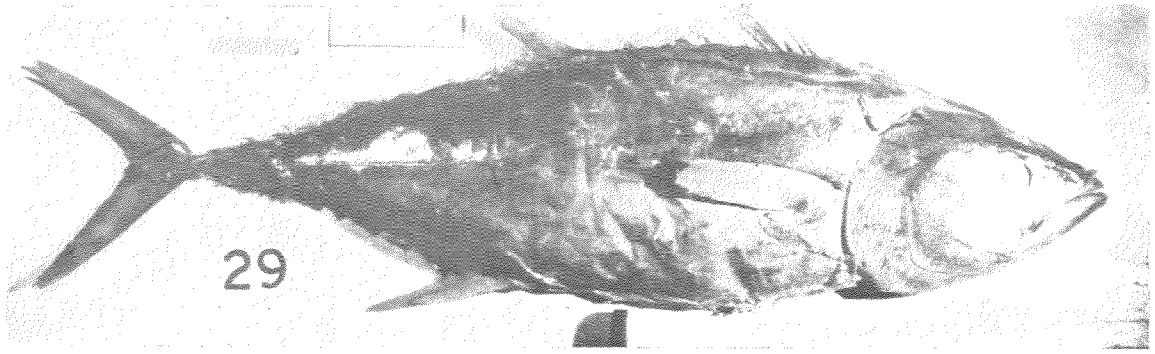

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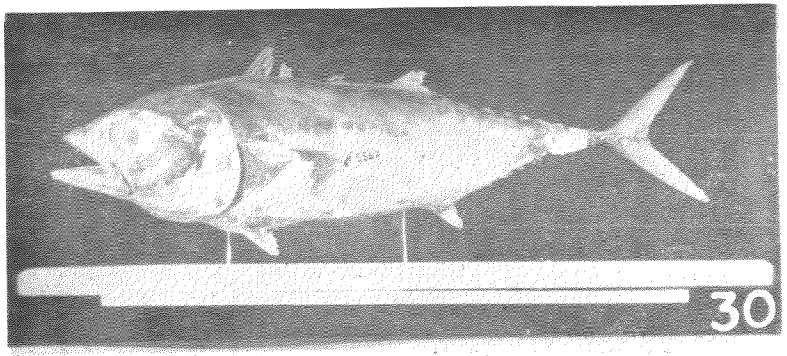

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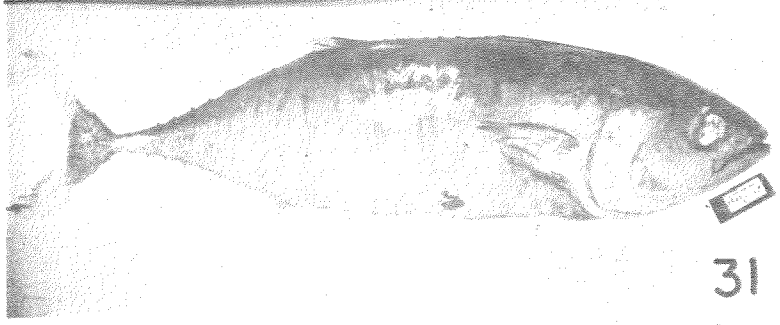

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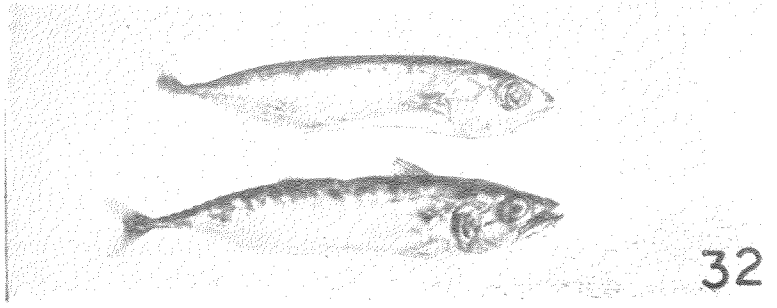

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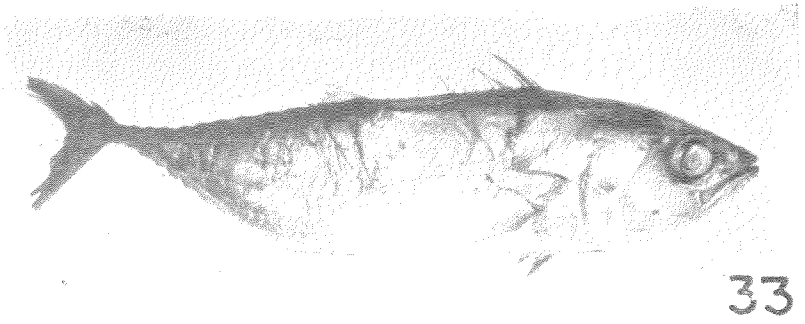

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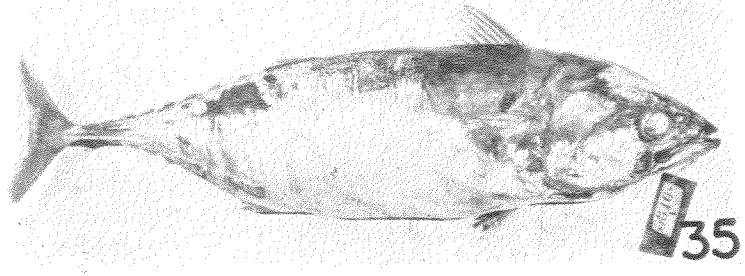

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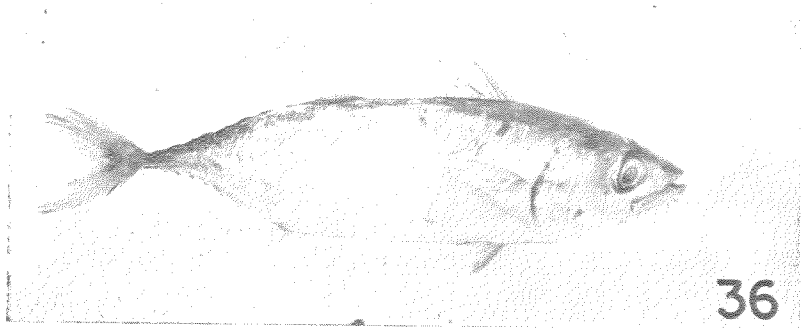

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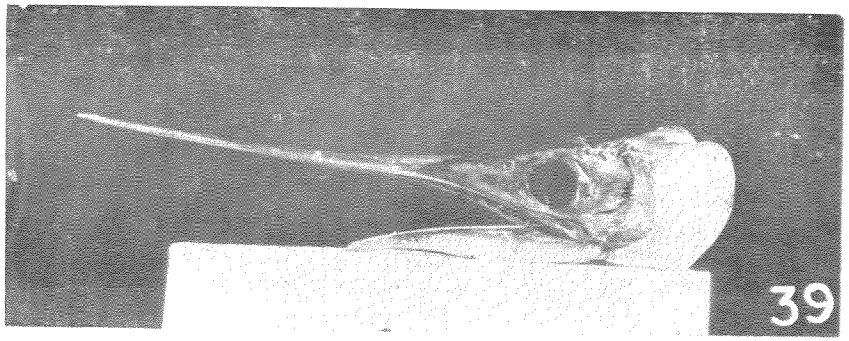

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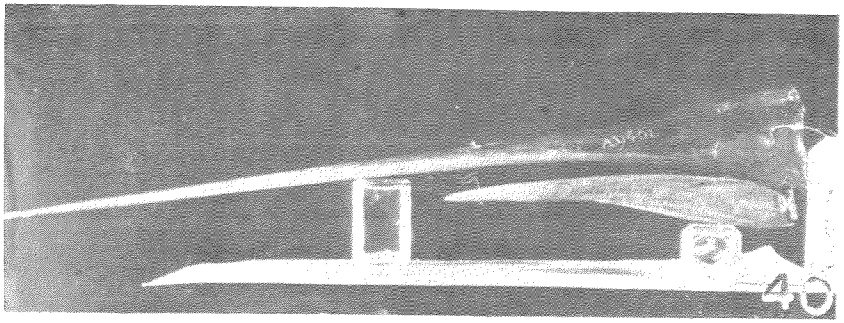

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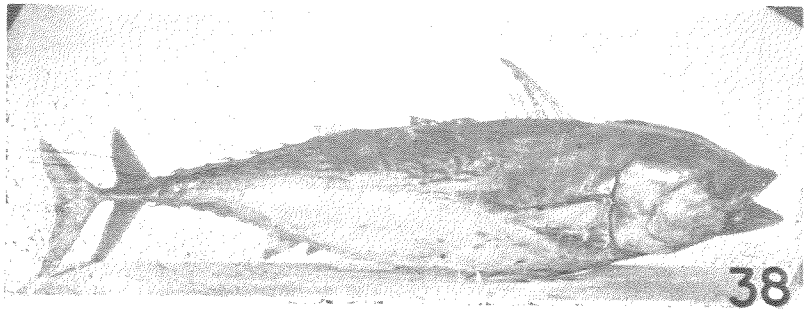

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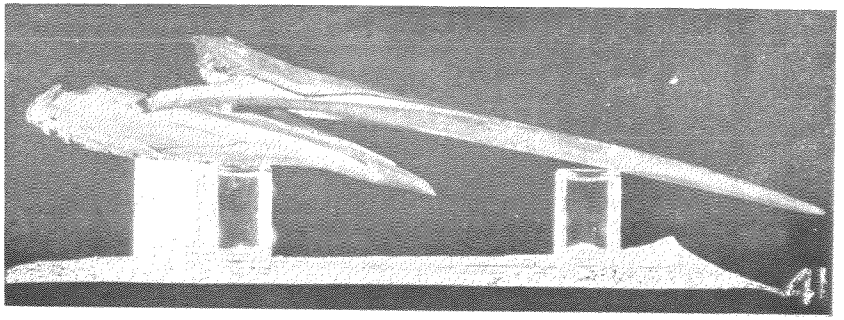

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SCOMBROID FISHES IN THE MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY

BY

MYVANWY M. DICK

Museum of Comparative Zoology, Harvard University, U.S.A.

By history, inclination and purpose, the fish collection housed in this museum does not contain large collections in certain groups of fishes, regardless of commercial interest, at the expense of groups biologically as interesting but of negligible economic importance. Neither will one find here the long series of specimens needed for studies of morphological variation and subspeciation. We have attempted to provide the worker with a few representatives of each genus or species and without regard to geographical specialization. Hence the list of "scombroid" specimens which follows includes more non-scombroid scombroids than tunas and tunalike fishes.

This list was taken from the collection itself, and time has not permitted the reidentification of the specimens. There are most certainly errors, and some of the names used, applied to these specimens as long ago as a hundred years, are nomenclaturally as well as ichthyologically improper. But the list should suggest to the scombroid expert that which he should or should not expect to find in our collection.

GEMPYLIDAE

Epinnula magistralis	8 lots	Vicinity of Cuba
E. orientalis	1 lot	Japan
Escolar violaceus	2 lots	Western North Atlantic
Gempylus coluber	3 lots	Zanzibar, Arabian Gulf, 34°08'N.; 127° 46' W.
G. serpens		(Holotype of *Gempylus ophidianus* Poey, Mem. 2,1860, 246.) 1 spec. Cuba.
G. thyrsitoides	1 lot	Cocos Is.
Neolotus tripes	2 lots	Western North Atlantic.
Nesiarchus nasutus	1 lot	Western North Atlantic.
Promethichthys prometheus	3 lots	Cuba, Hawaii, 40° 00'N ; 70° 54' W.
Scombrolabrax heterolepis	1 lot	Gulf of Mexico.
Thyrsites atun	5 lots	Chile, Australia.
T. garreti	1 lot	Society Is.
Thyrsitops violaceus	1 lot	Western North Atlantic.

SCOMBRIDAE

Gasterochisma SP.	1 lot	Chile.
Pneumatophorus japonicus	2 lots	California, Japan.
Scomber australicus	1 lot	Australia.
S. brachysoma	1 lot	Java.
S. chrysozonus	1 lot	Zanzibar.
S. colias	9 lots	Fayal, California, Peru, Galapagos.
S. grex	1 lot	Cuba.
S. kanagurta	2 lots	Ceylon, Zanzibar.
S. microlepidotus	3 lots	Java, Zanzibar.
S. pneumatophorus	5 lots	Italy, Spain, Madeira, Massachusetts.
S. scombrus	30 lots	Europe, Western North Atlantic.

THUNNIDAE

Auxis rochei	2 lots	Society Islands, Gulf of Maine.
A. thazard	4 lots	Gulf of Maine, Russia.
Euthynnus pelamys	7 lots	Argentine, Cuba, Society Is., Galapagos Is.
Gymnosarda alletarata	1 lot	Java.
Orcynus alalongus	1 lot	California.
O. thynnus	8 lots	Society Is., West Indies, Brazil.

THUNNIDAE

Pelamys sarda	2 lots	Gulf of Maine.
Sarda chilensis	4 lots	California, Peru.
S. pelamys	8 lots	Gulf of Maine, Cuba, Spain, Brazil.
Thunnus thynnis	1 lot	Gulf of Maine, North Carolina.
T. atlanticus	1 lot	40° 04′ N.; 70° 40′ W.

TRICHIURIDAE

Benthodesmus atlanticus	1 lot	Cuba.
Lepidopus caudatus	1 lot	Europe.
L. gouani	1 lot	Fayal.
Trichiurus haumela	9 lots	East Indies, Mauritius, Atlantic Ocean.
T. japonicus	1 lot	East Siberia.
T. lepturus	27 lots	Brazil, Western North Atlantic.
T. mutieus	1 lot	Brazil.
T. nitens		Garman Type Mem. Mus. Comp. Zool. 24, 1899, 69, Galapagos Is.
T. savala	3 lots	E. Indies, Siam, New Caledonia.
T. mutieus	1 lot	Philippine Is.

SCOMBROID TYPES IN THE LEIDEN MUSEUM COLLECTION*

BY

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The delimitation of the "Scombroids" is liable to extensive variation in modern literature (Fowler, 1936, Bull. Am. Mus. Nat. Hist., vol. 70 ; Berg, 1947, Class. Fish., reprint and translation of Trav. Inst. Zool. Ac. Sci. Leningrad, vol. 5, 1940; de Beaufort, in de Beaufort & Chapman, 1951, Fish. Indo-Austr. Arch., vol. 9; Norman, 1957, Draft Synopsis etc.), with Fowler and Berg as extremes. I have, rather arbitrarily, chosen the intermediate extent as used by de Beaufort, which covers the Trichiuroidea and Scombroidea sensu Norman*. The genera in each family, and the species in each genus, are given in alphabetical order to facilitate consultation.

The importance of the Leiden fish collection is clearly illustrated by the fact that during my researches I hitherto encountered types described by the following authors : de Beaufort, Bleeker, Boeseman, Cantraine, Cuvier (&Valenciennes), Day, van Hasselt, Heckel, Hoedeman, Hubrecht, Inger & Chen, Jordan (and collaborators), Kaup, Kner, Koumans, Kuhl (and van Hasselt), Lidth de Jeude, Mead, Metzelaar, Müller and Henle, Norman, Popta, Reuvens, Rüppell, Schlegel, Steindachner, Temminck (and Schlegel), Vaillant, Valenciennes, and Weber, while it seems most likely that this enumeration is still far from complete.

Finally, it seems interesting to note that in 1879, after Bleeker's death, when his collections were sold in five sets at a public auction, the principal part, presumed to contain most of the types, went to Leiden.

The assistance of Mr. H.F. Roman, who made the photographs and photostat copy, is kindly acknowledged.

Suborder SCOMBROIDEA

Family TRICHIURIDEA

The types belonging to this family are being dealt with elsewhere. [*J. Mar. Biol. Ass. India*, 4 (2) : 214–216].

*The invitation to prepare, for the forthcoming symposium on Scombroid fishes at Mandapam Camp, a paper on the Scombroid material in the Leiden Museum, unfortunately reached me at a most inopportune moment. Severely handicapped by the installation of a new central heating and lighting system in the museum building, scientific research was hardly possible on account of the partial inaccessibility of the necessary material and literature, the noise and the dust. These circumstances forced me to postpone the examination of the Scombroid specimens until the worst (seemingly) was over, but then lack of time compelled me to restrict the present list to only include the available type material (holo-, syn-, lecto-, paratypes and neotypes), while giving only the scantiest principal information. Furthermore, it was impossible to critically review or control the generally accepted synonymy. Those consulting the following enumeration should take these unfavourable circumstances into account and be warned of the possibility that some omissions or even errors may have slipped in.

Family SCOMBRIDAE

Genus **Rastrelliger** Jordan and Starks

Scomber brachysoma Bleeker, 1851, Nat. Tijdschr. Ned. Ind., vol.1, p. 356.

=*Rastrelliger brachysoma* (Bleeker), 1851, cf. de Beaufort, 1951, p. 210.

Holotype : reg. no. 6040, coll. Dr. P. Bleeker (auction 1879), Batavia, 121(132+) mm, in spirits. (fig. 1.)

Remarks : this specimen has already been mentioned as the type by de Beaufort, l.c. It is in a fairly good condition, with the body cavity cut open on one side and the guts removed, and the caudal fin slightly mutilated.

Scomber moluccensis Bleeker, 1856, Acta Soc. Indo-Neêrl., Batavia, vol. 1, p. 40.

=*Rastrelliger kanagurta* (Cuvier), 1817, cf. de Beaufort, 1951, p. 212.

Syntypes : reg. no. 6038, coll. Dr. P. Bleeker (auction 1879), Amboina, 178 & 185 (197+ & 209+) mm, in spirits. (fig. 2.)

Remarks : the large example has the body cavity cut open and the guts removed ; otherwise both in good condition, though with the tips of the caudal fins damaged.

Genus **Scomber** Linne.

Scomber janesaba Bleeker, 1854, Nat. Tijdschr. Ned. Ind., vol. 6, p. 406.

=*Scomber japonicus* Houttuyn, 1782.

Syntypes : reg. no. 6036, coll. Dr. P. Bleeker (auction 1879), Nagasaki, 3 ex., 144—153(156+ —165+) mm, in spirits. (fig. 3.)

Remarks : it is remarkable that the number of dorsal spines in these examples seems to agree exactly with that given by Bleeker : nine or ten, while de Beaufort mentions ten or eleven. Still, de Beaufort states : " My specimens agree with Bleeker's description of *janesaba*, which species most authors consider to be the young of *japonicus*." Doubting de Beaufort's judgment in this case, I prefer to consider *janesaba* Bleeker (and *saba* Bleeker, and *japonicus* Temminck & Schlegel, see below) as a synonym of *japonicus* Houttuyn, even though Houttuyn mentioned only eight dorsal spines, probably overlooking the small posterior one.

The general condition of the types is good, one example is cut open with the gut partly removed.

Scomber pneumatophorus japonicus (major and minor) Temminck and Schlegel, 1844, Faun. Jap., Pisces, Leiden, p. 93, pl. 47.

=*Scomber japonicus* Houttuyn, 1782.

Syntypes : reg. no. 834, coll. H. Bürger, Japan (southern part?), 300 (340) mm, stuffed (*major*); reg.no. 836, coll. H. Bürger, Japan (southern part?), 355(405) mm, stuffed (*major*); reg.no. 894, coll. H. Bürger, Japan (southern part?), 168(180+) mm, stuffed (*minor*); reg.no. 1274, coll. Ph. F. von Siebold, Japan, 5 ex., 87–220(112–260) mm, in spirits (*minor*) (figs. 4 and 5.)

Remarks : judging by their text (p.92), Temminck and Schlegel considered the identity of Houttuyn's *japonicus* doubtful, and did not intend to copy the name proposed by that author; therefore, *japonicus* Temminck and Schlegel should be accepted as new.

At first sight, the name proposed by Temminck and Schlegel certainly does not seem binomial, and one could doubt the availability of this whole volume of the Fauna Japonica for nomenclatorial purposes. Fortunately, as Temminck and Schlegel always give their subgeneric names between brackets, we may assume that *pneumatophorus* was intended as a specific name, *japonicus* as a subspecific name, and *minor* and *major* as infra-subspecific names or races (as, in fact, the authors clearly stated). The same reasoning can be applied to the previously mentioned *Trichiurus lepturus japonicus* and the next *Scomber scombrus japonicus*, while all further names proposed by Temminck and Schlegel are clearly binomial.

All these typical specimens have nine or ten dorsal spines and presumably, with *janesaba* Bleeker and *saba* Bleeker, belong to *japonicus* Houttuyn. Their condition is fairly good to excellent, the stuffed examples being covered with a heavy layer of paint and varnish.

Scomber scombrus japonicus Temminck & Schlegel, 1844, Faun. Jap., Pisces, Leiden, p. 92.

= (?) *Scomber tapeinocephalus* Bleeker, 1854.

Holotype: reg. no. 1259, coll. Ph. F. von Siebold, Japan, 350 (405) mm, in spirits. (Fig. 6.)

Remarks : according to Temminck and Schlegel, this species presumably has no air-bladder, an observation that could not be confirmed in the holotype, its entrails being badly damaged. As *Scomber tapeinocephalus* according to Bleeker (1854, Nat. Tijdschr. Ned. Ind., vol. 6, p. 407) has an air-bladder, I have given the above modern name with some reserve though, apparently, *tapeinocephalus* Bleeker and *japonicus* Houttuyn are the only Japanese species.

Though ventrally cut open, the holotype is in good condition. It has twelve dorsal spines, which clearly distinguishes the species from *japonicus* Houttuyn with only nine or ten dorsal spines.

Scomber saba Bleeker, 1854, Nat. Tijdschr. Ned. Ind., vol. 6, p. 405.

= *Scomber japonicus* Houttuyn, 1782.

Syntypes : reg. no. 6035, coll. Dr. P. Bleeker (auction 1879), Nagasaki, 181 and 183 (198+ and 204+) mm, in spirits. (Fig. 7.)

Remarks: body cavities cut open and guts removed, caudal fins mutilated. Otherwise condition satisfactory. Both have ten dorsal spines.

Scomber tapeinocephalus Bleeker, 1854, Nat. Tijdschr. Ned. Ind., vol. 6, p. 407.

Holotype: reg. no. 6041, coll. Dr. P. Bleeker (auction 1879), Nagasaki, 194 (208+ mm, in spirits. (Fig. 8.)

Remarks: cut open and gut removed, condition rather poor. Dorsal with eleven spines. A second specimen, put by Bleeker in the same jar, was removed as it apparently belongs to *Rastrelliger kanagurta* (Cuvier).

ADDITIONAL NOTES TO SCOMBRIDAE

I incidentally found topotypes pertaining to the following species:

Scomber grex Mitch. [= *Scomber colias* (Gmelin)], reg. no. 1262, coll. J. G. Milbert, New York, in spirits.

Scomber capensis Cuvier, nec Pappe (= *Scomber japonicus* Houttuyn), reg. no. 1264, coll. H. B. van Horstok, Cape of Good Hope, 2 ex., in spirits; reg. no. 2761, coll. F. de Castelnau, Cape of Good Hope, from coll. Dr. P. Bleeker (auction 1879), dried example with skin largely removed on one side.

Scomber chrysozonus Rüpp. [=*Rastrelliger kanagurta* (Cuvier)], reg. no. 15663, coll. J. H. Ziesel, Kamaran (Red Sea), 2 ex., in spirits; Kamaran (island) is situated in the southern Red Sea just opposite Massawa, where Rüppell probably got the species from the market.

The Leiden collection also contains a specimen labelled *Scomber gomfudensis* Rüppell, reg. no. 1265, coll. E. Rüppell, Red Sea. Though as far as I can ascertain this name has never been published, it is here included for certainty's sake, the Red Sea being type locality for numerous Rüppell species. The specimen definitely belongs to *Rastrelliger kanagurta* (Cuvier).

Family THUNNIDAE

Genus **Auxis** Cuvier

Auxis thynnoides Bleeker, 1855, Nat. Tijdschr. Ned. Ind., vol. 8, p. 301.

= *Auxis thazard* Lacépède, 1802, cf. de Beaufort, 1951, p. 226.

Holotype: reg. no. 6049, coll. Dr. P. Bleeker (auction 1879), Ternate, 250 (274) mm, spirits. (Fig. 9.)

Remarks: by bending the caudal fin slightly, a total length of 283 mm, as stated by Bleeker in the original description, is exactly reached. The vertebral column is broken

somewhat before the caudal fin, otherwise the condition is fairly good. The specimen has been collected near Ternate by C.F. Goldmann, and was presented to Bleeker.

Auxis tapeinosoma Bleeker, 1854, Nat. Tijdschr. Ned. Ind., vol. 6, p. 408.

Holotype: reg. no. 6050, coll. Dr. P. Bleeker (auction 1879), Nagasaki, 190 (215) mm, in spirits. (Fig. 10.)

Remarks: by slightly bending the caudal fin, the total length of 220 mm, as stated by Bleeker, is reached. The specimen is in a fairly good condition, only the opercle on one side being cut open by Bleeker. It has been collected near Nagasaki by A. N. Wolff, and was presented to Bleeker subsequently.

Genus **Sarda** Cuvier

Pelamys orientalis Temminck and Schlegel, 1844, Faun. Jap., Pisces, Leiden, p. 99, pl. 52.

= *Sarda orientalis* (Temminck & Schlegel), 1844.

Lectotype: reg. no. 2286, coll. H. Bürger, Japan (southern part?), 490 (580) mm, stuffed. (Fig. 11.)

Paratypes: reg. no. 842, coll. H. Bürger, Japan (southern part?), 425 (495) mm, stuffed; reg. no. 1244, (coll. Ph. F. von Siebold?), Japan, 435 (495) mm, stuffed with cotton, in spirits.

Remarks: both stuffed examples are in good condition, though covered with a thick layer of paint and varnish. The specimen in spirits was slightly shrunken, which accounts for the difference in size when compared with my measurements as previously given (Boeseman, 1947, Zool. Meded., Leiden, vol. 28, p. 94), in which paper I also already proposed the lectotype selection. Its label bears no indication except the words "Fauna jap," but most examples in spirits used for the Fauna Japonica were collected by von Siebold.

Genus **Thunnus** South

Thynnus macropterus Temminck & Schlegel, 1844, Faun. Jap., Pisces, Leiden, p. 98, pl. 51

= *Thunnus macropterus* (Temminck & Schlegel), 1844, cf. de Beaufort, 1951, p. 223.

Holotype: reg. no. 2252, coll. H. Bürger, Japan (southwestern part), 620 (720) mm, stuffed. Fig. 12.

Remarks: the specimen is in a fairly good condition, but thickly covered with paint and varnish.

Thynnus sibi Temminck & Schlegel, 1844, Faun. Jap., Pisces, Leiden, p. 97, pl. 50.

= *Thunnus sibi* (Temminck & Schlegel), 1844, cf. de Beaufort, 1951, p. 222.

Lectotype: reg. no. 2327, coll. H. Bürger, Japan (southern part?), 530 (635) mm, stuffed. (Fig. 13.)

Paratype: reg. no. 799, coll. H. Bürger, Japan (southern part?), 525 (615) mm, stuffed.

Remarks: the lectotype is in a good condition, the paratype is fairly good, but with the left side almost wholly removed and replaced by cardboard. Both specimens are thickly covered with paint and varnish. The selection of a lectotype has already been published previously (Boeseman, 1947, Zool. Meded., Leiden, vol. 28, p. 93).

Thynnus orientalis Temminck & Schlegel, 1844, Faun. Jap., Pisces, Leiden, p. 94.

= (?), *Thunnus thynnus* (Linné), 1758.

Holotype: reg. no. 794, coll. H. Bürger, Japan (southern part?), 420 (490) mm, stuffed. (Fig. 14.)

Remarks: the specimen is still in fairly good condition. Godsil & Byers (1944, Calif. Fish Game, Fish. Bull., no. 60, p. 3) tentatively accept *orientalis* Temminck & Schlegel as a separate species pending a direct comparison with *Thunnus thynnus* (Linné).

Thynnus tonggol Bleeker, 1851, Nat. Tijdschr. Ned. Ind., vol. 1, p. 356.

= *Thunnus tonggol* (Bleeker), 1851, cf. de Beaufort, 1951, p. 225.

Neotype: reg. no. 6046, coll. Dr. P. Bleeker (auction 1879), Batavia or Singapore(?), 700(810) mm, in spirits. (Fig. 15.)

Remarks: in Bleeker's original description, the total length of this holotype is given as 650 mm, the type locality being Batavia. In the collection of the Leiden Museum I found two examples from the Bleeker auction (reg. no. 6046), measuring about 700(810) and 485(570) mm. A separate skull from Batavia, coll. Bleeker (reg. no. 84), measuring 180 mm, must have belonged to a specimen measuring approximately 750 mm, as deduced by comparison with the 810 mm example. None of these can be considered as Bleeker's holotype of the species, which therefore I presume to be lost.

The proposed neotype has the right side partly removed by Bleeker, which must have enabled him to fold the rather large specimen and put it in a jar. Otherwise, it is in a fairly good condition, useful for scientific research. For descriptive data, I refer to Bleeker's description.

De Beaufort (l.c.) mentions to have seen typical specimens in the Leiden collection. This remark must refer to both specimens hitherto kept under register number 6046, both definitely non-typical, but one now proposed as neotype and the other one removed.

ADDITIONAL NOTES TO THUNNIDAE

For several species in this family, the type locality is very extensive (Mediterranean, Atlantic Ocean, etc.), while I am not acquainted with any subsequent restrictions. In these cases, indications of topotypes only have sense if accompanied by a type restriction. Unfortunately, in the two species for which I incidentally found material from the original type "region" (*Thynnus brevipinnis* Cuvier, reg. no. 803, 804, Mediterranean; *Scomber sarda* Bloch, reg. no. 841, 2251, 2261, 2404, Mediterranean) the locality is equally vague and not fit for restriction.

Family CYBIIDAE

Genus **Scomberomorus** Lacépéde

Cybium konam Bleeker, 1851, Nat. Tijdschr. Ned. Ind., vol. 1, p. 357.

= *Scomberomorus commersoni* (Lacépéde), 1800, cf. de Beaufort, 1951, p. 230.

Lectotype: reg. no. 6051, coll. Dr. P. Bleeker (auction 1879), Batavia, 410 (490) mm, in spirits.

Paratypes: reg. no. 24087, coll. Dr. P. Bleeker (auction 1879), East Indies, 12 ex, 81-238 (94-272) mm, in spirits (partly only!)

Remarks: Bleeker had the disagreeable habit to include subsequent additions with his original material in the same jar, which makes sorting out of types difficult, sometimes even impossible. In the present case, the largest example accurately agrees with the upper size limit in Bleeker's original description, thus beyond doubt represents a type specimen, and is selected as lectotype with the original register number. Among the other specimens, two are below the original size limits, and were removed, while the remaining twelve, definitely including type material, were removed to the new register number 24087 as 'including paratypes'.

All types are in a very good condition, with only the lectotype with three large transverse cuts on the left side.

Cybium croockewitii Bleeker, 1850, Nat. Tijdschr, Ned. Ind., vol. 1, p. 161.

= *Scomberomorus croockewiti* (Bleeker), 1850, cf. de Beaufort, 1951, p. 234.

Holotype; reg. no. 6054, coll. Dr. P. Bleeker (auction 1879), Banka, strait near Muntok, 350 (425+) mm, in spirits. (Fig 17)

Remarks: this is the specimen also indicated as the type by de Beaufort (1951, p. 235), and there described. The anterior portion of the body, on the left side, is badly damaged, most of the fins more or less damaged or mutilated, especially the caudal tips. Rest in reasonably good condition. The holotype was collected by Dr. J. H. Croockewit, and presented to Bleeker.

Cybium kuhlii Cuvier, 1831, Hist. Nat. Poiss., Paris, vol. 8, p. 178.

= *Scomberomorus guttatus* (Bloch; Schneider), 1801, cf. de Beaufort, 1951, p. 232.

Syntypes: reg. no. 1239, coll. H. Kuhl & J. C. van Hasselt, Java, 190 (225) mm, in spirits; reg. no. 1241, coll. H. Kuhl & J. C. van Hasselt, Java, 100 (120) mm, in spirits. (Fig. 18.)

Remarks: already de Beaufort (1951. p. 234), after investigating these examples, stated: "They have been labelled" "*Cybium kuhli*" probably by Valenciennes, hence they can almost be considered as paratypes. After some hesitation, I designate these specimens as syntypes; the specimens described by Cuvier, measuring up to four "pouces" (about 10 cm), still must be in the Paris Museum, one of these should be selected as lectotype.

Both specimens are in excellent condition.

ADDITIONAL NOTES TO CYBIIDAE

I incidentally found a specimen of *Chriomitra concolor* Lock. [=*Scomberomorus concolor* (Lockington)], reg. no. 16036, from Soquei, California. As Soquel is situated on the shore of Monterey bay, quite near Monterey which is the type locality for *concolor*, the more accurate type locality evidently being Monterey bay near Monterey, our present specimen can be considered as topotypical.

Family ISTIOPHORIDAE

Genus **Istiophorus** Lacépéde

Histiophorus orientalis Temminck & Schlegel, 1844, Faun. Jap., Pisces, Leiden, p. 103, pl. 55.

= *Istiophorus orientalis* (Temminck & Schlegel), 1844.

Of this species the authors never received any material. It was based entirely on a description and a plate provided by H. Bürger, made by him or under his supervision in Japan. The plate (Fig. 19), still in the Leiden Museum collection, is excellent and well reproduced in the Fauna Japonica, and can be considered as "iconotype" of the species, though this term has no official status. The selection and indication of a neotype do not seem necessary.

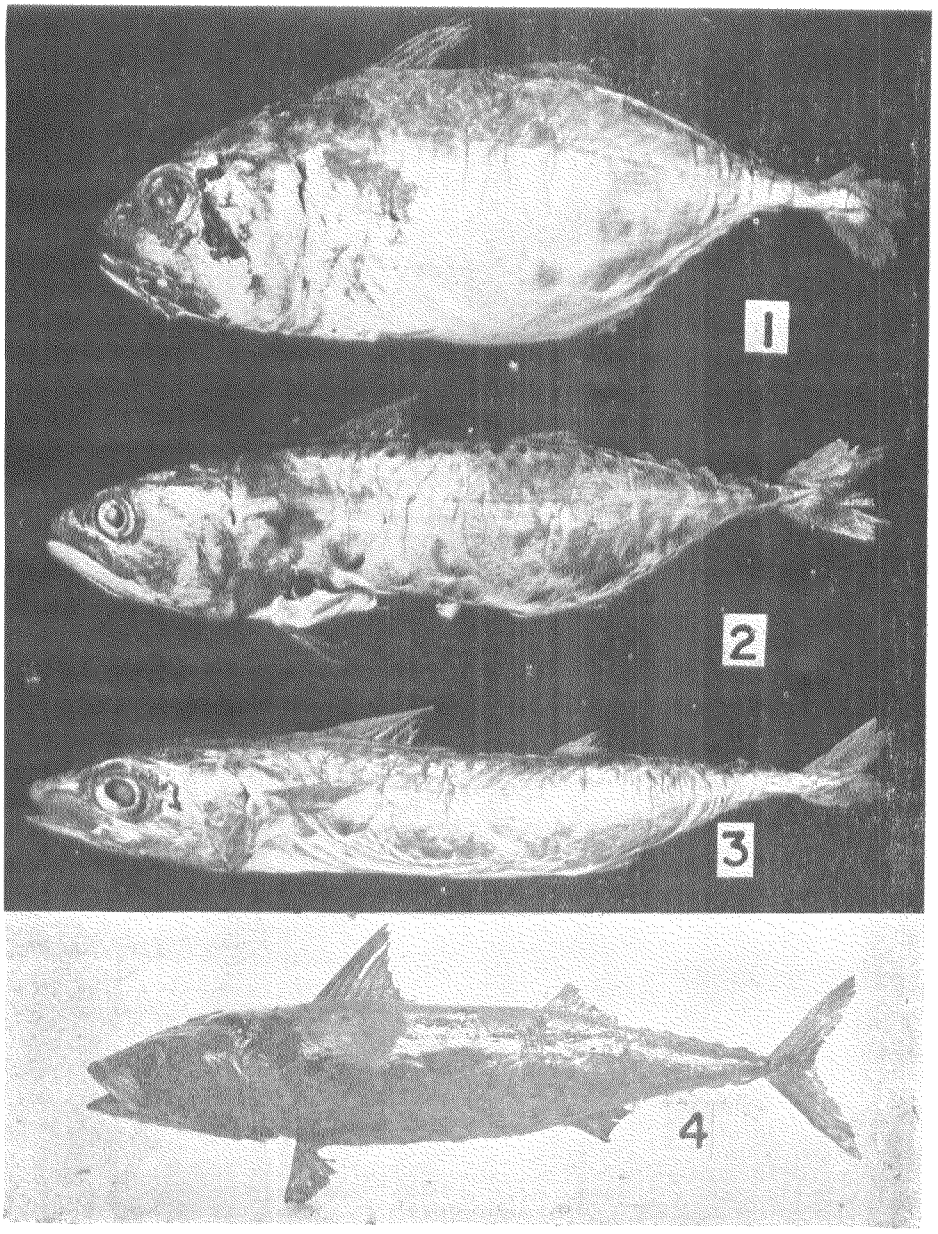


Fig. 1. *Scomber brachysoma* Bleeker, reg. no. 6040, 121 (132 +) mm, holotype. Fig. 2. *Scomber moluccensis* Bleeker, reg. no. 6038, 185 (209+) mm, syntype. Fig. 3. *Scomber ianesaba* Bleeker, reg. no. 6036, 153 (165+) mm, syntype. Fig. 4. *Scomber pneumatophorus japonicus* Temminck & Schlegel, reg. no. 836, 355 (405) mm, syntype (*"major"*).

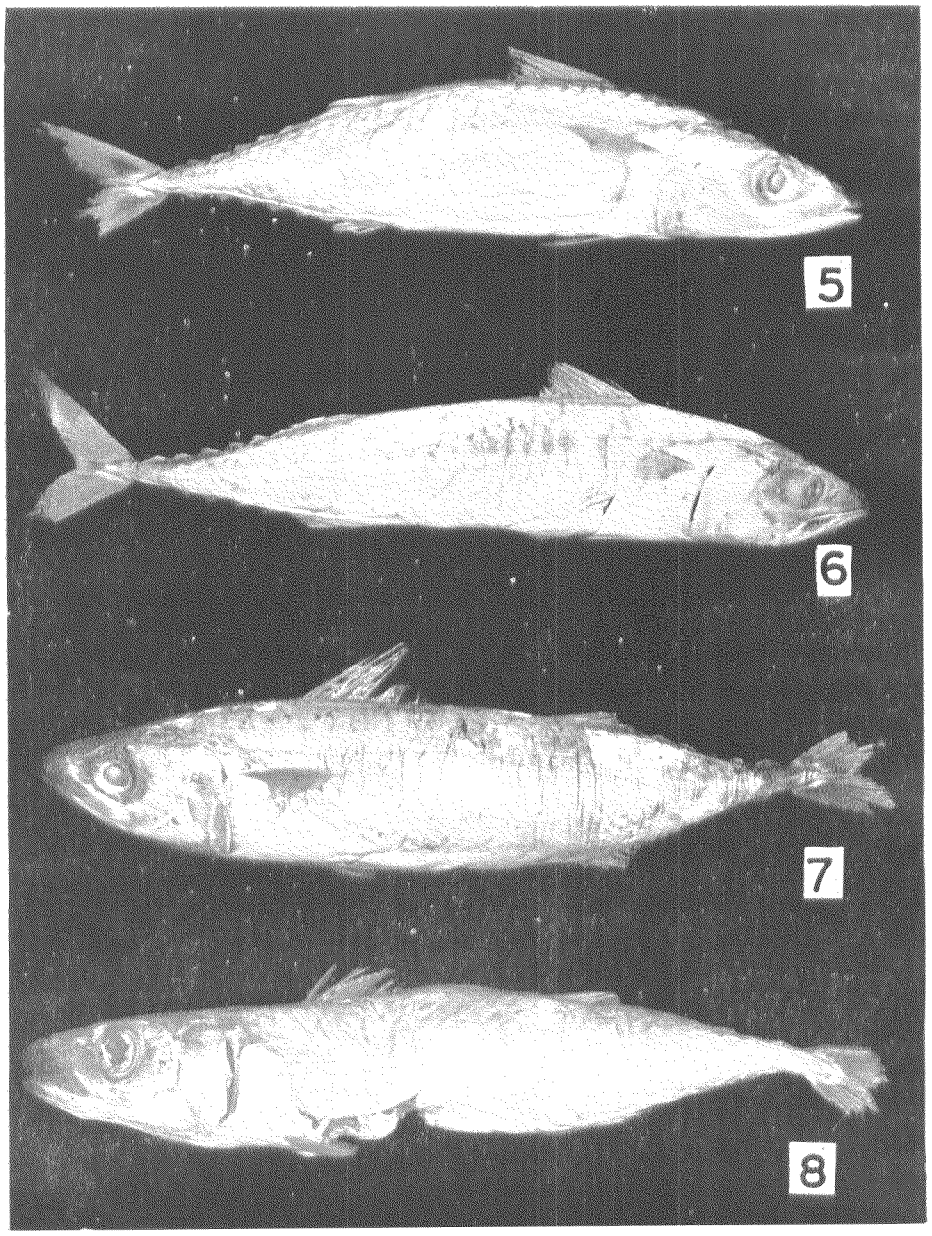


Fig. 5. *Scomber pneumatophorus japonicus* Temminck & Schelegel, reg. no. 1274, 220 (260) mm, syntype ("*major*"). Fig. 6. *Scomber scombrus japonicus* Temminck & Schlegel, reg. no. 1259, 350 (405) mm, holotype. Fig. 7. *Scomber saba* Bleeker, reg. no. 6035, 183 (204 +) mm, syntype. Fig. 8. *Scomber tapeinocephalus* Bleeker, reg. no. 6041, 194 (208 +) mm, holotype.

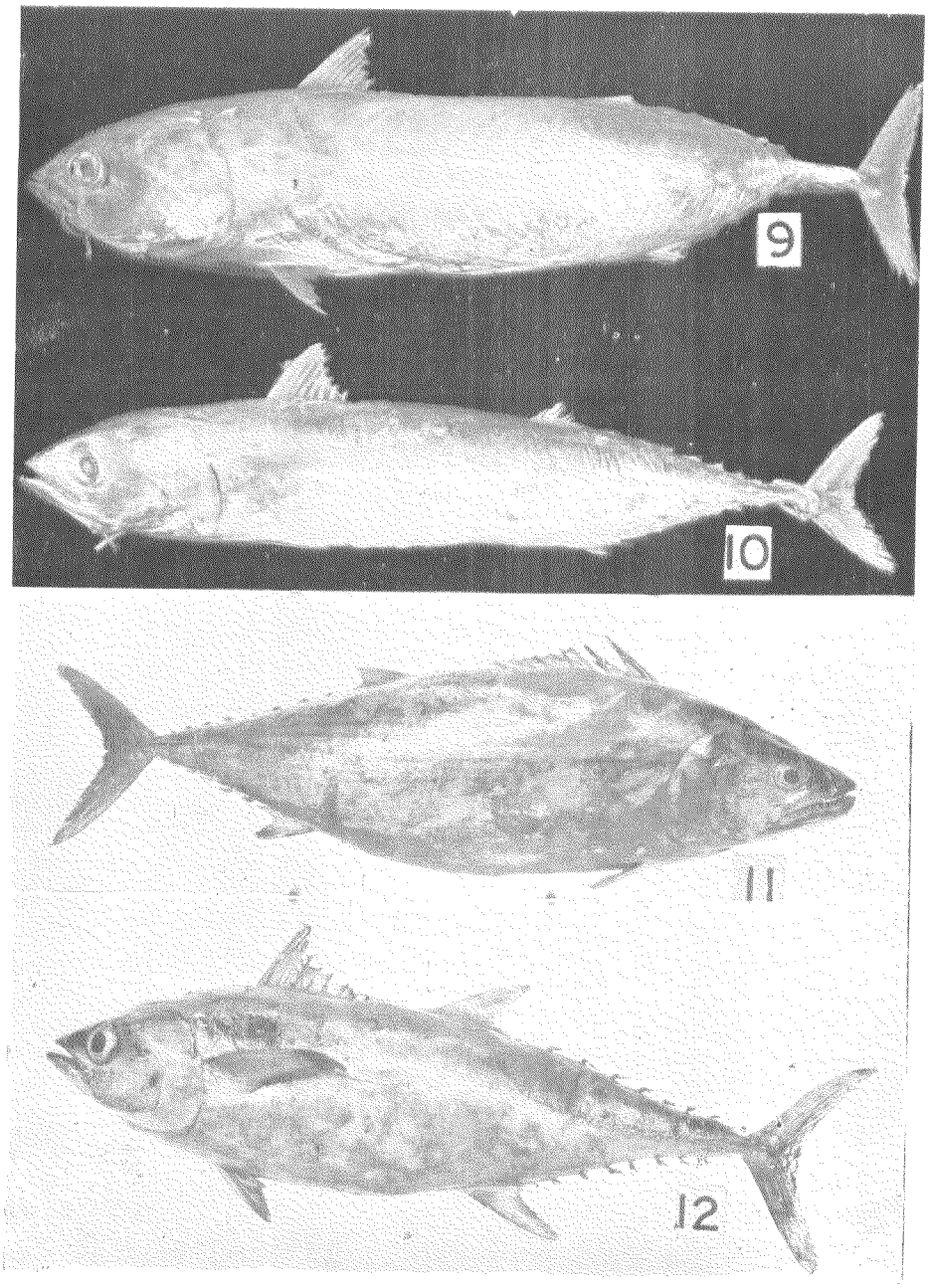


Fig. 9. *Auxis thynnoides* Bleeker, reg. no. 6049, 250 (274) mm, holotype. Fig. 10. *Auxis tapeinosoma* Bleeker, reg. no. 6050, 190 (215) mm, holotype. Fig. 11. *Pelamys orientalis* Temminck & Schlegel, reg. no. 2286, 490 (580) mm, lectotype. Fig. 12. *Thynnus macropterus* Temminck & Schlegel, reg. no. 2252, 620 (720) mm, holotype.

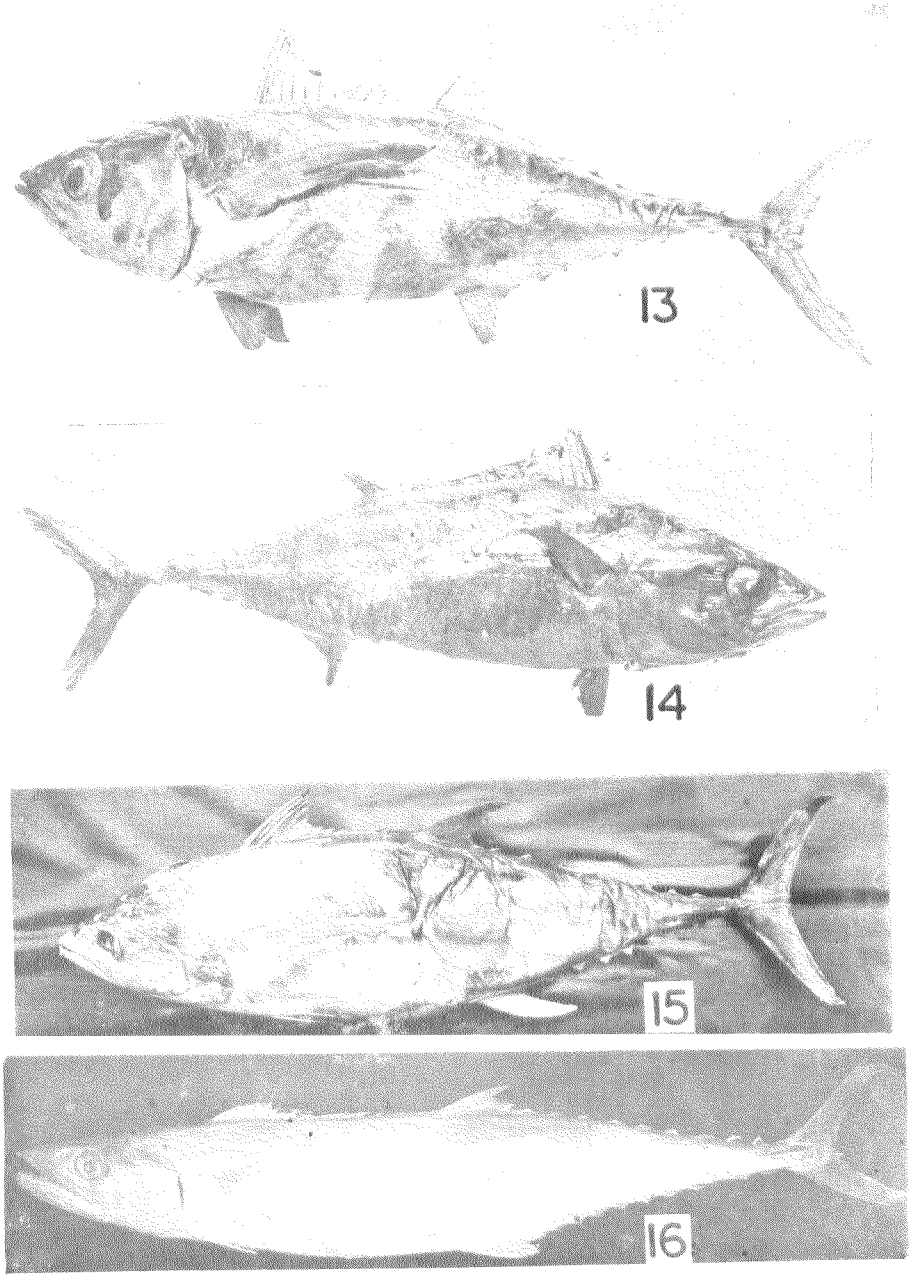


Fig. 13. *Thynnus sibi* Temminck & Schlegel, reg. no. 2327, 530 (635) mm, lectotype. Fig. 14. *Thynnus orientalis* Temminck & Schlegel, reg. no. 794, 420 (490) mm, holotype. Fig. 15. *Thynnus tonggol* Bleeker, reg. no. 6046, 703 (810) mm, neotype. Fig. 16. *Cybium konam* Bleeker, reg. no. 6051, 410 (490) mm, lectotype.

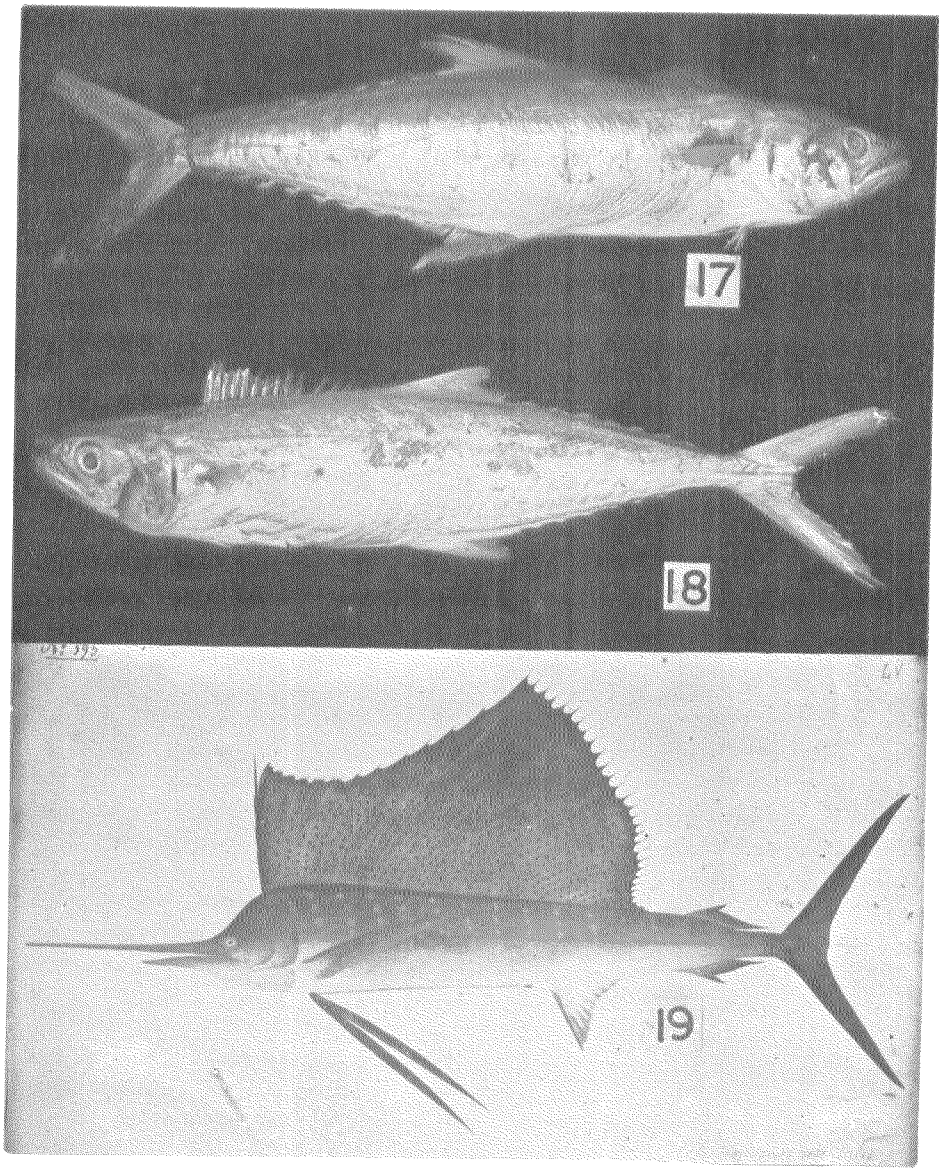


Fig. 17. *Cybium croockewitii* Bleeker, reg. no. 6054, 350 (425 +) mm, holotype. Fig. 18. *Cybium kuhlii* Cuvier, reg. no. 1239, 190 (225) mm, syntype. Fig. 19. *Histiophorus orientalis* Temminck & Schlegel, photostat copy of original Japanese plate made under supervision of H. Bürger, "iconotype" of the species.

DISTRIBUTION OF THE YOUNG STAGES OF THE MACKEREL, *RASTRELLIGER KANAGURTA* (CUVIER) IN THE INDIAN INSHORE WATERS *

BY

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The aim of this paper is to present a consolidated account of the information so far available both from the published and unpublished reports of different scientific workers on the periodical occurrence of the young stages of the mackerel, *Rastrelliger kanagurta* from the Indian inshore waters with a view to emphasising the importance of obtaining such additional information as would enable filling up certain lacunae which at present exist in our knowledge of the biology of the mackerel. If very young juveniles of the same size range occur in different seasons in different areas, as observed by several workers, it follows that the spawning activity of the adult mackerel, which has resulted in them, cannot be restricted to any one particular period all along the Indian coasts. The extent of diversity in the spawning behaviour of the mackerel from different regions is worthwhile investigating for it provides the basic information to determine the rate of recruitment of the year classes which enter the fishery. A study of the rate of growth of mackerel in the first and subsequent years of life needs immediate attention for a knowledge of this would help in fixing precisely the age of the young of any known size and tracing them back in the time scale to the spawning stocks. It is also necessary to initiate an ecological study to ascertain the relationship between the environment and the feeding habits of the mackerel in view of the very diverse opinions expressed as to whether the food of the species is determined in a general way by the availability of the edible planktonic elements or a specific selectivity is exercised by it at definite growth stages.

SIZE-FREQUENCY DISTRIBUTION OF THE MACKEREL WITH PARTICULAR REFERENCE TO THE OCCURRENCE OF JUVENILES AND THEIR FEEDING HABITS IN INSHORE WATERS

In the life-history of a fish, after the post-larva, the stage at which the young one is essentially similar to the adult is called the juvenile, which as the age advances is ascribed to the O-year class, 1-year class, 2-year class etc. When the young one attains the size of first sexual maturity it is known as the adult. The term juvenile is used here to mean a young fish. The minimum size at sexual maturity is known to be 224 mm.

Juveniles of *R. kanagurta* of very small size are occasionally obtained along with other fishes like the white-bait, silver bellies etc., in different types of gear ordinarily employed for commercial catches. The mackerel fishery of India is supported mostly by immature ones of about 170 mm and above which move in enormous shoals and are caught almost exclusively in bag nets, gill nets, boat seines etc. The smaller ones, however, do not in general appear in appreciably large schools in the inshore waters. They have been reported from the

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Arabian Sea off the coasts of Ratnagiri, Karwar, Mangalore, Cannanore, Calicut, Ernakulam and Vizhingam, from the Bay of Bengal off Madras and Visakhapatnam and from the Andaman Sea near Port Blair. The region-wise and length-wise distribution of the mackerel catches with notes on their biology are given below :

Ratnagiri: From Pawas a fishing village near Ratnagiri on the 24th September, 1959 young mackerel from 62 to 112 mm with two dominating groups 78 mm and 88 mm were obtained in the cast nets (George and Annigeri 1960). The feeding intensity of these was observed to be high and their stomach contents revealed diatoms, dinophysids, copepods and penaeid protozoeae. It was considered that the very young stages obtained in September were probably the result of spawning having taken place a few months earlier. From Myria Bay near Ratnagiri from 28th to 30th October, 1961, young ones from 108 mm to 151 mm with mode values at 125 to 135 mm were obtained in 'rampani nets' (Narasimham, 1962).

Karwar: Occasional stray specimens from the fishermen's catches measuring 83 mm and 95 mm on 17th April 1949, 144 mm to 154 mm on 24th April, 1953, 140 mm and 154 mm on 28th April, 1953, 172 mm to 188 mm on 7th May, 1953 and 130 mm and 170 mm on 23rd August, 1953 have been reported from Karwar (Pradhan 1956) in addition to the normally occurring individuals in different months of the year when they seem to show a definite pattern of distribution in size-groups *viz.* 120 mm to 240 mm groups averaging from 175 mm to 185 mm in October, 160 mm and still smaller groups gradually becoming less in the subsequent two months, 195 mm to 205 mm groups dominating in December-January, 195 mm to 205 mm, 215 mm to 225 mm groups dominating in succession in February and March, 200 mm to 250 mm groups with a sprinkling of 190 mm ones in April-May, 190 mm to 240 mm groups with dominating size at 225 mm in May and 200 mm to 260 mm groups in June to September. In the first half of September, mackerel from 120 mm to 160 mm have been known to be common. It may be noted that the fishery lasts from about October to March and the spawning season of the species along the coast from June to September.

From Pradhan's findings for the period 1948—1953 there is an indication that the younger groups contribute to the major portion of the catch in the mackerel fishery. Radhakrishnan (1958) has given the length frequency distribution of the catches, which show that the groups from 170 mm to 219 mm constitute over 52% of the total in 1954-55 and those between 140 mm and 219 mm to the extent of over 76% in 1955-56. The month-wise composition of the mackerel catch at Karwar for 1955-56 season given by him shows that 140 mm to 220 mm groups constitute 96.7% of the total in October, 170 mm to 200 mm groups 77% in November and 200 mm to 220 mm groups 39% in February and 49% in March.

Regarding food of mackerel from the Karwar coast in general, Pradhan (1956) states that they feed both on phytoplankton and zooplankton. Common among the phytoplanktonic elements are *Coscinodiscus, Rhizosolenia, Biddulphia* etc., and among the zooplanktonic elements are copepods, Lucifer, crustacian larvae and molluscan larvae. Occasionally some fish eggs are encountered, forms like chaetognaths, spionid larvae, stomatopods, hydromedusae, ctenophores and salpae are rarely recorded and *Noctiluca* is conspicuously absent from their stomach contents.

Malpe and nearby places, north of Mangalore between Baikampady and Tarapathy in South Kanara district, Mysore State: Sekharan's (1958) data on the age composition of the catches for 1954-55 and 1955-56 mackerel seasons for the area show that the fishery draws

its support mainly from single age-group consisting of 180 mm, 190 mm and 210 mm groups. The modal values in 1954-55 season from November to March are 185 mm, 195 mm, 215 mm, 225 mm and 225 mm for the respective months. From the analysis of the size frequency data for the South Kanara coast and from the data collected by the Madras Fisheries Department at West Hill he concludes that the mackerel attains a total length of 120 mm to 150 mm at the end of the first year and 210 mm to 230 mm at the end of second year. It may be pointed out here that Pradhan's (1956) estimation is that the species attains 100 mm at the end of the first year and 180 mm or more after completing the second year.

In the material collected in 1954-55, Sekharan found that the gonads were immature in stages I and II in November and December and in the maturing stages III and above in the following months. They were in stages III and IV in February and in a very advanced state of maturity in March, probably in stage V and some with a few transparent eggs which oozed out readily when the abdomen was slightly pressed. A study of the ova-diameter measurements for the period December to April in 1955-56 confirmed the observations he made earlier. It has therefore been concluded that the spawning commences in March or April, although the height of the breeding activity may occur later.

Ullal near Mangalore: In September 1961 mackerel obtained in the fishery ranged from 155 mm to 209 mm with one dominant mode at 185 mm - 189 mm. In the southern centres smaller ones from 65 mm to 169 mm with two modes between 80 mm-84 mm and 150 mm-154 mm comprised the catches. At Ullal in the catches by rampanis 180 mm-184 mm group dominated in October-November and 170 mm - 174 mm group in December and in those by castnets 110 mm - 114 mm group in December.

Copepods formed the main item of food. In October mackerel in stage VIa and VIb were landed in considerable numbers (*Quart. Sci. Rept., C.M.F.R.I.* Sept. and Dec. '61).

Cannanore: From July to September 1961 the mackerel fishery was supported mainly by individuals of larger sizes between 196 mm and 245 mm to the extent of about 98% the rest being composed of smaller individuals between 95 and 105 mm. The intermediate sizes commonly met with in the fisheries were absent. In October to December '61 the size range was between 102 mm and 195 mm with 175 mm - 185 mm group dominating.

The maturity stages of the adults obtained in the fishery for the six months period commencing from July were in IV to VII; in October they were in stages V to VII with VI b and VII dominating and by November all were in stage VII. The occurrence of individuals in maturity stages of V and VI b as late as in October indicates that the spawning has extended beyond the usual period from June to September. The feeding intensity was found to be high in July but low in about September, the mackerel feeding on copepods ostracods, pteropod larvae and *Bacillariophycae*. In October and November they were feeding on equal amounts of phytoplankton and zooplankton but in December, more on phytoplankton.

Calicut: Mackerel measuring 40 mm to 70 mm with a modal size at 60 mm were observed in June 1940 (Madras Fisheries Administrative Report for 1940). Bhimachar and George (1952) noticed 100 mm to 130 mm individuals in July and 56 mm to 80 mm ones in August 1949. The size frequency dtstribution of the mackerel which appear in the fishery follow more or less the same pattern as in other nearby northern centres on the west coast.

Chidambaram *et al.* (1952) have divided the mackerel season broadly into three periods *viz.*, (i) July to September when fish of all sizes appear in the inshore waters, (ii) October to

January when mostly those of intermediate sizes constitute the catches and (iii) February to the end of the season in about April when fish of larger sizes of 190 mm and above only occur. For 1949-50 season they reported the occurrence of mackerel of 135 to 152 mm in July, 60 to 245 mm (with mode values at 80, 130, 150 and 200 mm) in August, 100 to 200 mm (110, 140 and 200 mm) in September, 170 to 200 mm (180 mm) in October, 140 to 200 mm (150 and 195 mm) in November, 160 to 200 mm (180 mm) in December, 190 to 210 mm (210 mm) in January, 190 to 210 mm (200 mm) in February, 200 to 230 mm (220 mm) in March and 200 to 250 mm (215 mm) in April.

In the following account are given the size ranges of mackerel from particulars available in the quarterly Scientific Reports of the C.M.F.R.I., June-December, 1961. The size ranges in April and May 1961 were 213 mm to 230 mm and 218 mm to 231 mm respectively and these should be regarded as members comprising the fishery of the later part of 1960-61 season. In 1961-62 the mackerel fishery has been a failure all along the west coast and the season at Calicut commenced in the last week of August when a very small catch of individuals from 62 mm to 105 mm with a modal size of 85 mm were obtained in the boat-seines. In September the catch was represented by two distinct groups, one ranging from 124 mm to 154 mm with a modal size of 145 mm by gill nets (Aila chalavala) and the other ranging from 181 mm to 238 mm with a modal size of 225 mm by boat-seines (Paithuvala). The catches ranged from 157 mm to 187 mm with a modal size at 165 mm in October, 155 mm to 187 mm with a dominant size of 175 mm in November and 165 mm to 186 mm with a modal size at 175 mm in December.

Bhimachar and George (1952) have observed that the mackerel are exclusively plankton feeders, depending mainly on "copepods, cladocerans, larval and adult decapods, peridinians, diatoms and to some extent on post-larval bivalves, fish eggs and larvae, polychaete larvae, cirrepede nauplii, appendicularians and pteropods". The non-edible forms like salps, medusae, stomatopod larvae, chaetognaths and *Noctiluca* are avoided. A low feeding intensity has been observed in the pre-spawning and spawning periods and no difference between the food of the young and adults has been noticed. Feeding intensity in juveniles of 160 mm-200 mm range was found to be the highest in September to December when the inshore waters are rich in plankton.

In July to September period of 1961 in Mackerel measuring from 72 mm to 226 mm copepods formed the major portion of the stomach contents along with some decapod eggs and larvae and in a few cases with fish eggs. Phytoplankton also constituted their food, represented by *Ceratium* and *Coscinodiscus*. In October to December '61 in mackerel of 159 mm to 183 mm copepods formed the main item of the food; crustacian eggs, zoeae, bivalve larvae and *Pleurosigma* were present to some extent; fish eggs in a few (in October) and fish scales in large numbers (in December) were also noticed in the stomach contents (Quart. *Sci. Report, C.M.F.R.I.*, Sept. Dec. 1961). Chidambaram *et al.* (1952) have noticed a high fat content in two periods, October-November and March-April and this has been correlated with the greater feeding intensity in the preceeding months. In the larger size groups the higher fat content has been attributed also to the relatively greater gonadal development before the spawning season.

Regarding the breeding periodicity of mackerel along this coast, Devanesan and John (1940), Devanesan and Chidambaram (1948) and Chidambaram *et al.* (1952) have stated that spawning commences in about April, May or June and lasts till September.

Vizhingam: Balakrishnan (1957) has furnished an account of the occurrence of spawners and juveniles of mackerel along the region for the periods of March to August of 1955 and 1956. The adult mackerel of 220 mm to 240 mm groups obtained in March-April months were mostly with ripe gonads and some with spent gonads, indicating that spawning had already commenced. In the subsequent months till July the percentage of individuals with spent gonads increased in the samples examined. In plankton hauls made during the period, what could possibly be considered as mackerel eggs were observed. Very young stages of mackerel 27 mm to 50 mm were obtained in March, 1955. The size range of young ones (dominant size group within brackets) were 70 mm to 160 mm (150 mm) in March, 40 mm - 150 mm (110 mm) in April, 30 mm to 140 mm (40 mm) in May, 30 mm to 130 mm (70 mm) in June, 60 mm to 180 mm (120 mm) in July and 100 mm to 160 mm (130 mm) in August, 1956.

The size ranges of the mackerel in the fishery during 1961 are 60 mm to 270 mm with dominant size of 135 mm for the juvenile group and 225 mm for the adult group in April to June, 40 mm to 240 mm with only one mode at 130 mm in July to September, and two distinct groups one from 35 mm to 140 mm with modes at 60 mm and 120 mm and the other from 195 mm to 240 mm with a mode at 230 mm in October to December.

From July to September, phytoplankton formed the major item of food whereas in the earlier and subsequent quarters copepods and other crustaceans dominated (*Quart. Sci. Rep. C.M.F.R.I.*, for June–Dec. 1961).

Ernakulam: As compared with other regions mentioned above, the fishery here is confined to backwaters and is of moderate magnitude. The dominant sizes or the size ranges, monthwise for the year 1960 and 1961 are given in the following table:—

Month	Dominant size or size range in 1960 (in mm.)	Dominant size or size range in 1961 (in mm.)	Month	Dominant size or size range in 1960 (in mm.)	Dominant size or size range in 1961 (in mm.)
January ...	...	210	July ...	130	...
February ...	...		August ...	160	...
March ...	...		September ...	190	110 & 180 (90-210)
April ...	210	210–230	October ...	200	180
May ...	210 & 110–150	200–220	November ...	200	(150–210)
June ...	...	200–230	December	210	150–210

Examination of the gonads of the adult mackerel had shown spent-resting condition from January to March but in one female in March spent condition with a few large residual eggs was noticed. In general feeding intensity was moderate in April to September and active from October to March; copepods, tintinnids, fish larvae, bivalvae larvae, *Fragilaria* sp, *Coscinodiscus*, dinoflagellates and diatoms formed its food. In October mackerel of 150 mm to 160 mm in length were found to feed mostly on post-larval fishes. In July to September period fish scales were often found in the stomach contents (*C M.F.R.I. Annual Report* 1960–61 and *Quart. Rep.* for April–Dec. 1961).

Madras: As compared with the mackerel catches on the west coast of India, those on the east coast are very poor comprising only about 20% of the total landings even in the best of the years when the fisheries are good (Pradhan and Rao 1959). Landings of some magnitude have been in recent years reported from Mandapam, Madras, Kakinada,

Visakhapatnam and some parts of Orissa. The appearance of the shoals is erratic and no size frequency data are available to show variation in catch composition from season to season. In the following account are dealt with the size ranges of small mackerel obtained from the fishermen's catches in certain months.

Rao and Basheeruddin (1953) reported for the first time from the east coast of India the occurrence of small juveniles of mackerel in the inshore waters of Madras, ranging from 49 mm to 103 mm with a dominant size at 89 mm. Along with these, three other groups *i.e.* 130 mm to 170 mm, 190 mm to 210 mm and 220 mm to 240 mm individuals were also obtained in the seine-net catches. It is of interest that the occurrence of juveniles of about 50 mm or slightly above in March-April months on the east coast after the north-east monsoon is similar to almost the same size groups being very commonly found along the west coast about the close or immediately after the south-west monsoon.

Basheeruddin and Nayar (1962) recorded in 1954 juveniles of 130 mm to 150 mm (135 mm) in March, 40 mm to 120 mm (70 mm) in April, 40 mm to 60 mm (50 mm) in May and in 1955, 50 mm to 110 mm (90 mm) in February, 40 mm to 100 mm (80 mm) in March, 40 mm to 120 mm (80 mm) in April, 110 mm to 140 mm (130 mm) in June and 90 mm to 170 mm (110 mm) in July. In respect of the food of the juveniles they have noted predominantly phytoplanktonic organisms with fair amounts of small zooplanktonic organisms in individuals upto 80 mm ; post larval fishes, stomatopod larvae, and other crustaceans with very little of phytoplanktonic organisms in those between 90 mm and 100 mm and crustaceans like advanced zoeae, *Acetes* and copepods along with fair amounts of phytoylanktonic organisms in those above 100 mm in total length.

Kuthalingam (1956) has given an account of the food and feeding of the mackerel at different growth stages. According to him the "post-larvae" from 5 mm to 6 mm feed on diatoms and filamentous and other types of algae, but when they grow into " juveniles ", they become omnivorous feeding on all available, edible planktonic organisms ; the " adults " are carnivorous feeding on post-larval and juvenile bony fishes. The terms " juveniles " only to those upto about 25 mm and "adults" to all from 35 mm upto 225 mm in length as applied by the author based on the material he examined are not in confirmity with the generally accepted definitions (Hubbs, 1943; Jones, 1950).

Visakhapatnam: Rao and Basheeruddin (1953) recorded juvenile mackerel from 100 to 140 mm in the month of June of both the years 1951 and 1952. Satyanarayana (1955) observed in 1954 juveniles from Lawson's Bay measuring 57 mm to 90 mm (65 mm) on 5th May, 68 mm to 121 mm (85 mm) on 24th May and 48 mm to 75 mm (55 mm) on 4th August.

Rao and Rao (1957) have studied the food habits of the mackerel from 32 mm to 243 mm in length occurring along the coast and found that in those from 32 to 90 mm, post-larval fishes formed the staple food along with some amounts of lucifers, copepods and protophyta; in those above 90 mm relatively very little of zooplankton constituted their food. They also observed that the relative growth of the alimentary canal is greater in the adults than in the juveniles and that the change in the food habits is closely associated with the relatively greater increase in the alimentary tract as the fish grows to reach the adult stage.

Port Blair (Andaman Sea): In January 1961 from the Jungleghat area near Port Blair a few small mackerel of about 50 mm in total length were obtained. Subsequently (Rao & Luther 1961) in the middle of March for a few days a large number, nearly 800 individuals,

ranging from 58 mm to 100 mm with a modal length of 74 mm were collected from the drag-nets operated in the Phoenix Bay. The stomach contents revealed copepods, polychaete remains, fish scales, diatoms as *Pleurosigma* and *Coscinodiscus*, some filamentous blue-green algae, unrecognisable green pulpy matter and fairly often detritus and sand grains. The condition of the feed was poor as the stomach contents in a majority of the individuals showed food items only in traces. The young ones in the sample after careful examination have been ascribed to *R. kanagurta*. Dr. Jones of the Central Marine Fisheries Research Institute has informed the writer that in the Andaman Sea, *R. brachysoma* also occurs and that it is worthwhile finding out differences if any in the periodical occurrence of the juveniles of the said two species.

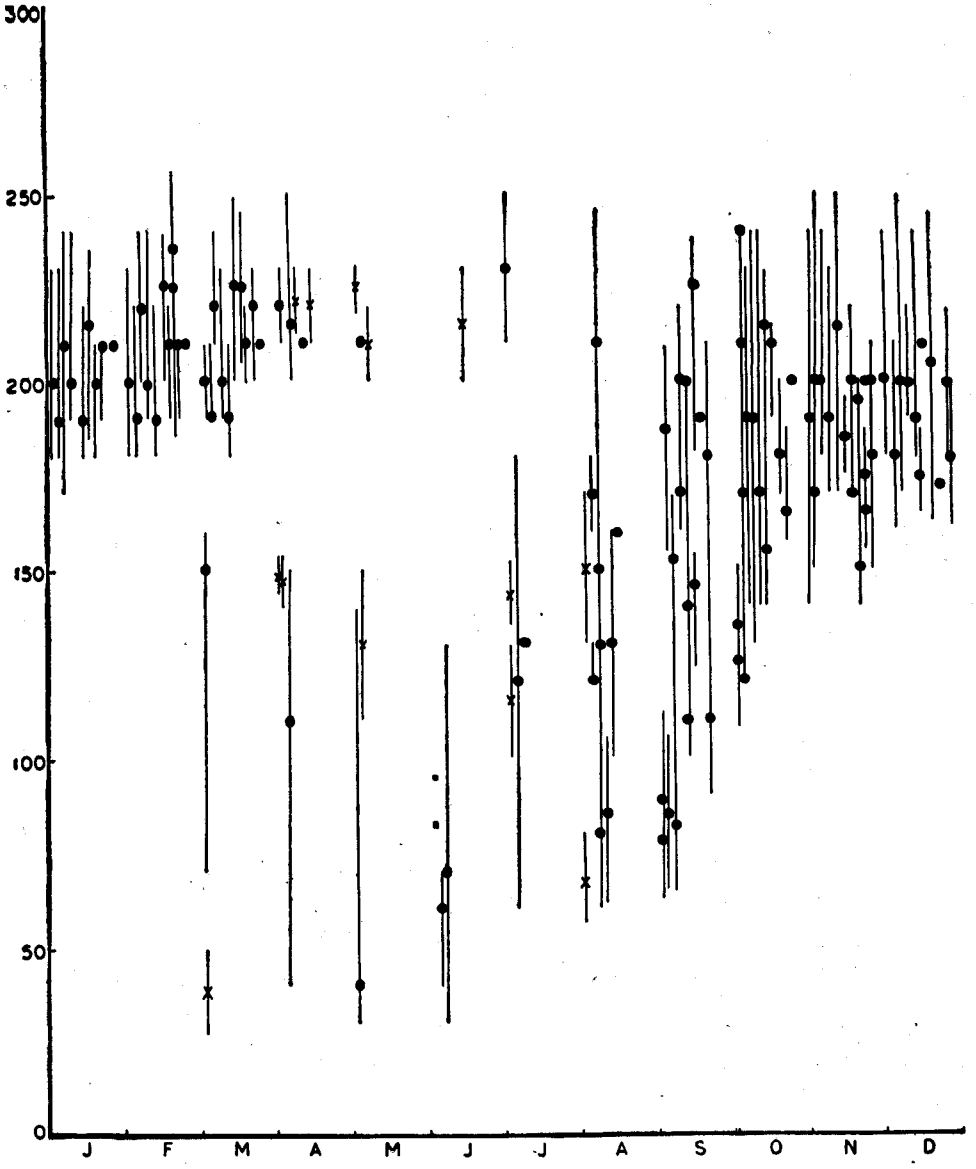
Growth of the Year Classes and Spawning Periodicity

The monthwise size frequency of the mackerel landed as gathered from the foregoing account has been shown in text figures 1 to 3, separately for the west and the east coasts of India. The data of a number of years have been treated together so as to obtain a fairly clear idea as to the probable trends in the spawning periodicity of the mackerel by tracing back the modal values of the population occurring in different months from the very older groups to the youngest ones on record.

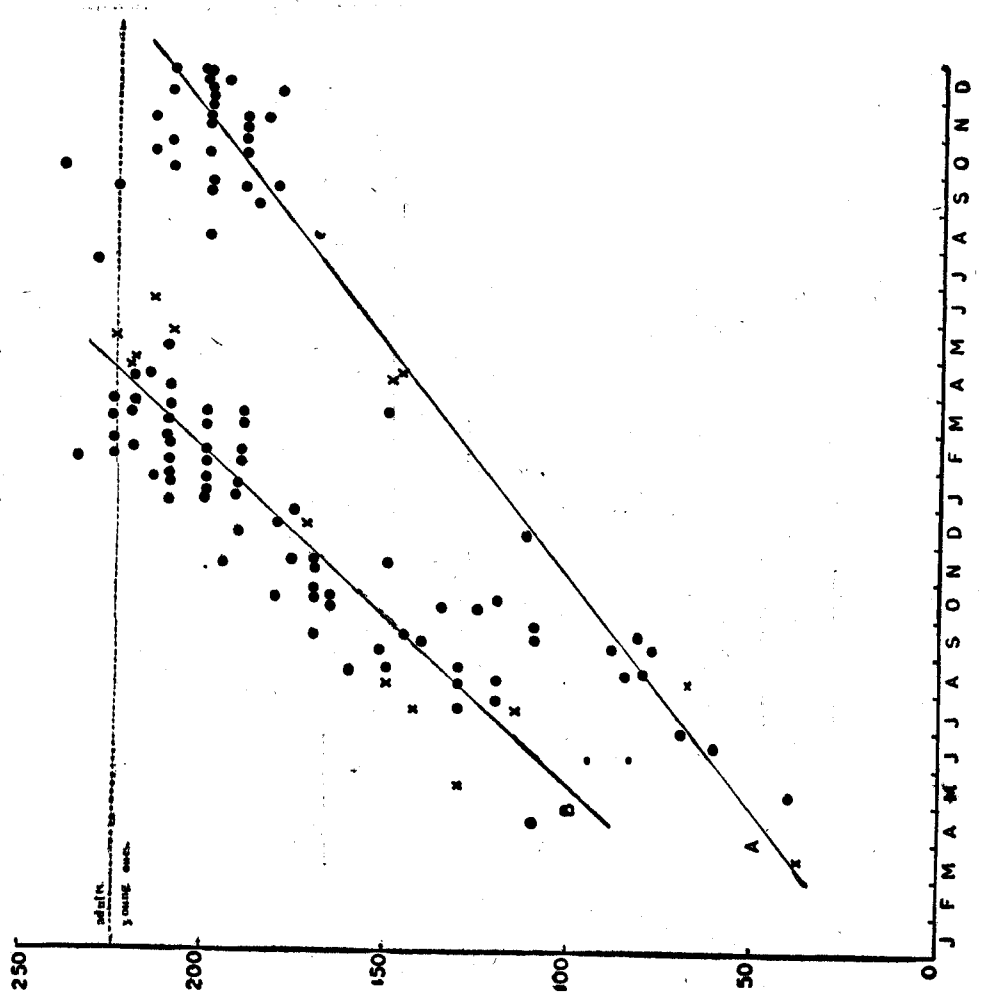
In respect of the data on the west coast in text figure 1 are shown the size ranges of different groups occurring in each month; their modal values are represented by solid circles; where the latter are not known the mid-points in the ranges are marked by crosses; and where isolated individuals only are on record they are shown by small dark solid squares. With figure 1 as the basis, figure 2 is drawn up omitting the size ranges and taking only the modal values or the mid-points of the ranges; and the higher groups, which appear along with the smaller ones in the same months, are shown separately in the corresponding months of the following year to obtain a continuity of the modal shift to trace the growth rate of the year classes. As may be seen from the figure, there appear to be two distinct groups of young ones 'A' and 'B' entering the inshore waters in different periods of a year. A freehand line passing close to the modal values or the mid-points to each one of the groups has been fitted to trace the course of the juvenile groups to the adult ones.

According to Sekharan (1958) as cited earlier the mackerel attains a size of 120 to 150 mm after completing one year and 210 to 230 mm after the second year. On this assumption the individuals of the lot 'B' in the months of July-August showing mode values of 120 to 160 mm are just one year old and are therefore the result of spawning that should have taken place in about the same months of the previous year. There is a gradual shifting of the mode values in this group in the subsequent months *viz.*, to 140 to 170 mm in September, 165 to 180 mm in October, 150 to 195 mm in November, 170 to 190 mm in February, 190 to 225 mm in March and 210 to 220 mm in April. The modal size remains more or less the same in May and it is difficult to follow this group thereafter as the catches seldom show adults of 230 mm and above. As indicated by the extension of the line representing this group the members are expected to attain a modal size of about 240 mm by July-August when they complete the second year of their life.

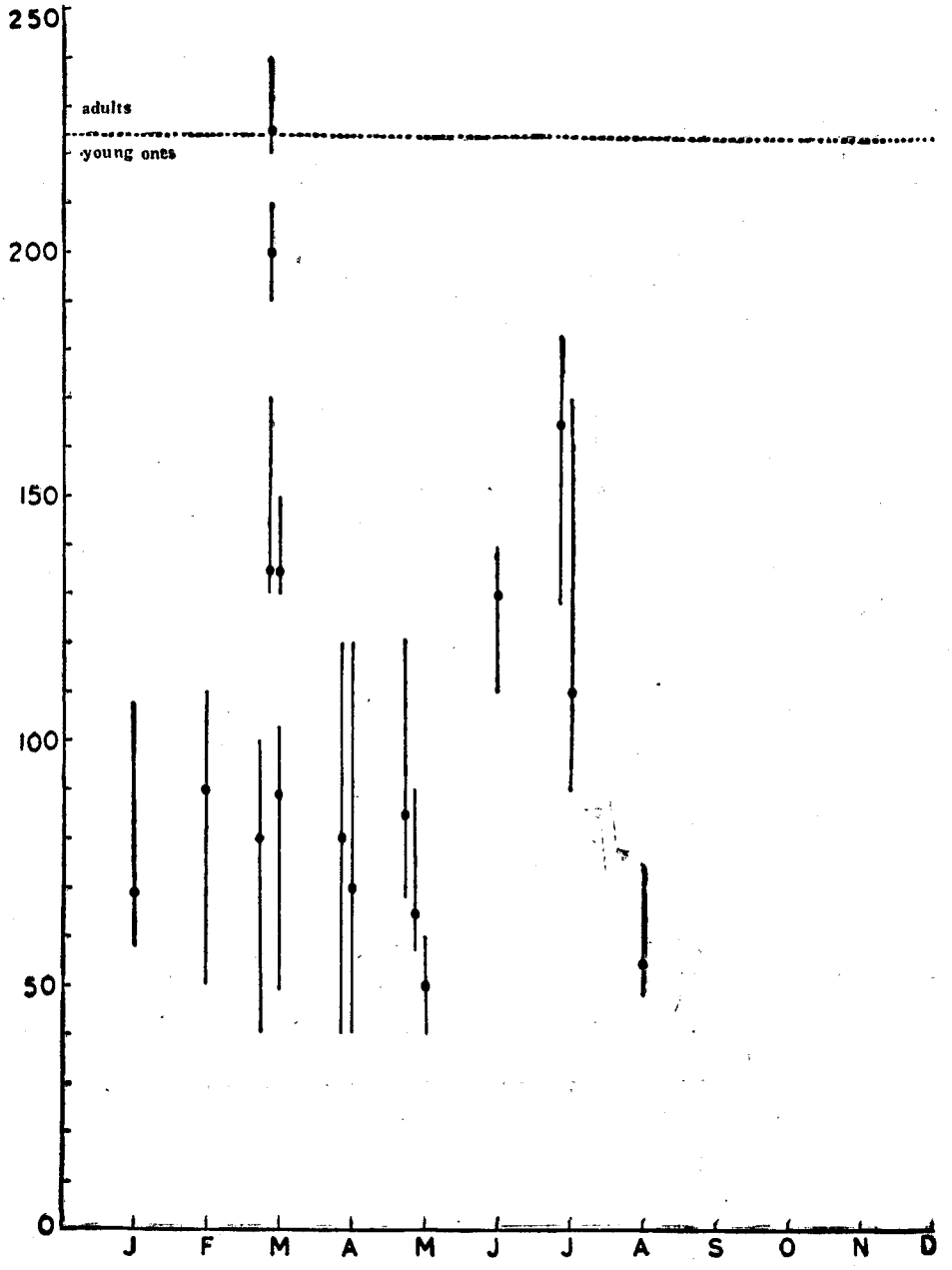
That in the months of July-August spawning takes place in mackerel is supported by the findings of several workers as already stated. Hornell (1910) observed "On the West Coast mackerel are found with fully developed roe in June-July and August; the bulk of spawning occurs at the end of July and beginning of August". However, that there is also



Text Fig. 1. Size-Frequency Distribution of the Mackerel, *Rastrelliger kanagurta* along the West Coast.



Text Fig. 2. Size-Frequency Distribution of the Mackerel *Rastrelligen kanagurta* along the West Coast.



Text Fig. 3. Size-Frequency Distribution of the Mackerel, *Rastrelliger kanagurta* along the East Coast.

a supplementary or late spawning period in mackerel in about November-December is evident from the following account:—

The second lot of individuals under 'A' shows a mid-value of the range at 38 mm in March and a mode value of 40 mm in May. The corresponding values in the subsequent months are 62 mm to 70 mm in June, 78 to 88 mm in September and about 112 mm in December of the same year. In the following year the respective values are 150 mm in March, 170 to 200 mm in August, 180 to 225 mm in September, 190 to 215 mm in October, 185 to 215 mm in November and 180 to 210 mm in December. As two-year old mackerel are between 210 mm and 230 mm according to Sekharan, the occurrence of about this size range of individuals in November-December, traceable through younger individuals in earlier months is suggestive of their being the result of spawning two years earlier. Sekharan's data reveal an average growth of 10 to 12 mm per month when the mackerel are in their first year and on this assumption too the recorded occurrence of mackerel between 27 and 50 mm with a mid-value range at 38 mm in March (Balakrishnan's data 1957) is traceable to spawning at about the end of December. It may be mentioned in this connection that George *et al* (1959) had observed adult mackerel from the Netravati estuary showing partially spent gonodal condition during the period of the fishery commencing from January 1958 indicating presumably spawning having taken place about January. The occurrence of maturity stages of V and VI b in mackerel examined from Cannanore area in October 1951 (*Quart. Sci. Rept. CMFRI* for Dec. 1961) is also indicative of either a supplementary or very late spawning in November-December period.

Although the main spawning is about July-August followed by a supplementary spawning as explained above, yet from the wide scattering of the mode values in between 'A' and 'B' there appears to be some intermittent spawning. As stated by Pradhan (1956) the Indian mackerel like the European species *Scomber scombrus* seems to spawn in succession over a prolonged period liberating each time a small number of eggs. The range of the spawning period in *Rastrelliger kanagurta* is not yet fully understood. It is stated to extend from June to September (Devanesan and John 1940) or from May to September (Chidambaram and Venkataraman, 1946) or from March to September (Sekharan, 1958). In the light of a few findings in recent years, the period of spawning seems to be yet more prolonged, probably extending upto December.

The size frequency data of the mackerel on the east coast of India are too meagre to draw any definite conclusions ; yet it may be seen that juvenile mackerel falling within the range of 40 to 100 mm from Madras and Visakhapatnam occur from February and occasionally upto July. Mackerel coming within the range appeared in Port Blair region in the months of January to March. On the west coast of India, the mackerel of this range occur mostly from July to September in all the observation centres except in Vizhingam where the dominant sizes observed were 40 and 70 mm in the months of May and June respectively (Balakrishnan, 1957). Thus the distribution of juveniles in time and space seems to indicate that the period of spawning of the mackerel differs in different regions in the inshore waters.

Assuming a rate of growth of 10 to 12 mm a month, the occurrence of mackerel of modal size of 89 mm in March-April is traceable to spawning in about October; similarly those of modal size of 70 mm in April to spawning in November and those of modal value of 50 mm in May to spawning in December (Data from Rao and Basheeruddin, 1953 and Nayar, 1962). Possibly therefore the intensive spawning season is about October to December

on the east coast. Satyanarayana's data (1954) show mackerel of modal size of 55 mm in August and these, on the basis of the same rate of growth, should have resulted from spawning in April. Unless we have more data on the size frequency measurements and sexual maturity stages of mackerel from this coast for a continuous period of a few years, it is difficult to say with certainty whether there is a single period of spawning from October to April or more than one spawning period.

In Ceylon small juveniles of *Rastrelliger* are encountered annually in about April onwards on the southern coast and occasionally again in about September (de Zylva, 1956 *). It is possible that as in Ceylon on the east coast of India there are two distinct broods of juveniles entering the inshore waters during the same year.

One point of interest to note is in regard to the location of the spawning grounds. From the occurrence of the spawners in the usual fishing grounds, the eggs and early stages of development in the plankton hauls from Vizhingam to Cape Comorin, Balakrishnan (1957) observes that the spawning grounds are about this region on the west coast of India. Observations on the east coast of India (Kuthalingam, 1956) point out to the presence of similar spawning grounds in the Madras inshore area.

SUMMARY

1. Small juveniles of *Rastrelliger kanagurta* have been known to occur periodically in the inshore waters and are reported from several places off the coasts of the Arabian Sea, the Bay of Bengal and the Andaman Sea.
2. The region-wise and lengthwise distribution of the catches obtained in the mackerel fisheries at various centres with notes on the biology of the species is given.
3. A careful study of the length-frequency distribution of the mackerel on the west coast of India revealed that two distinct groups of young ones enter the inshore waters in different periods of a year.
4. On the west coast intensive spawning appears to take place in about July-August followed by a supplementary spawning in November-December. However, there seems to be also intermittent spawning in between the two periods. The exact period of spawning is not definitely understood, but from the available data it appears to commence from the end of March and extend upto December.
5. On the east coast of India spawning appears to commence by about October. A second spawning period is also likely to occur in about April.
6. There appear to be good spawning grounds in the inshore waters off Vizhingam on the west coast and off Madras on the east coast. There may be similar spawning grounds of mackerel in yet other places but we have as yet no knowledge of them.
7. An analysis of the stomach contents of the juvenile mackerel from different coastal regions shows that there is no uniformity in their feeding habits. In general the juveniles are plankton feeders like the adults, but the proportion of the phytoplanktonic to zooplanktonic elements has been reported by some workers

* de Zylva, E.R.A. 1956, *Rastrelliger* (MS) as referred to by Rosa, Jr. H. 1956.

to vary at different stages of growth. The juveniles occasionally feeding on post-larval fishes exhibit a carnivorous tendency.

The writer expresses his gratitude to Dr. S. Jones, Director of the Central Marine Fisheries Research Institute for according permission to make use of the data available in the departmental reports and for offering his encouragement in the presentation of this paper. The writer is also thankful to his co-workers in the Institute who made available unpublished information based on their own observations.

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DISTRIBUTION OF LARVAL BILLFISHES (XIPHIIDAE AND ISTIOPHORIDAE) IN THE INDO-PACIFIC WITH SPECIAL REFERENCE TO THE COLLECTIONS MADE BY THE DANISH DANA EXPEDITION*

BY

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INTRODUCTION

The life history and biology of billfishes have been engaging increasing attention of fishery workers in recent years primarily owing to the potential importance of this group of fishes in the development of oceanic fisheries. Of the two families, Istiophoridae and Xiphiidae comprising the billfishes, the taxonomy of the former is still in a state of confusion while the latter comprise of only a single species *viz.*, *Xiphias gladius* which is widely distributed in the Pacific, Indian and Atlantic Oceans. Five species of istiophorids *viz.*, *Istiophorus gladius*, *Tetrapturus angustirostris*, *Istiompax indicus*, *Makaira mazara* and *Makaira audax* are definitely known to occur in the Indo-Pacific. Larvae of all these have been reported, mostly from the Pacific by Japanese workers, while the records from the Indian Ocean are comparatively few.

The present study is mainly based on the larval specimens collected from the Indian and Pacific Oceans by the Danish *Dana* Oceanographical Expedition of 1928–30. In all 144 specimens obtained from the Indo-Pacific have been studied. Some of the specimens were in a damaged condition and so specific identification was not possible. All available information about the distribution of larvae given by other workers is also incorporated in this article. A recent report of special interest is the one on collections made by the *Vityaz* from the Indian Ocean during her 31st cruise (Bogorov and Rass 1961) but detailed information is not available about the species collected. Though as stated before, the taxonomy and validity of certain species are in a state of confusion, we have used the latest accepted names for the species occurring in the Indo-Pacific. Observations are so scarce that it is not possible to delimit the spawning areas and the season of spawning. Charts showing the distribution of larvae of all species together with the surface isotherm for 24°C are given.

DISTRIBUTION

Istiophorus gladius (Broussonet)

Common synonyms

Scomber gladius Broussonet

Istiophorus immaculatus Rüppell

Istiophorus (*Histiophorus*) *orientalis* Temminck and Schlegel

Istiophorus greyi Jordan and Hill

It would appear that the sailfishes of the Indian and Pacific Oceans comprise only of a single species and as such the name *Istiophorus gladius* has priority over any other name proposed for the sailfish of this region.

* Papers from the *Dana* Oceanographical Collections No. 50.

Distribution

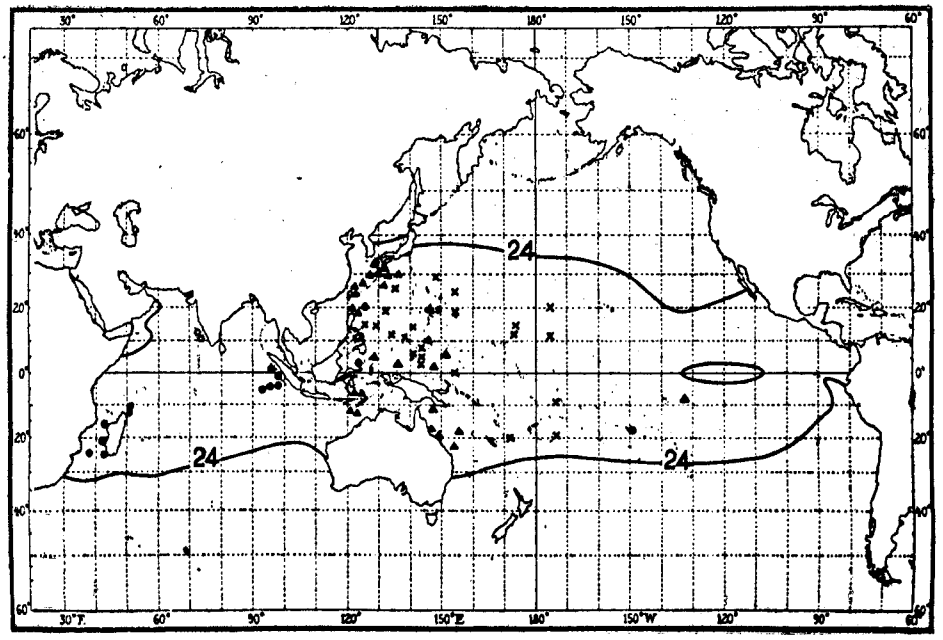
I. gladius is widely distributed from the coast of Union of South Africa and across the entire Indo-Pacific to the coast of California in the north to Peru in the south.

Distribution of larvae

LaMonte and Marcy (1941) described a specimen of 16.5 mm. in length collected from the Eastern Pacific. Bebe (1941) also has figured a juvenile sailfish obtained from the Eastern Pacific. Based on the collection of 28 larval specimens and distribution of mature individuals Yabe (1953) infers that spawning occurs south-west of Kyushu and near Riu Kiu Islands. All the areas of capture of larvae are within the influence of the Kuroshio current and hence it was presumed that the larvae were carried towards the north by the current. According to Yabe (*op. cit.*) spawning is extended over a long period but the main season is from May to July. Larval istiophorids were collected from the Central and Western Pacific by the *Vityaz* Expedition in 1957-58. Most of the smaller specimens were collected during February-March and in December. On the basis of distribution of these larvae Sun Tsi-Zhen (1960) observes that swawning takes place in the full winter season.

From the Laccadive Sea 17 larvae were collected in the month of February and one in April (Jones, 1959*a*). One juvenile measuring 432 mm. was collected from the Laccadive Sea in April (Jones, 1959*b*). The juvenile sailfish measuring 127 mm. collected from Ceylon was also in April (Deraniyagala, 1936). As collections from this area have not been made during other months nothing further could be said about the spawning of the fish.

The research ship *Dana* during her voyage in the Indo-Pacific collected 55 larvae of I. *gladius* of length 3.82—21.75 mm. of which all except three were from the Indian Ocean. Areas of capture of larvae are plotted in Fig. 1. It can be seen from Table 1 that from the



Text Fig 1.—Records of capture of larvae of *Istiophorus gladius*. ● Dana collections, × Vityaz, ○ Indian collections, ▲ Japanese collections.

TABLE 1

Details of collection of sailfish (*Istiophorus gladius*) larvae by *Dana* Expedition from the Indo-Pacific

Station No. (1)	Date (2)	Position (3)	Surface temperature (4)	No. of specimens (5)	Size range in mm. (6)	Depth of capture (7)
3576 VI	17—10—28	17°36.5′ S 149°43.6′ W	...	1	6.03	Ca. 100–200
3718 IV	20—5—29	20°04′ N 123°59′ E	28.6	1	7.86	Ca. 30
3739 III	2—7—29	3°20′ N 123°50′ E	28.3	1	10.48	Ca. 100–200
3823 I	15—9—29	1°10′ S 97°53′ E	...	2	4.24 & 21.75	Ca. 50–70
3824 VIII	Do.	0°08′ S 97°15′ E	28.4	1	4.87	0—Ca. 20
3828 XVIII	18—9—29	1°22′ N 96°06.5′ E	27.8	1	5.76	Ca. 30
3828 XIX	Do.	Do.	27.8	3	3.82—7.61	0—Ca. 20
3850 III	14—10—29	6°01′ S 93°12′ E	27.5	2	4.60 & 4.76	Ca. 50–70
3850 IV	Do.	Do.	27.5	1	4.92	Ca. 50–70
3854 III	16—10—29	5°31′ S 96°35′ E	...	3	6.39—10.48	Ca. 50–70
3854 IV	Do.	Do.	...	2	4.35 & 6.28	Ca. 30
3856 III	17—10—29	4°45.5 ′S 98°28′ E	...	7	4.87—9.06	Ca. 50–70
3856 IV	Do.	Do.	...	8	4.24—7.17	Ca. 30
3860 XVIII	18—10—29	2°57′ S 99°36′ E	28.7	1	6.28	Ca. 100–200
3927 IV	17—12—29	10°55′ S 50°15′ E	...	4	3.97—8.95	Ca. 30
3928 III	18—12—29	11°20′ S 50°10′ E	27.3	1	4.76	Ca. 50–70
3928 IV	Do.	Do.	27.3	1	5.76	Ca. 30
3928 V	Do.	Do.	27.3	3	4.50—8.02	0—Ca. 20
3929 II	Do.	12°11′ S 50°18′ E	...	1	5.02	Ca. 100–200
3929 V	Do.	Do.	...	1	4.45	Ca. 100–200
3934 III & C	20—12—29	11°24′ S 50°05′ E	...	1	5.87	Ca. 100–200
3934 V & C	Do.	Do.	...	1	8.22	Ca. 50–70
3954 I	9—1—30	16°53′ S 42°12′ E	...	1	4.81	Ca. 100–200
3954 V	9—1—30	16°53′ S 42°12′ E	...	2	3.98 & 5.02	0—Ca. 20
3957 V	11—1—30	21°30′ S 42°32′ E	...	1	4.03	0—Ca. 20
3960 II	13—1—30	25°23′ S 42°52′ E	26.0	3	3.98—4.76	Ca. 50–70
3963 I	Do.	24°30′ S 37°48.5′ E	...	1	5.97	Ca. 70–100

Western Pacific two larvae were obtained in the months of May and July and one from the Central Pacific west of Tahiti in October. This is in general agreement with the observation of Yabe (1953) about the supposed spawning season of sailfish in that region. Larvae are probably abundant in the tropical and sub-tropical Pacific and Indian Oceans and is supposed to have wide distribution. Thirty-one specimens were collected from the eastern part of the Indian Ocean west of Sumatra during the months of September and October. Twenty-one specimens were obtained from the Western Indian Ocean near Madagascar during December 1929 and January 1930 and of these the majority were from between Madagascar and the African coast. Complete absence of sailfish larvae over a wide area between Andamans and Seychelles covered by about 60 stations from 3866 to 3926 remains to be explained. The only inference that can be drawn from the available data is that the warmer regions of the Eastern and Western Indian Ocean are specially favourable during the months of September-October and November-December respectively for the reproduction of this species. Though this condition is in sharp contrast to the occurrence of larvae almost throughout the year in the Pacific, no definite conclusions can be drawn without additional data.

Tetrapturus angustirostris (Tanaka)

Common synonyms

Tetrapturus illingsworthi Jordan and Evermann

Tetrapturus kraussi Jordan and Evermann

Distribution

The shortnosed spearfish does not form a fishery of any significance anywhere and in the Pacific its distribution extends from the Western Pacific to Baja California and off the Chilean coast. There is only one report of occurrence of this species in the Indian Ocean (Yabe, *et. al.*, 1958). We have had no opportunity to see any specimen so far.

A specimen with running-ripe ovaries from the Pacific was examined by Royce (1957) in March. From the tropical and sub-tropical areas of the Pacific 30 larvae of length 3—50 mm. were taken (Ueyanagi, 1960b). They were abundant between latitudes 15°—20°W. The only other record is of two juveniles measuring 210 mm. and 185 mm. from the Pacific collected by the Vityaz (Sun Tsi-Zhen, *op. cit*). Two larvae of 5 and 5.5 mm. in length presumably of this species were collected by the Dana Expedition from Station 3855 on 17th October 1929, the location being south-west off Sumatra (*Vide* Fig. 2).

Istiompax indicus (Cuvier and Valenciennes)

Common synonyms

Histiophorus brevirostris Playfair

Makaira marlina Jordan and Hill

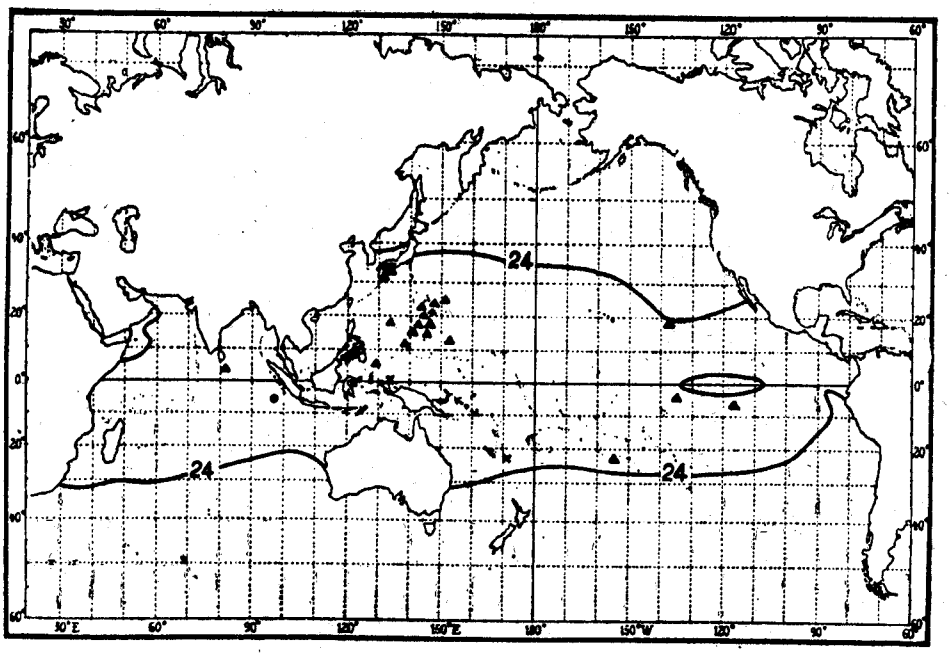
Marlina marlina Hirasaka and Nakamura

Makaira indica Fowler

Distribution

The black marlin is widely distributed in the Indo-Pacific from the east coast of Africa to the west coast of America. It is fairly abundant in the Western Pacific and in the adjacent

seas of South China, Sulu and Celebes (Nakamura, 1949). Good catches have been reported from Hawaian waters, the Equitorial Pacific from Baja California to the Caroline Islands, off Peru and New Zealand.

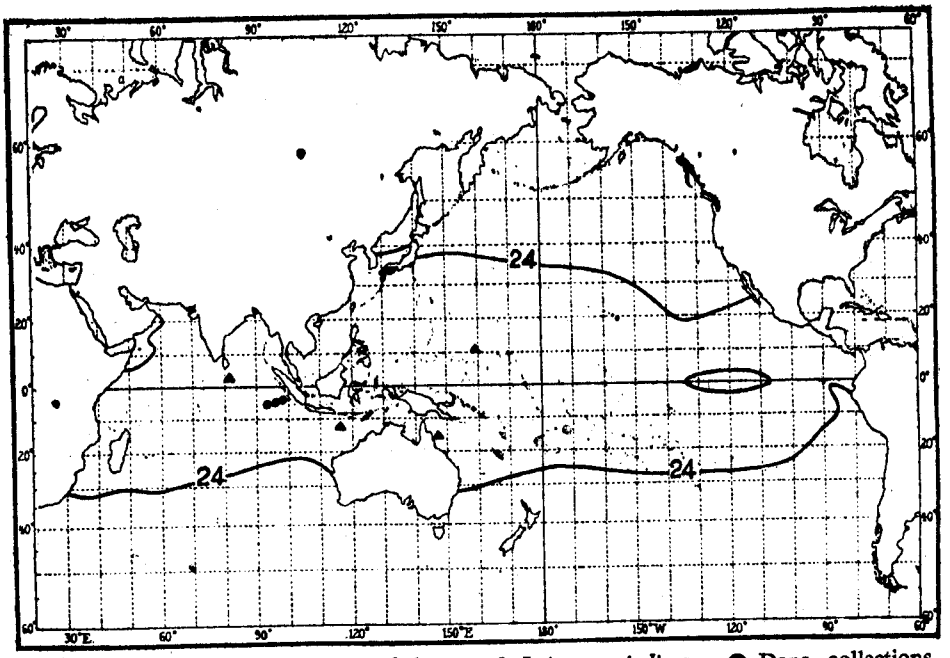


Text Fig. 2.—Records of capture of larvae of *Tetrapturus* angustirostris. ● Dana collections, × Vityaz collections, ▲ Japanese collections.

Distribution of larvae

Ueyanagi and Yabe (1960) described a juvenile measuring 26 mm. collected near the Caroline Islands. In addition, four larvae were collected from the Indian and Pacific Oceans (Ueyanagi, 1960a). Based on the state of maturity of gonads and the abundance of distribution of adults Ueyanagi (1960a) suggested that the Indo-Australian Archipelago is the spawning area of this fish and that intensive spawning occurs during October and November in the Coral Sea.

Areas of capture of larvae by the Dana Expedition and by other workers are shown in Fig. 3. Ten larvae measuring 4.14—7.33 mm. were obtained from the Indian and Pacific Oceans by the Dana Expedition as per details shown in Table 2. Of these 9 specimens were obtained during October 1929 from the Eastern Indian Ocean where adults are reported to be abundant. In November one larva was collected from the Pacific west of the Samoan Islands. Spawning occurs in the tropical Eastern Indian Ocean during October but nothing is known about other months. Nakamura (1949) examined mature specimens from the Western Pacific and inferred that the black marlin spawns off Formosa around August to October. It is therefore perhaps reasonable to assume that the black marlin has a fairly extended spawning period in the Pacific.



Text Fig. 3.—Records of capture of larvae of *Istiompax indicus*. ● Dana collections, ▲ Japanese collections.

TABLE 2

Details of collection of black marlin (*Istiompax indicus*) larvae by the Dana Expedition from the Indo-Pacific

Station No. (1)	Date (2)	Position (3)	Surface temperature (4)	Number of specimens (5)	Size range in mm. (6)	Depth of capture (7)
3590 III	7—11—28	13°56′ S 172°30′ W	...	1	5.50	Ca. 30
3850 IV	14—10—29	6°01′ S 93°12′ E	27.5	1	5.18	Ca. 30
3854 III	16—10—29	5°31′ S 96°35′ E	...	2	6.25 & 6.39	Ca. 50-70
3854 IV	Do.	Do.	...	2	4.14 & 4.65	Ca. 30
3856 III	17—10—29	4°45.5′ S 98°28′ E	...	3	4.87—7.33	Ca. 50-70
3856 IV	Do.	4°45.5′ S 98°28′ E	...	1	4.76	Ca. 30

Makaira mazara* (Jordan and Snyder)

Common synonyms

Tetrapturus mazara Jordan and Snyder

Makaira mazara Jordan and Evermann

*According to Rivas (1956) this is synonymous with *Makaira ampla* of the Atlantic because the two forms cannot be distinguished on the basis of external characters. However, Morrow (1957) states that the proper name for the Pacific form is *Makaira ampla mazara* (Jordan and Snyder) as their pectoral girdle shows differences indicating they are sub-specifically distinct.

Eumakaira nigra Hirasaka and Nakamura

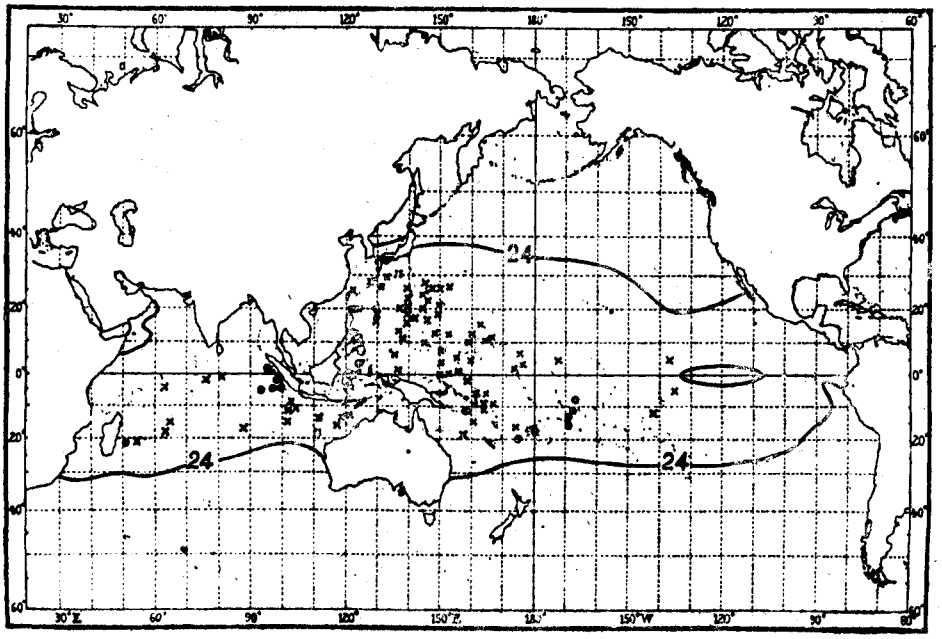
Istiompax howardi Whitley

Distribution

The blue marlin is comparatively abundant in the tropical parts of the Indian Ocean especially near Java, Sumatra and Nicobar Islands. In the Pacific it occurs throughout the year near Caroline and Marshall Islands and is abundant off Formosa and Hawaii.

Distribution of larvae

Ueyanagi (1957) considers that the young blue marlin is concentrated in the North Equitorial Current area. Ueyanagi and Yabe (1959) refer to the collection of about 400 larvae of which most were from the Western Pacific (west of 180°, from 30°N to 15°S lat.) and a few from the Indian Ocean south of Sumatra and Java. It was presumed by them that spawning extends throughout the year in the tropical low latitude areas. In the sub-tropical area of the Western Pacific west of 140°E spawning season is from April to August. There are 36 larval specimens in the Dana collection of which 24 are from the Indian Ocean. From the Pacific (between 7°S to 20°S) near Samoan and Fiji Islands area 11 larvae were collected in October and November. From the Celebes Sea one larva was obtained in July. In the tropical and sub-tropical parts of the Pacific west of 165°W spawning occurs during October to November. It is possible that spawning area is more extensive and that spawning period extends throughout the year in the sub-tropical areas of the Pacific but at present lack of data for the other months of the year precludes such an assumption. From the tropical Indian Ocean between 3°N—6° S and east of 93°E 22 larvae were collected during September and October. Two larval specimens were collected in December from the Indian Ocean east of Madagascar. Areas of capture of larval specimens by the *Dana* together with Japanese records are plotted in Fig. 4 and details of capture of larvae by the *Dana* are given in Table 3.



Text Fig. 4.— Records of capture of larvae of *Makaira mazara*. ● Dana collections, × Japanese collections.

TABLE 3

Details of collection of blue marlin (*Makaira mazara*) larvae by the Dana Expedition from the Indo-Pacific

Station No. (1)	Date (2)	Position (3)	Surface temperature (4)	No. of specimens (5)	Size range (6)	Depth of capture (7)
3582 VII	27—10—28	15°36′ S 168°57′ W	28.0	1	7.07	0—Ca. 20
3583 VI	28—10—28	13°14′ S 169°.51′ W	...	2	5.76 & 6.28	0—Ca. 20
3584 VII	29—10—28	10°51′ S 168°40′ W	...	1	17.29	0—Ca. 20
3585 VI	31—10—28	7°46′ S 167°10′ W	28.5	1	9.22	Ca. 30
3585 VII	Do.	Do.	28.5	3	4.40	0—Ca. 20
3593 IX	10—11—28	17°27′ S 179°33′ E	...	1	8.38	Ca. 30
3602 II	22—11—28	20°00′ S 174°29′ E	24.5	2	4.03 & 4.50	Ca. 100-200
3739 IV	2—7—29	3°20′ N 123°50′ E	28.3	1	5.02	Ca. 30
3817 VII	11—9—29	2°15′ S 98°55.5′ E	...	1	4.50	Ca. 50-70
3830 IX	19—9—29	2°36′ N 96°31′ E	28.1	1	6.54	0—Ca. 20
3833 IV	22—9—29	1°50′ S 98°23′ E	...	2	4.76 & 5.02	Ca. 30
3850 III	14—10—29	6°01′ S 93°12′ E	27.5	1	4.24	Ca. 50-70
3850 IV	Do.	Do.	27.5	3	7.85—9.48	Ca. 50-70
3851 IV	15—10—29	5°27′ S 93°50′ E	...	1	7.85	Ca. 30
3856 III	17—10—29	4°45.5′ S 98°28′ E	...	1	6.81	Ca. 50-70
3856 IV	Do.	Do.	...	1	9.95	Ca. 30
3837 IV	18—10—29	4°31.8′ S 99°13′ E	...	6	4.76—8.64	Ca. 50-70
3927 V	17—12—29	10°55′ S 50°15′ E	...	3	5.66—11.00	0—Ca. 20
3928 IV	18—12—29	11°20′ S 50°10′ E	27.3	4	5.50—9.22	Ca. 50-70

Makaira audax (Philippi)

Common synonyms

Histiophorus audax Philippi

Tetrapturus mitsukurii Jordan and Snyder

Makaira mitsukurii Jordan and Evermann

Kajikia mitsukurii Hirasaka and Nakamura

Kajikia formosana Hirasaka and Nakamura

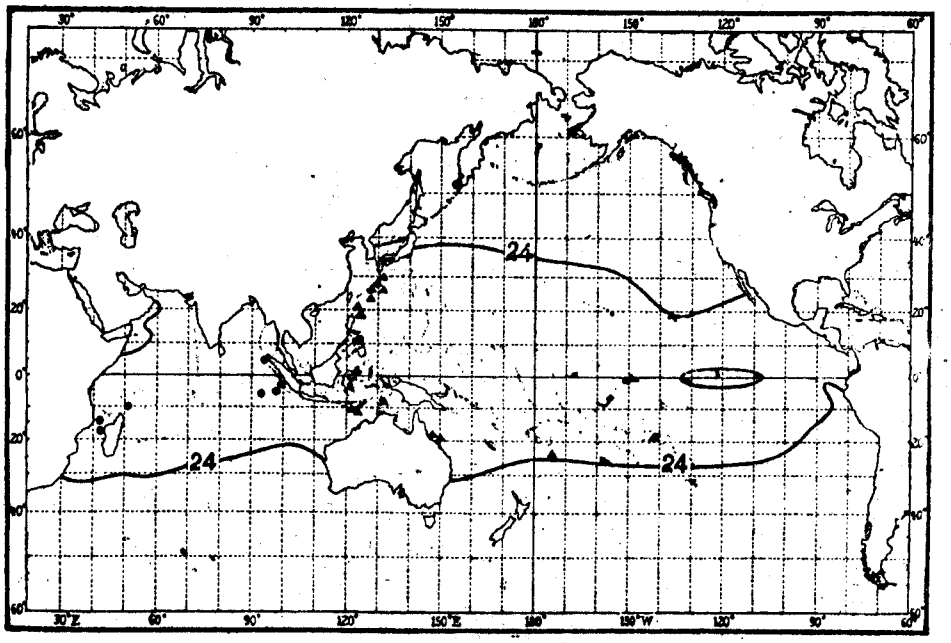
Distribution

The striped marlin is widely distributed in the Indian and Pacific Oceans, from the east coast of South Africa to the coast of America from California to Chile. The best fishing areas are around Ceylon, Andamans and Nicobars, south-west coast off Sumatra, off the coast of Japan, Formosa, Philippines, Hawaian Islands, New Zealand, Chile, Peru, Mexico and Southern California.

Distribution of larvae

Ueyanagi (1959) studied 42 larval specimens collected from North Pacific, South Pacific and the Indo-Australian Archipelago and from the pattern of distribution of larvae suggested that the striped marlin population of North Pacific spawn around 20°N—30°N latitude, with the peak spawning season in May and June. He is also of opinion that in the South Pacific, striped marlin spawn during October to January around 20 S lat. whereas in the Banda, Flores and Timor Seas spawning occurs during January-February.

It is of special interest to note that larvae of this species were not obtained from these areas by the Dana Expedition. Eight specimens were collected from the Eastern Indian Ocean west and north of Sumatra and 11 from the Western Indian Ocean near Madagascar. Striped marlin do congregate in these areas as evidenced by the good catches obtained by the Japanese fishing vessels in the Indian Ocean (Nankai Regional Fisheries Research Laboratory, 1958). From the available data it appears that the striped marlin spawn in the Western Indian Ocean during December-January between 10°S—18°S lat. and in the Eastern Indian Ocean during October-November between 10°S and 6°N latitude. In Fig. 5 the locations of capture of larvae are plotted. In Table 4 particulars of stations from where larvae were collected are given.



Text Fig. 5—Records of capture of larvae of *Makaira audax*. ● Dana collections. ▲ Japanese collections.

TABLE 4

Details of collection of striped marlin (*Makaira audax*) larvae by the Dana Expedition from the Indo-Pacific

Station No. (1)	Date (2)	Position (3)	Surface temperature (4)	No. of specimens (5)	Size range in mm. (6)	Depth of capture (7)
3850 IV	14–10–1929	6°01′S 93°12′E	27.5	1	8.12	Ca. 30
3856 IV	17–10–1929	4°45.5′S 98°28′E	...	5	5.02–14.98	Ca. 30
3858	18–10–1929	3°28′S 99°58.5′E	28.6	2	5.24 & 5.76	...
3902 V	17–11–1929	6°05′N 95°30′E	...	1	6.81	0—Ca. 20
3927 I	17–12–1929	10°55′S 50°15′E	...	1	5.40	Ca. 100–200
3927 IV	Do.	Do.	...	6	4.76–5.76	Ca. 30
3951 V	7–1–1930	14°16′S 41°48′E	...	1	7.75	0-Ca. 20
3952 I	8–1–1930	15°05′S 41°53′E	...	1	5.07	Ca. 100–200
3955 IV	9–1–1930	18°30′S 42°18′E	...	1	6.03	Ca. 30

Xiphias gladius Linnaeus

The swordfish is distributed in the Atlantic, Pacific and Indian Oceans and tolerates lower temperatures than the marlins and sailfishes. Important fishing areas are mainly in the temperate waters.

Juveniles of *X. gladius* have been collected from the Reunion area (Lutken, 1880) but no information is available about the period of collection. From the Pacific, larvae and juveniles have been collected from the North Equatorial Current and the Kuroshio Current (Yabe, 1951 ; Nakamura *et al*, 1951). Larvae, juveniles and mature specimens were collected from the Equator to the sub-tropical convergence in the North Pacific and from the Coral Sea (Yabe *et al*, 1959). They concluded that spawning season in the North Pacific is from

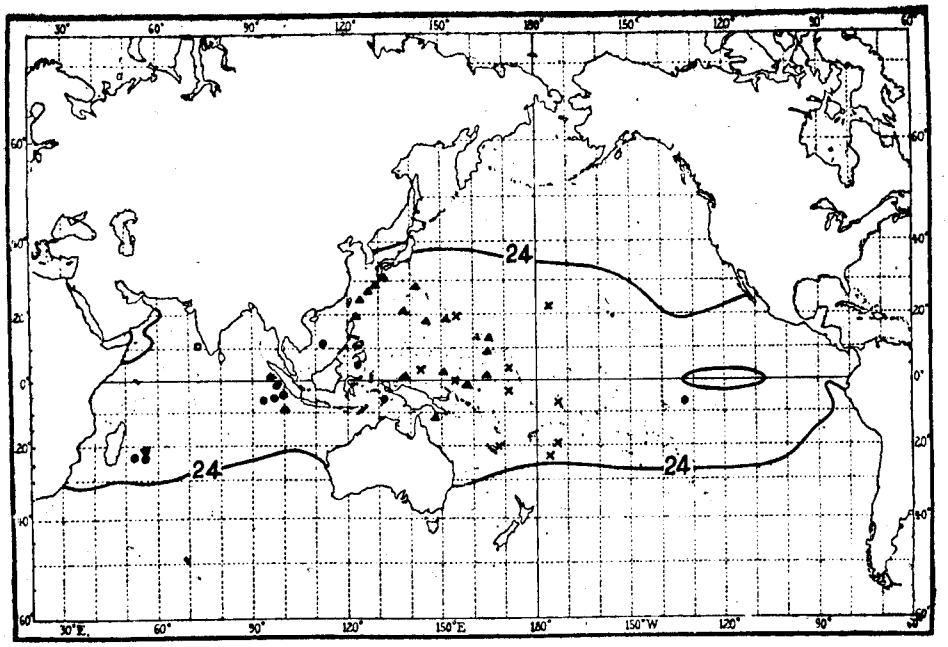
February to August with the peak from March to June and that in the equitorial region spawning might take place throughout the year. From the Laccadive Sea one postlarva measuring 16.27 mm. was collected in February (Jones, 1958). The swordfish larvae collected by the *Dana* have been worked out in detail by Tåning (1955). In the Indian and Pacific Oceans larvae were obtained from west of Sumatra, South China Sea, Celebes and Banda Seas and off the Marquesas. In addition to the seven specimens reported by him three larvae are present in the *Dana* material examined by us. These three specimens were obtained from the Indian Ocean west off Sumatra. Details of stations are given in Table 5. Localities of collection of larvae including all other previous records are shown in Fig. 6. It is possible that the swordfish has an extended spawning period in the Indian Ocean.

TABLE 5

Details of collection of swordfish (*Xiphias gladius*) Larvae*

Station No. (1)	Date (2)	Position (3)	Surface temperature (4)	No. of specimens (5)	Size range (6)	Depth of capture (7)
3563 V	29- 9-1928	7°45.5′S 131°22′W	25.9	1	11.1	0—Ca. 20
3676 V	22- 3-1929	5°52′S 131°14′E	28.9	1	17.1	Ca. 30
3683 X	3- 4-1929	4°08′N 123°00′E	28.6	1	7.0	0—Ca. 20
3816 I	11- 9-1929	3°03′S 97°38.5′E	28.0	2	4.9 and 5.2	Ca. 50-70
3851 IV	15-10-1929	5°27′S 93°50′E	...	1	6.0*	Ca. 30
3855 IV	17-10-1929	5°17′S 97°06′E	27.6	1	7.4	Ca. 50-70
3857 I	18-10-1929	4°31.8′S 99°13′E	...	1	6.6	Ca. 100-200
3887 III	4-11-1929	0°36′N 96°25.5′E	28.4	1	13.5	Ca. 100-200
4819	22-6-1937	12°10′N 111°38′E	31.0	1	6.3	Ca. 50-70

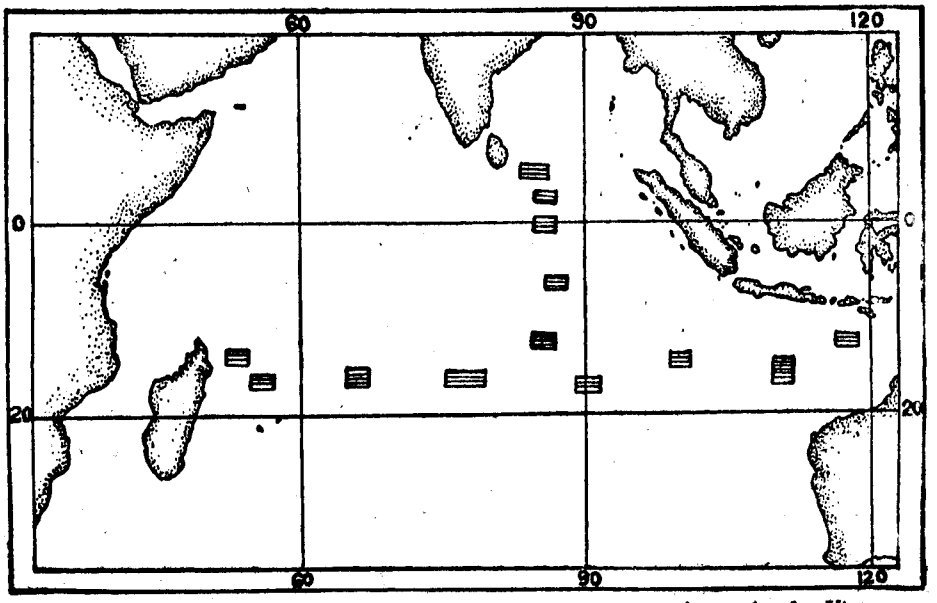
* Inclusive of specimens worked out by Tåning (1955).



Text Fig. 6—Records of capture of larvae of *Xiphias gladius*. ● Dana collections, ▲ Japanese collections, × Vityaz collections, ○ Indian collection, ⊙ Lutken's collections.

DISCUSSION

According to Bogorov and Rass (1961) the findings of the 31st cruise of *Vityaz* indicate the presence of numerous spawning schools of swordfishes and sailfishes in the Indian Ocean. Localities of capture of larval billfishes from the Indian Ocean by the *Vityaz* as indicated by them are shown in Fig. 7. As the specific identity of the species



Text Fig. 7.— |≡| Represents localities of collection of billfish larvae by the *Vityaz*.

collected are not known, these locations are not shown in the distribution charts for the different species. It is evident from the figure that larvae were abundant between 12°—17°S lat. *i.e.*, approximately in the area of the South Equitorial Current and in the eastern sector along 85°—87°E long, between 5°N to 17°S. The absence of any billfish larvae in the stations covered by the *Vityaz* between west coast of Ceylon and Seychelles area is more or less comparable to the condition encountered by the *Dana*.

From the foregoing account it is clear that there is a concentration of larval billfishes in the low latitudinal areas of the Indian Ocean. Even though fairly extensive collections were made by the *Dana* Expedition from the Central and Western Pacific only very few larval billfishes were obtained from these areas (*Vide* Table 7). Oceanographical

TABLE 6

Monthly distribution of larvae and number per 100 hours of plankton hauls

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Istiophorus gladius	8	...	...	...	1	...	1	...	7	25	...	13
Istiompax indicus	...	...	...	...	...	...	...	..	...	9	1	...
Makaira mazara	...	...	...	...	...	...	1	...	4	21	3	7
Makaira audax	3	...	...	..	...	...	...	...	...	8	1	7
Tetrapturus angustirostris	...	...	...	...	...	...	...	...	...	2	...	...
No. of hours hauled	193	20	45	65	41	94	415	149	378	393	212	309
No. per 100 hours of haul	5.7	...	...	...	2.4	...	0.5	...	2.9	16.5	2.4	8.7

conditions like direction and velocity of currents, distribution of temperature and salinity and the availability of food must be important factors regulating the distribution of the larvae. On the basis of smaller specimens in the collections it is presumed that south-west off Sumatra and neighbouring areas are important spawning areas in the Indian Ocean. Larvae were not obtained from a vide area between near Andamans and Seychelles by the *Dana*.

Some areas where good catches of larvae have been reported are under the influence of strong currents. Probably spawning takes place even earlier than October far west off Sunda Archipelago in the tropical Indian Ocean and the slow swimming larvae are carried by the Monsoon Current which flows from west to east. The flow of the Equitorial Current might also be helpful for the larvae hatched out near the low latitudinal areas of southern hemisphere to move to the eastern part of the Indian Ocean. A more or less similar situation prevails in the Western Indian Ocean also. The South Equitorial Current flows from east to west north of about 20°S and so it is possible that the larvae hatched out in the nearby areas get distributed by this current. Larvae have been observed in the Mozambique Channel between Africa and Madagascar and it is presumed that these are eventually carried into the open Indian Ocean as the main stream of the Agulhas Current after reaching the southern part of Africa flows towards the east.

Larvae were collected mainly during October to January from the Indo-Pacific. Monthly distribution of larvae is given in Table 6. It can be seen from Tables 8 to 11 wherein the depth of capture of larval specimens by the *Dana* are given that most of the larvae were captured near the surface layers *viz.*, the upper 30 metres. However, a good number of them were obtained from nets operated in the lower layers but the chances

that many of these could have been caught in the nets from the surface while they were being hauled in cannot be ruled out. Most of the smaller specimens were obtained from nets operated in the upper 30 metres. The surface temperature at stations where the larvae were collected ranged from 24.5° to 28.7°C. It therefore appears that areas of fairly high temperature are favourable for the breeding of billfishes.

TABLE 7

Numbers of istiophorid larvae collected from the Indian and Pacific Oceans by the Dana Expedition

Species	Indian Ocean	Pacific Ocean	Total
Istiophorus gladius	52	3	55
Istiompax indicus	9	1	10
Makaira mazara	24	12	36
Makaira audax	19	...	19
Tetrapturus angustirostris	2	...	2
Unidentified istiophorids	10	9	19

TABLE 8

Distribution of larvae of *Istiophorus gladius* according to depth of towing

Depth of capture in metres	No. of specimens	No. of hours hauled	No. of specimens per 100 hours of haul
0—Ca. 20	10	46	21.7
Ca. 30	17	54	31.5
Ca. 50–70	21	85	25.0
Ca. 100–200	7	103	6.8

TABLE 9

Distribution of larvae of *Istiompax indicus* according to depth of towing

Depth of capture in metres	No. of specimens	No. of hours hauled	No. of specimens per 100 hours of haul
0—Ca. 20 ...	...	...	...
Ca. 30 ...	5	26	19.2
Ca. 50–70 ...	5	16	31.2
Ca. 100–200 ...	...	...	...

TABLE 10
Distribution of larvae of *Makaira mazara* according to depth of towing

Depth of capture in metres	No. of specimens	No. of hours hauled	No. of specimens per 100 hours of haul
0—Ca. 20 ...	11	36	30.6
Ca. 30 ...	7	45	15.6
Ca. 50–70 ...	16	55	29.1
Ca. 100–200 ...	2	5	40.0

TABLE 11
Distribution of larvae of *Makaira audax* according to depth of towing

Depth of capture in metres	No. of specimens*	No. of hours hauled	No. of specimens per 100 hours of haul
0—Ca. 20 ...	2	8	25.0
Ca. 30 ...	13	30	43.3
Ca. 50–70 ...	...	...	...
Ca. 100–200 ...	2	14	13.5

* Two specimens were collected by haul from a depth of 1,200 m. up to the surface.

SUMMARY

Larval istiophorids collected from the Indian and Pacific Oceans by the Danish Dana Expedition of 1928–30 were studied along with the recorded information available on the spawning areas of billfishes in the Indo-Pacific. The species dealt with are *Istiophorus gladius* (Broussonet), *Tetrapturus angustirostris* (Tanaka), *Istiompax indicus* (Cuvier and Valanciennes), *Makaira mazara* (Jordan and Snyder), *Makaira audax* (Philippi) and *Xiphias gladius* (Linnaeus.)

Judging from the pattern of distribution of larval specimens it is presumed that spawning takes place usually in the vast tropical and sub-tropical areas at temperature of about 24 C. and higher. The larvae prefer surface and sub-surface waters. Charts showing their distribution in the Indo-Pacific are given.

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DESCRIPTION AND DISTRIBUTION OF LARVAE OF FIVE ISTIOPHORID SPECIES IN THE INDO-PACIFIC

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INTRODUCTION

In 1949 the Nankai Regional Fisheries Research Laboratory (NRFRL) initiated a program to collect the larvae of tunas and istiophorids in order to bring to light their early life-history in the Western Pacific and other areas. The program was expanded in 1957 with the co-operation of the vessels of prefectural fisheries experimental stations and fisheries high schools, which enabled the said laboratory to expand its coverage to the Indo-Pacific Ocean.

Since 1949, about 2,600 tows of plankton nets have been made and thereby about 1,400 istiophorid larvae have been collected, as shown in Table 1. Most of the collection was made either by 15 minute single layer horizontal towing of a larval net, 1.4 m. in diameter, or three layer simultaneous horizontal towing of three larger nets, each 2 m. in diameter. In addition, dip-net collection, at day and night, was made from time to time. Size of collected specimens was mostly under 7 mm in total length, ranging from 3 mm to 60 mm. As for those above 7 mm in length, number of specimens collected showed a gradual decrease with increased body length. Specimens larger than 20 mm in length are seldom caught by larval nets.

TABLE 1

Numbers of istiophorid larvae collected

Species	Pacific Ocean	Indian Ocean*	Total
Black marlin ...	1,015	35	1,050
Sailfish ...	74	55	129
Striped marlin ...	104	12	116
Shortnosed spearfish ...	84	...	84
White marlin ...	3	2	5
			1,384

* Including Banda Sea & Timor Sea.

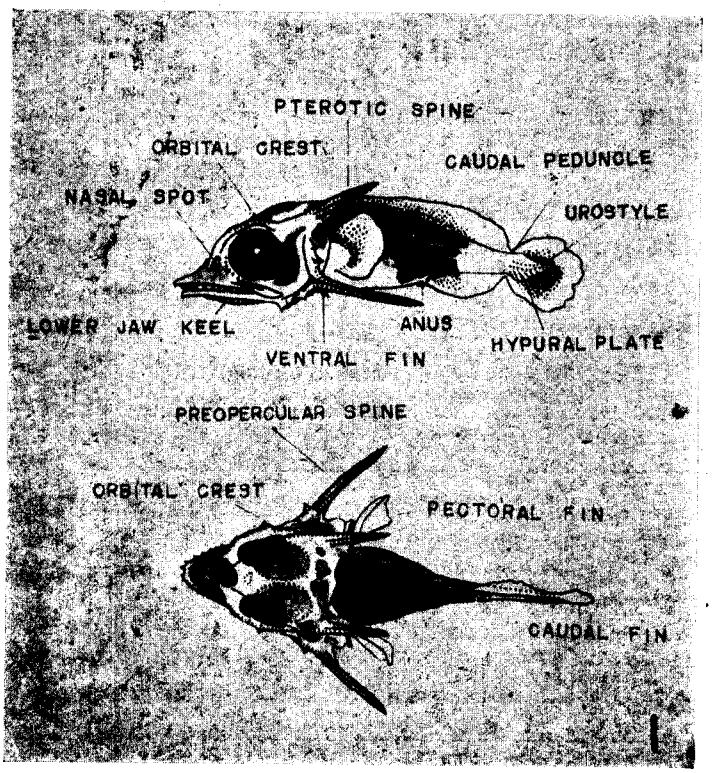
Since the start of the program, the author has examined the morphological features of these specimens and established necessary criteria to identify the following all five species of Istiophoridae of the Indo-Pacific throughout their entire larval stage : shortnosed spear-fish *Tetrapturus angustirostris* Tanaka, sailfish *Istiophorus orientalis* (Temminck et Schlegel),

striped marlin *Makaira mitsukurii* (Jordan et Snyder), black marlin *Eumakaira nigra* Nakamura, white marlin *Marlina marlina* (Jordan et Hill). Some knowledge regarding their vertical and horizontal distribution, and spawning grounds and season has also been accumulated.

The author wishes to thank the staff of his laboratory, and crew of Shunyo-maru and research boats of various prefectural experimental fisheries stations and fisheries high schools for their co-operation in collecting specimens, Drs. Hiroshi Nakamura and Hiroshi Yabe for their very helpful advices, Mrs. Sumiko Nakazawa, Mr. Hisaya Watanabe and Miss Natsuko Yamazaki, for their kind assistance in preparing figures of this report, and Mr. Kunio Yonezawa for translation of this report. The author also appreciates the kindness of the following people in letting him review literature ; Dr. Yoshie Dōtsu, Nagasaki Univ., Mr. John K. Howard, Miami Univ., Mr. Walter M. Matsumoto, Honolulu Biological laboratory, Mr. Witold L. Klawe, Inter-American Tropical Tuna Commission.

Description of species

As illustrated in Fig. 1, istiophorid larvae are characterized by their large head, mouth and eyes, long pterotic and preopercular spines with serrated edge, and also serrate edge of



Text Fig. 1. Showing a typical istiophorid larva.

their orbital crest and lower jaw keel, and heavy pigmentation, and hence can be rather easily recognized from others. However, specific discrimination of istiophorid larvae, particularly those under 10 mm in length, is very difficult, because of their close resemblance in their morphological characteristics.

The purpose of this report is, therefore, to present reliable criteria which can be used for their specific identification.

Before describing such criteria, the author tried to give full and detailed explanation on shortnosed spearfish, which comes first in this report, and make the description on other species as concise as possible, avoiding redundant references. It is also noted that measurements for each species were made on several specimens selected so as to represent different developmental stages. (App. Tables 1—5). Some of these specimens are illustrated.

1. Shortnosed spearfish—*Tetrapturus angustirostris*

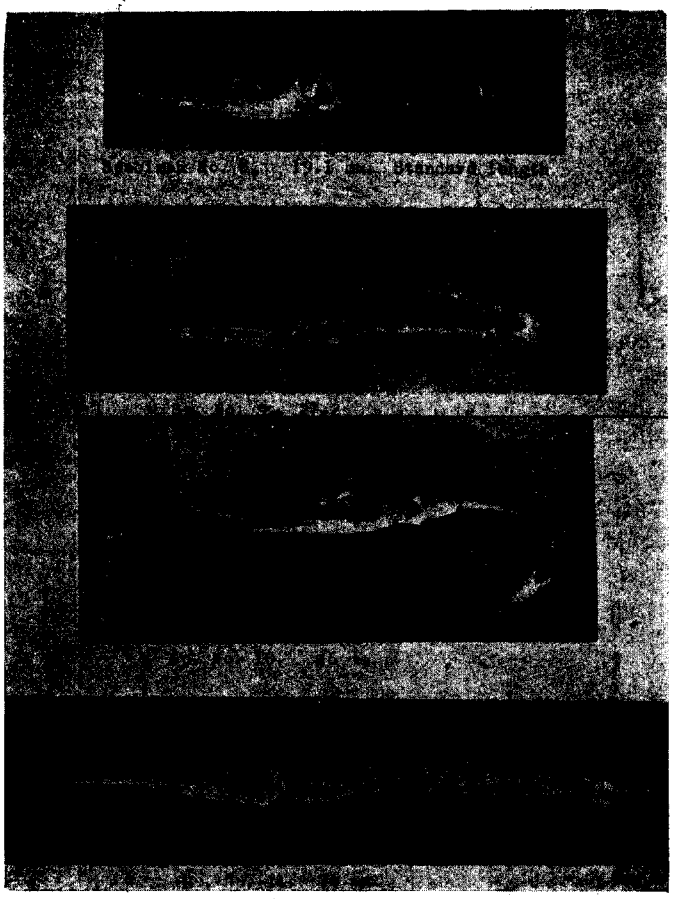
Total of eighty-four specimens has so far been collected from the sub-tropical and tropical waters of the Pacific. Total length of these specimens varied from 2.5 mm to 83 mm. The largest specimen of 83 mm in length was caught when cast on board by waves. The largest of the specimens caught by larval net was 51 mm.

As compared with the other istiophorid species, shortnosed spearfish larvae are characterized by their longer snout * (elongation of which starts at around 5 mm in body length), black chromatophores on branchiostegal membrane, larger number of the first dorsal fin rays, which exceeds 48, and wider space between the first anal fin insertion and anus.



Text Fig. 2 (*a*). Larvae of *Tetrapturus angustirostris*.

* Adults of this species have the shortest snout.

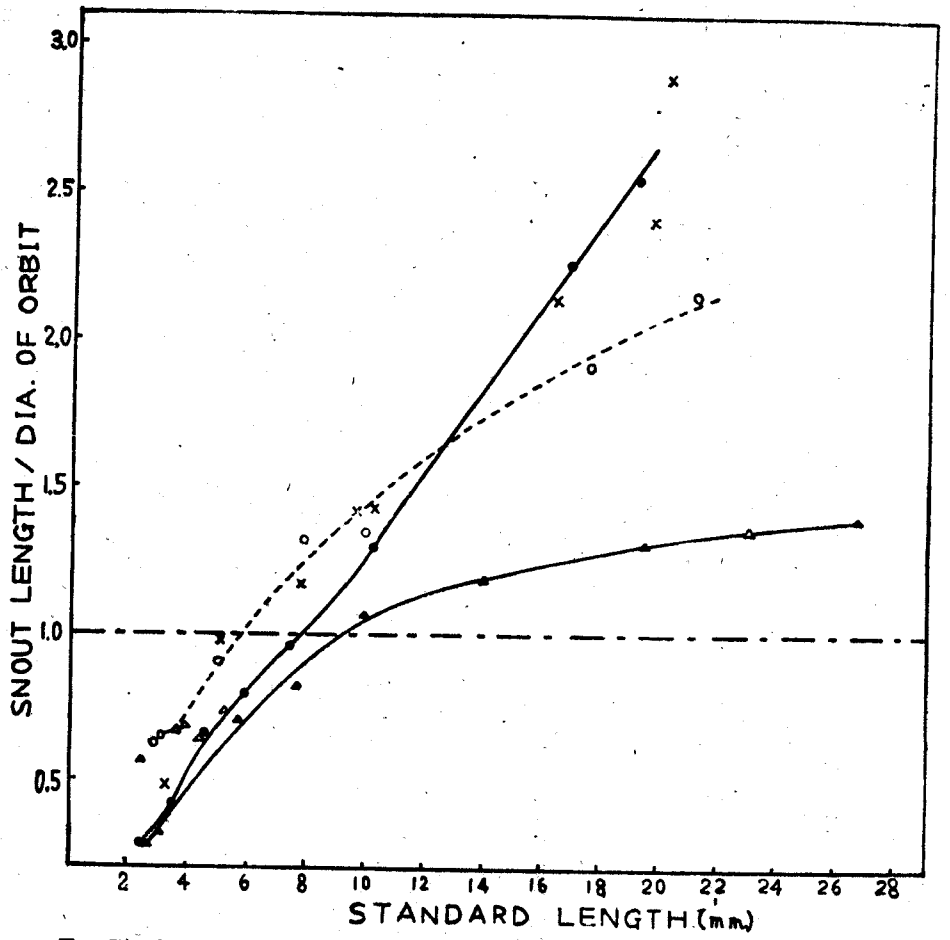


Text Fig. 2 (*b*). Larvae of *Tetrapturus angustirostris*.

Head: Head is rather small and does not exceed 3/10 of the body length (standard length), until the latter reaches 4 mm. Thereafter, the proportion of head increases sharply and attains half of the body length at 7 mm. Elongation of snout starts also at 4 mm, when it is less than 1/4 of the head length. The proportion of snout rises with growth; 3/10 at 5 mm, 35/100 at 7 mm and 2/5 (or 1/5 of the body length) at 10 mm. In larger specimens exceeding 20 mm, snout measures over half of the head length or more than 3/10 of the body length. Eyes are fairly large. Fig. 3 shows the growth of the diameter of orbit in terms of the snout length. The proportion of the snout length to the orbit diameter rises with growth, from 0·7 at 5 mm to 1·0 at 7-8 mm, and further to over 1.5 at 12 mm and over. Nasal spot of the larvae below 4 mm in length has only one opening before eye, but, as they grow, the orifice becomes lengthened and separated into two at 6 mm. Dentition does not occur until their body length reaches about 3 mm, and very minute conical teeth are recognized in specimens of about 4 mm long. Number of teeth, which include a group of very conspicuous fang-like teeth at the tip of both jaws, increases with growth. Palatine teeth are found in specimens of about 6 mm long and larger. Specimen of about 20 mm long has more than 30 upper jaw teeth and 8 well-developed palatine teeth. However, the number of the upper jaw teeth of specimen of 27 mm does not noticeably

increase beyond this, so that the plantation of the teeth appears to be less thick. (The lower jaw has thickly planted teeth). In the two specimens of 46 mm and 76 mm, the condition of the teeth plantation does not indicate any further development, but rather demonstrates signs of degeneration.

Head spination and scaling: Spination does not occur until their body length exceeds about 3 mm. Minute pterotic and preopercular spines are recognized first in specimens of about 4 mm long. Serration of the orbital crest and lower jaw keel comes to be apparent at 4.5 mm in length. Larvae of this size have fairly well-developed characters (characteristic for istiophorid larvae), such as long and serrate pterotic and preopercular spines, serrate orbital crest and lower jaw keel and the secondary spines besides the main preopercular spine. At 6-7 mm in length, spination and serration become more pronounced. Especially, pterotic and preopercular spines lengthen to a great extent, or to the maximum length in proportion to their body length throughout the larval stage. The preopercular spine reaches the anus, when turned alongside the body. However, the growth of spination and serration thereafter comes to slow down and they indicate even a faint sign of degeneration at about 10 mm



Text Fig. 3. Ratio of snout length to diameter of orbit in relation to standard length. Black dots represent shortnosed spearfish ; crosses, sailfish ; circles, striped marlin ; black triangles, black marlin ; white triangles, white marlin.

in length. At about 20 mm, elongation of spines comes to complete halt and serration becomes less distinct. And with the progress of degeneration of the head spination, minute spine-like scales start to appear over the trunk and operculum. Lateral line is also recognized in part, though not clear yet. In a 76 mm specimen, spine-like scales cover all over its trunk, tail and operculum, and a simple lateral line runs all through tail, while serration of the orbital crest and lower jaw keel is hardly recognizable.

Fin-formation : Vertical fin of specimens under 4 mm is a mere continuation of membrane which surrounds back, tail and belly and ends before anus. It is somewhat narrowed near caudal peduncle and thickened underneath urostyle which extents straight backward. In these small specimens, pectoral fins show very early stage of formation, only thickened at its base, and ventral fins not formed yet. Ventral fins appear at 4 mm in body length. At 5 mm in length, signs are evident for a single continuous vertical fin to separate into three divisions and narrows above and beneath caudal peduncle. Membrane before anus is only rudimentary. The bases of caudal, dorsal, and anal fins are thickened, impending the formation of fin rays. The rays of pectoral fin are partially formed at its upper part. Ventral fin is still bud-like. In specimen of 6 mm long, separation of vertical fin at caudal peduncle is almost complete. Urostyle curves slightly upwards and hypural plate is in the process of formation. In specimen of 7 mm in length, differentiation of vertical fin to caudal, anal and dorsal fin is complete, their fin rays being formed. Among these three fins, the development of slightly forked caudal fin is most advanced with complete hypural plate. Ventral and pectoral fins are further elongated. At 10 mm in length, the sheath of dorsal fin in which to contain the folded fin is formed all over its entire base. Caudal fin is deeply forked. Pectoral fin becomes longer and has 16 rays. Ventral fin reaches in length 45% of body cavity. At 20 mm, fin rays of each fin reach their full complement. Dorsal fin stands high, and pectoral and ventral fins reach 8/10 of the body depth and 6/10 of the body cavity length respectively. At 27 mm, dorsal fin stands conspicuously high like a sail and demonstrates a indication of differentiation into the first and second fin, though it is still a continuous fin. Same indication is also recognized in anal fin. The second anal fin locates somewhat ahead of the second dorsal fin. Numbers of rays of dorsal, anal, and pectoral fins were 50+7, 19+6, and 17, respectively. In two large specimens of 46 mm and 76 mm, numbers of dorsal fins were both 49+6. (App. Table 1). Pectoral and ventral fins further grew longer and caudal fin forked deep. The first anal fin insertion is further separated from anus, and the distance between the two in the 76 mm specimen reaches 1/5 of the body cavity length.

Pigmentation: In specimens under 3 mm in length, black chromatophores are found over the head, dorsal and lateral side of the trunk and dorsal wall of the body cavity, but very few on the ventral side of the body except inside of isthmus. Small spots are also detected in lines along urostyle of the tail end. Beneath the head are found scatterings of chromatophores on the tip and center of the under part of the lower jaw and on branchiostegal membrane. With growth, the pigmentation pattern on the lateral side of body reaches farther out towards the tail and ventral side, and is gradually darkened. In specimen of about 4 mm in length, a pair of distinct semi-circular chromatophore clusters is found on the top of head. The pigmentation on the lateral side reaches the tail at 5 mm in length, and close to the caudal peduncle and covers most part of the tail at 7 mm in length. At the latter stage, pigmentation occurs all over the ventral side, except around anus, although it is far lighter in coloration. At 10 mm, the lateral pigmentation pattern is found reaching the caudal peduncle. Chromatophores are recognized yet, though not

clear, on branchiostegal membrane. At 16 mm in length, chromatophores appear on dorsal fin, but not on the other fins. Pigmentation further develops with their growth and at 20 mm, there are no places free of colouration, except the end of hypural plate. The head and ventral side are coloured dark brown. Part of the ventral side of the body along the ventral groove is coloured white, because of the thickened skin. There is no pigmentation on fins, except dorsal fin with 4 heavily pigmented stripes. Chromatophores appear at the tip of caudal fin at about 46 mm in length. A 76 mm specimen in length has chromatophores on the lateral side of the lower jaw and faint indications of pigment on branchiostegal membrane. Pectoral and ventral fins lack pigmentation.

2. Sailfish—*Istiophorus orientalis*

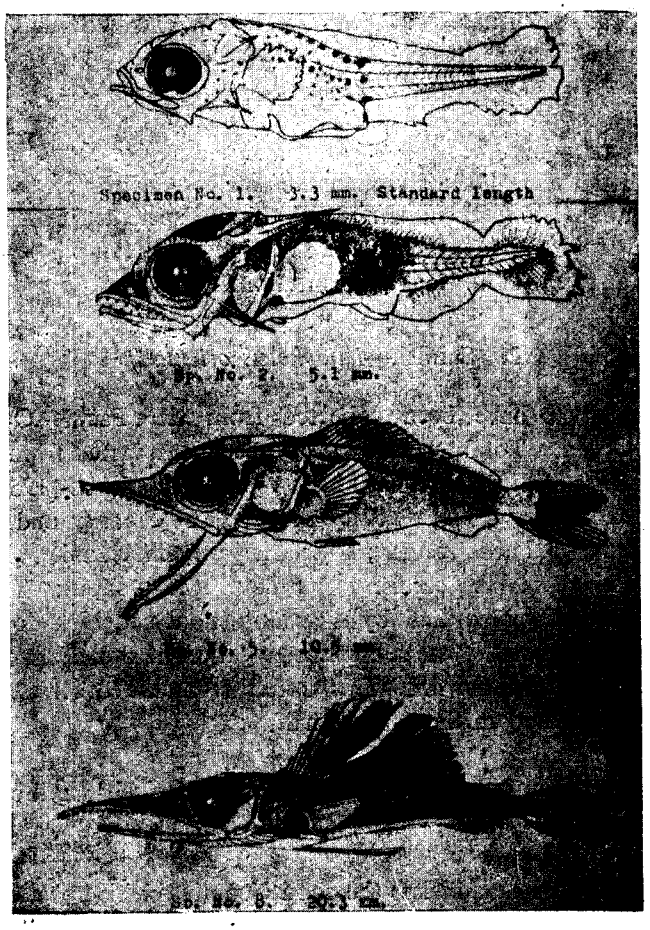
Seventy-four larvae have been collected from the Pacific Ocean, and fifty-five from the Indian Ocean. Total length of these specimens varied from 3 mm to 60 mm. Morphological characters of the larvae have been reported by Yabe (1953) and Jones (1959) on specimens collected in the western Pacific and Indian Oceans, and by Voss (1953), Gehringer (1956), etc. on Atlantic sailfish; both being very much alike. Like those of shortnosed spearfish and striped marlin, sailfish larvae have a long snout. Those exceeding 20 mm in body length are easily identified by their long snout and high dorsal fin, which are suggestive of those of their adults. The maximum height of the dorsal fin of the sailfish larvae occurs in the posterior half of the fin. This differs from the other istiophorids in which the maximum height is located in the anterior half.

Head : The profile of head is characterized by relatively small eyes and long beak-like snout.

In specimens of 10 mm and less the snout length of this species varies little from that of shortnosed spearfish, but tends to be less in larger specimens (Fig. 5). Relationship between the snout length and diameter of orbit varies with growth. The former does not exceed the latter in specimens under 5 mm, is almost equal to in those between 5 and 6 mm, and surpasses in those of 7 mm and over (Fig. 3).

Head spination and scaling: As in the case of shortnosed spearfish larvae, their head spination starts to develop at around 4 mm in body length, and becomes, at about 7 mm, most prominent; pterotic and preopercular spines being longest relative to their body length. After this stage, head spination tends to degenerate. Spine-like scales are first noted, though in trace, in 25 mm specimen. Specimen of 33 mm long are covered with scales almost all over their body surface. In specimen 50 mm long, lateral line is distinct.

Fin-formation: The pattern of development of fins of sailfish larvae is very similar to that of shortnosed spearfish larvae. At about 7 mm in length, the differentiation of membranous vertical fin to dorsal, anal, caudal fins comes to completion. Rays of all the fins attain full complement at about 20 mm. Ventral fin starts to develop at about 4 mm, but the growth of the fin is rather slow compared with that of the body length until the latter reaches about 7 mm. After this stage, it becomes much faster (Fig. 7). The height of dorsal fin starts to prominently increase at about 10 mm in body length and exceeds the body depth



Text Fig. 4. Larvae of *Istiophorus orientalis*.

at about 20 mm. Unlike those of the other species, the dorsal fin of this species is raised posteriorly.

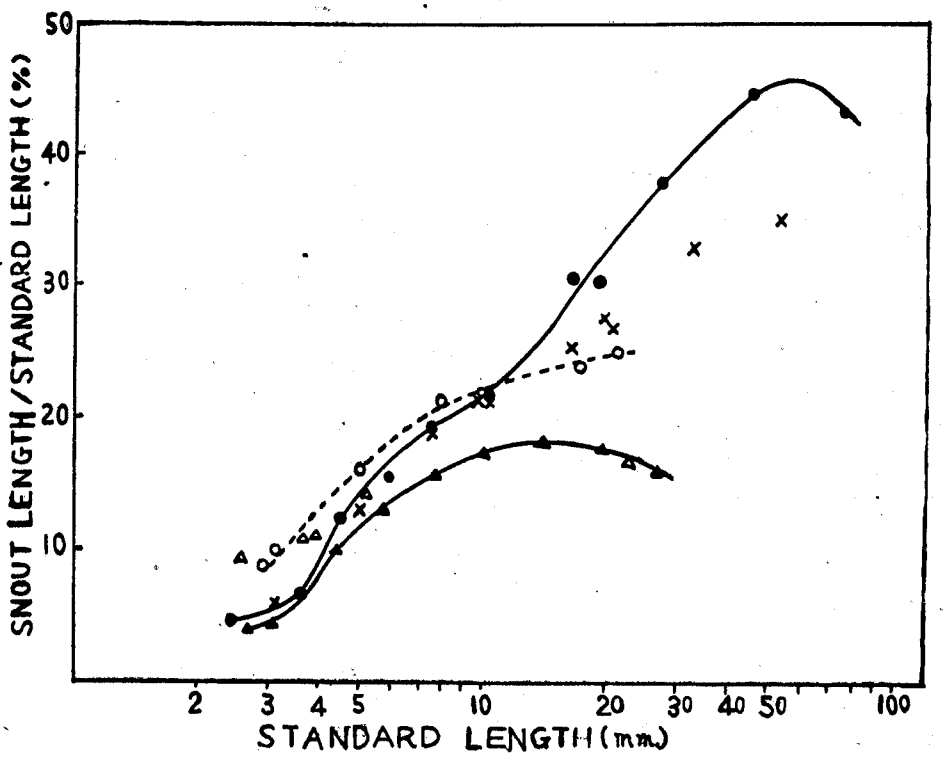
Pigmentation : The pigmentation pattern beneath the head is different between sailfish larvae and shortnosed spearfishlarvae. Chromatophores are found, in the former, along the periphery of the lower jaw and not on branchiostegal membrane. Development of pigmentation of the lateral and ventral side of the body lags somewhat behind that of shortnosed spearfish.

3. Striped marlin, *Makaira mitsukurii*

One hundred and sixteen specimens, 3 mm to 25 mm in total length, have been collected from the Indian and Pacific Oceans. The larvae of striped marlin resemble those of shortnosed spearfish and sailfish in having a long snout, but can be recognised by their specific head profile.

Head : Unlike sailfish, the snout of this species projects straightforward, its end being on the same level with the center of eyes. (In the other species, the latter is above

the former). The proportion of snout to body increases with growth, from 0.1 at 4 mm in body length to 0.25 at 20 mm when the upper jaw somewhat outgrows the lower jaw.



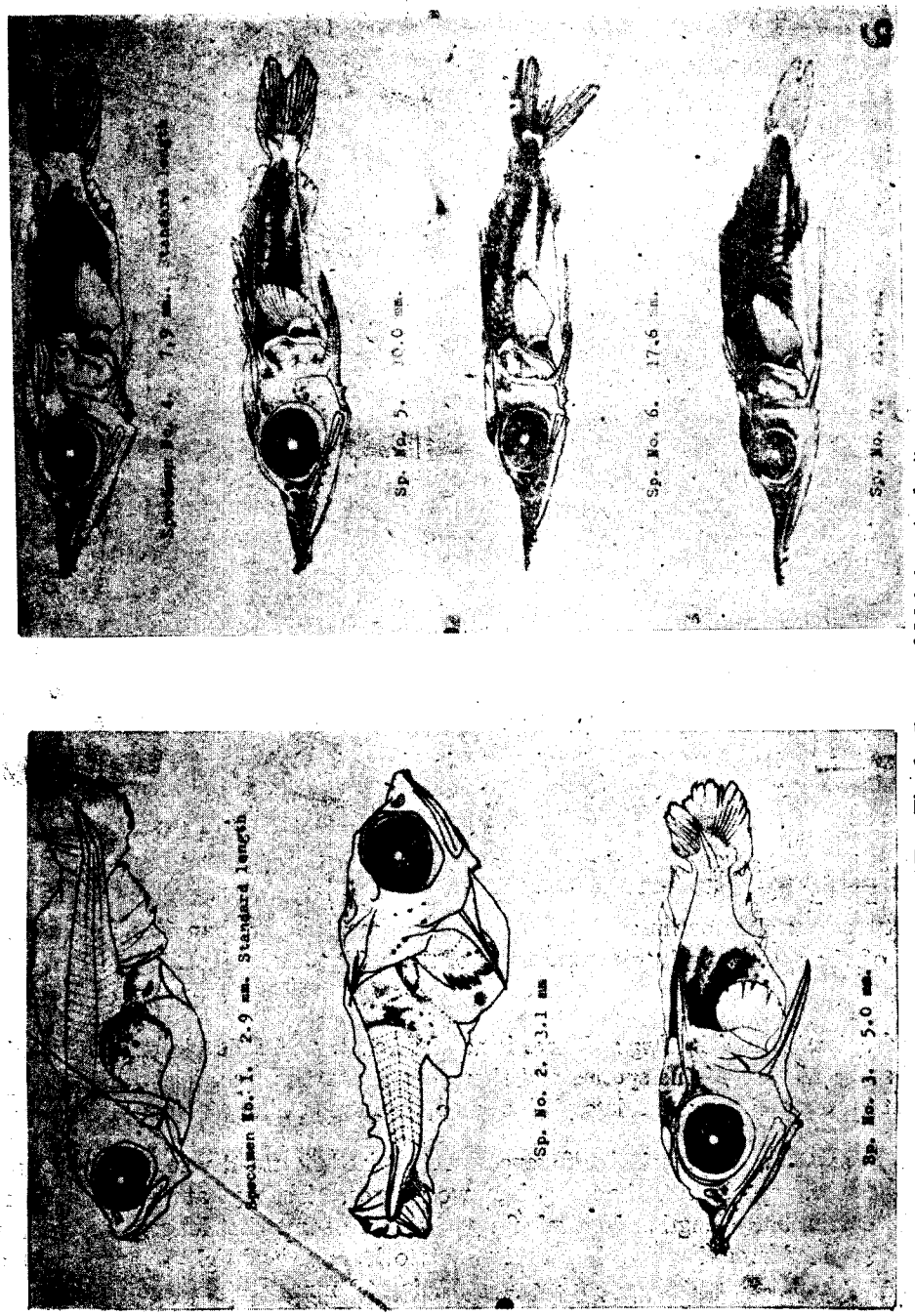
Text Fig. 5. Percentage of snout length to standard length in relation to standard length. Black dots represent shortnosed spearfish ; crosses, sailfish ; circles, striped marlin ; black triangles, black marlin ; white triangles, white marlin.

In specimens larger than 20 mm, the snout of striped marlin tends to be shorter than that of sailfish (Fig. 5). The relationship between the snout length and diameter of orbit is also different between striped marlin and sailfish. In specimens larger than 10 mm length, the proportion of the snout length to the diameter of the orbit tends to be smaller in the former (Fig. 3).

Head spination and scaling: There is no difference in the development of head spination and scaling between this species and shortnosed spearfish or sailfish. Minute spine-like scales start to develop on the lateral side and operculum at about 20 mm in body length.

Fin-formation: No marked difference is recognized in the development of fin-formation between this species and the foregoing two species. Fin-rays attain full complement at about 20 mm in body length. Ventral fin tends to be somewhat longer, as compared with that of sailfish larvae (Fig. 7). Dorsal fin starts to increase its height at around 10 mm, and stands very high like a sail in specimens exceeding 20 mm.

Pigmentation: No chromatophores are recognized on branchiostegal membrane or periphery of the underpart of the lower jaw except the tip. At around 7–8 mm in body length, the pigmentation pattern comes to cover most part of the lateral side of the body. At about 8 mm in length, a few chromatophores appear on dorsal fin membrane and, at

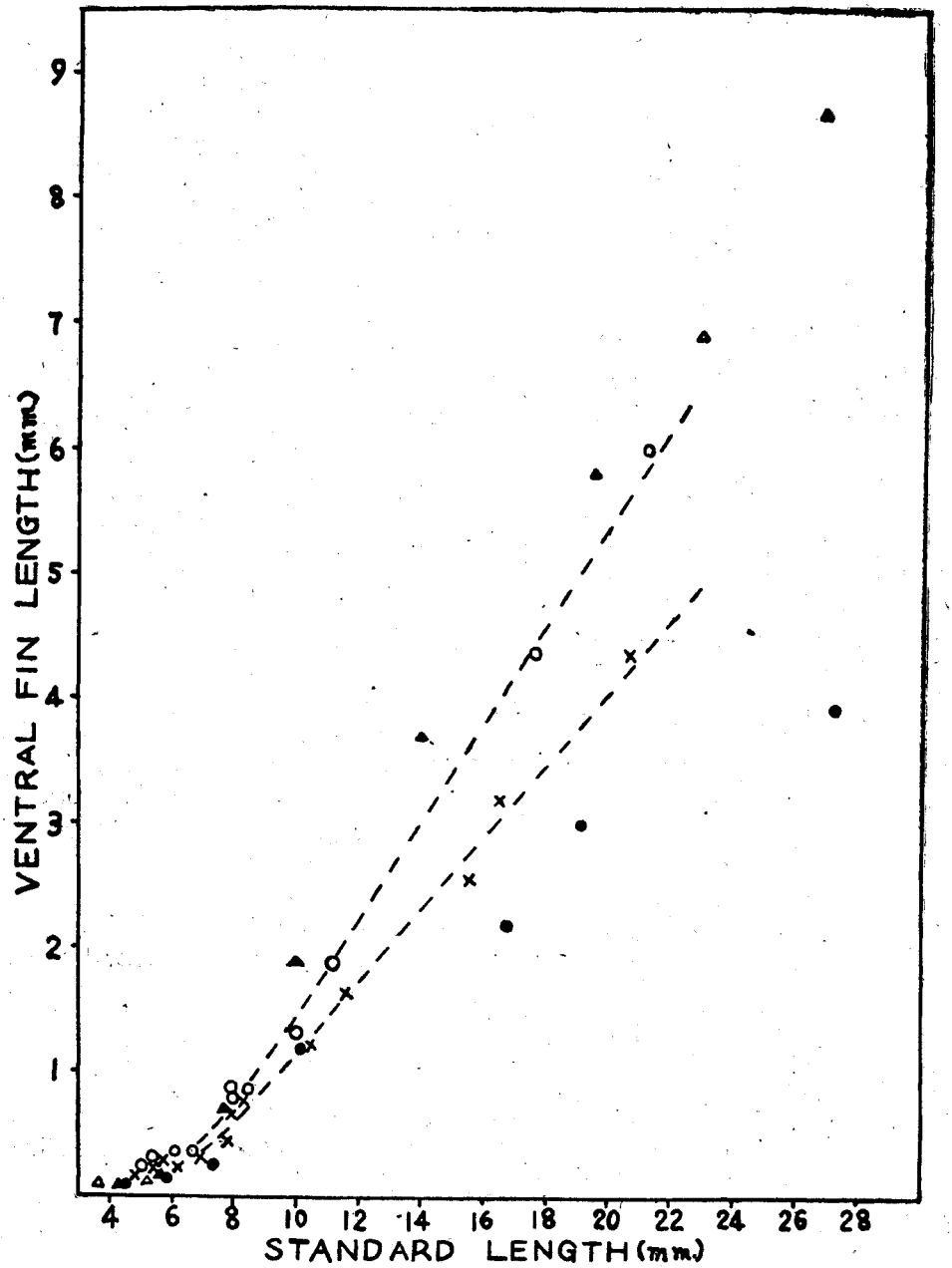


Text Fig. 6. Larvae of *Makaira mitsukurii*.

about 17 mm, they scatter almost over the fin, concentration of which is recognized as four stripes.

4. Black marlin—*Eumakaira nigra*

Over 1,000 specimens have been collected from the Indian and Pacific Oceans mostly by larval net and the rest by dip-net. The size of specimens was mostly under about



Text Fig. 7. Relation between ventral fin length and standard length.
Black dots represent shortnosed spearfish ; crosses, sailfish ; circles, striped marlin ; black triangles, black marlin ; white triangles, white marlin.

7 mm, ranging from 3 mm to 33 mm. The most outstanding characteristics of black marlin larvae are their short snout and vertebral formulae. The formula of this species is 11 + 13, like white marlin and is different from that of shortnosed spearfish, sailfish, and striped marlin, which is 12 + 12. The larvae and adults of black marlin are markedly different in their external appearances, as in the case with shortnosed spearfish. In sailfish and striped marlin, there are no such differences.

Head : The profile of head is characterized by a short snout, large eyes and the protruding anterior edge of orbit. The snout length can be used as the basis of identification only in specimens exceeding about 7 mm, because in the smaller specimens under 5 mm, the snout of black marlin is no shorter than that of the other species. In specimens of 15 mm and over, the growth of snout is negatively allometric to that of the body length. The quotient of snout length by diameter of orbit is smaller than that of any other istiophorid species (Fig. 3). The larvae of this species with large eyes and short snout resemble those of shortnosed spearfish in specimens under 7 mm length, but can be recognized by their protruding anterior edge of orbit and narrower frontal.

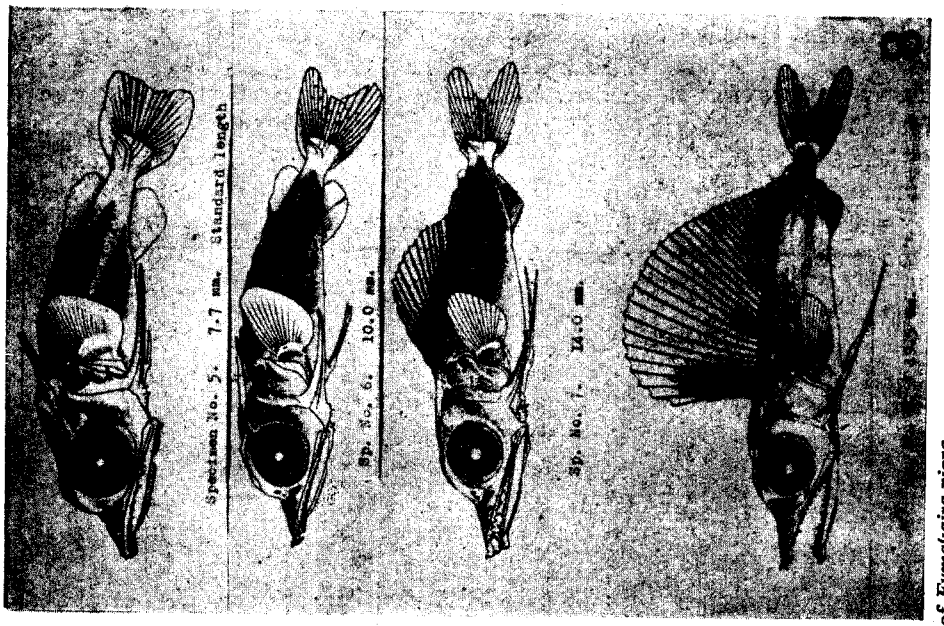
Head spination and scaling : The development of head spination of this species is much the same as that of the foregoing three species ; shortnosed spearfish, sailfish and striped marlin. Their pterotic and preopercular spines become longest relative to their body length when they are 6-7 mm in body length. Thereafter, the spination tends to degenerate gradually. Spine-like scales appear on the body surface at about 20 mm, and come to cover almost all of it at about 25 mm. Their specific lateral line pattern is recognized in specimens over 25 mm.

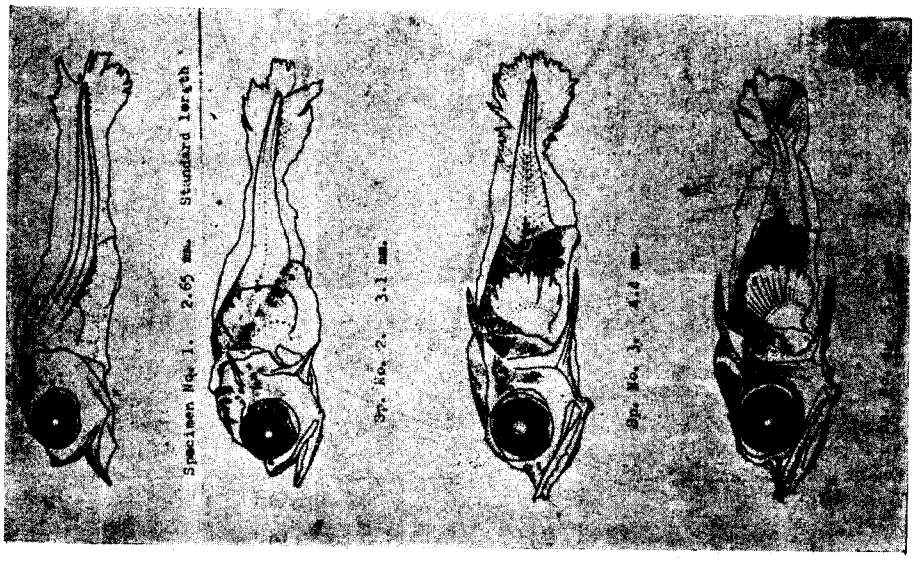
Fin-formation : The process of fin-formation is also much alike that of the foregoing three species. Number of rays of different fins reaches full complement when they are about 15 mm in body length. The dorsal fin starts to rise towards its front end at about 10 mm, and becomes prominently high in specimens of 20 mm and over. The shape of this fin differs from that of the sailfish in which the height of it increases posteriorly. The growth of ventral fin is noticeably faster, as compared with the other species (Fig. 7). Forking of the caudal fin starts at about 7 mm in body length and progresses to a considerable extent at around 20 mm.

Pigmentation : Development of their pigmentation on the ventral side lags slightly behind that of shortnosed spearfish. The pigmentation pattern on the lateral side reaches the caudal peduncle when they are 10 mm in body length. At this stage, chromatophores also begin to appear on the dorsal fin. At 20 mm or thereabout, the pigmentation pattern comes to cover all the body surface, except a very limited portion of the hypural plate. The pigmentation of the dorsal fin also makes considerable progress at this body length and the entire fin is covered with dark brown spots, concentrations of which are recognized as five distinct stripes. The pigmentation pattern beneath the head is found, unlike shortnosed spearfish or sailfish, only on the tip of the lower jaw.

5. White marlin—*Marlina marlina*

Inspite of our extensive search, only 5 specimens, either over 20 mm or below 6 mm in body length, have been collected from the Indian and Pacific Oceans. Because of such

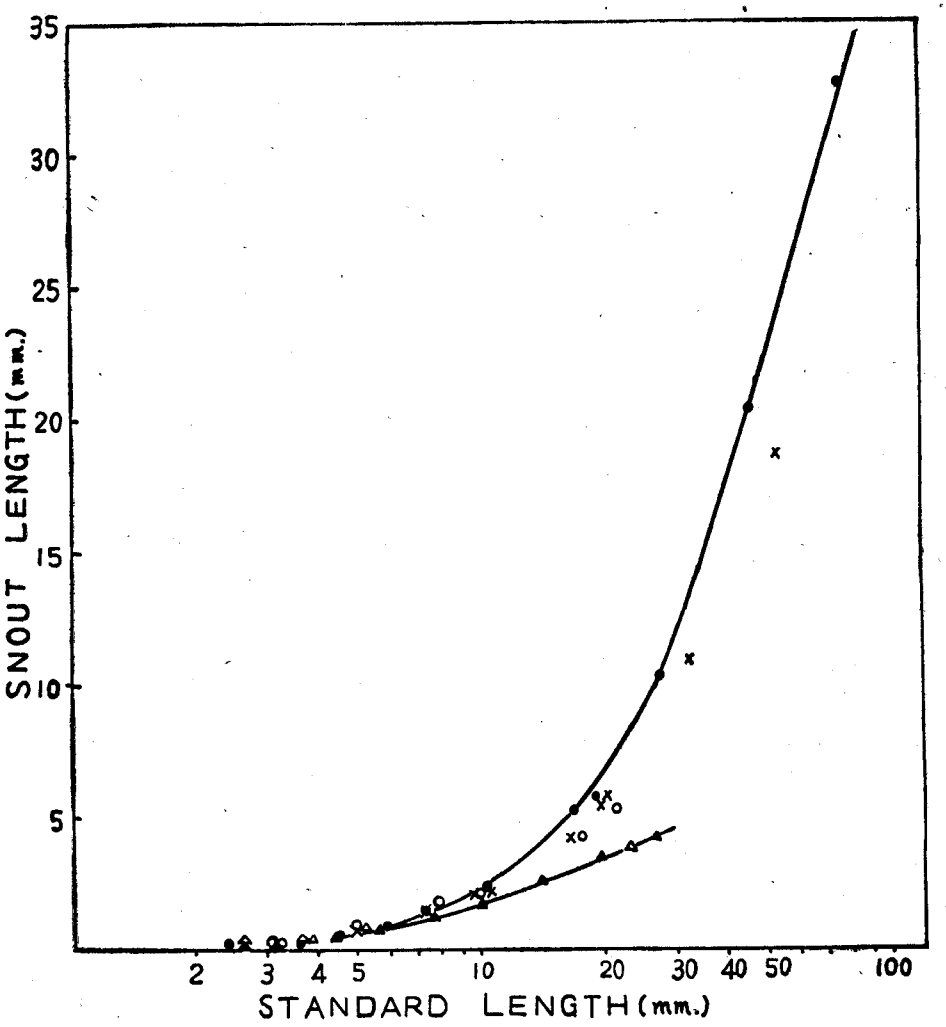




Text Fig. 8 (*a*). Larvae of *Eumakaira nigra*.

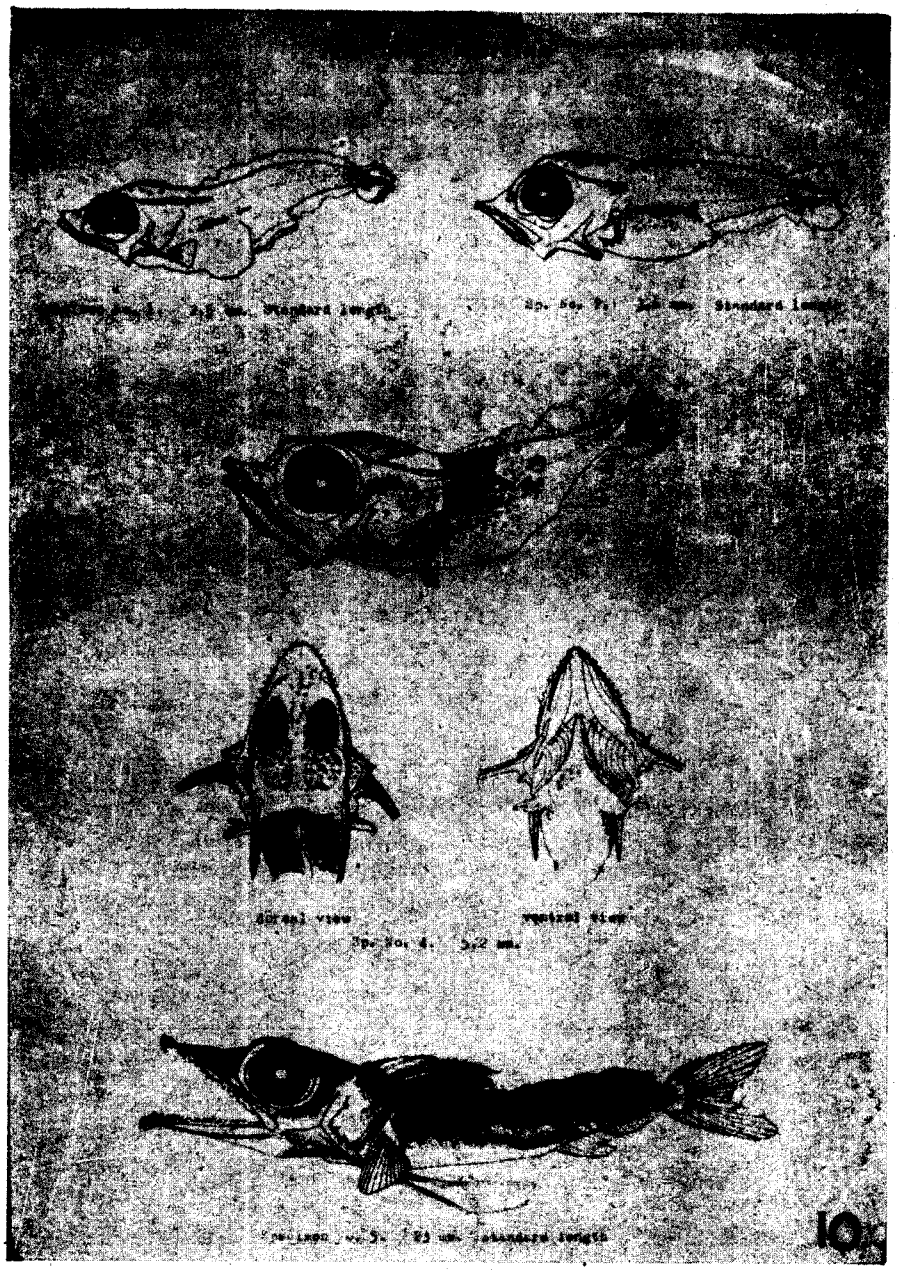
small number of available specimens and lack of those of the intermediate length, our knowledge on this species is still very imperfect. The back of the larvae is slightly concave, or slightly rising forwards and backwards from where the head joins the trunk. This species can be identified also by their short snout, specific shape of pectoral fin, and vertebral formulae (11+13).

Head: The profile of head resembles that of black marlin larvae because of their short snout, but can be discriminated from the latter by the latter's projecting anterior edge of orbit. The snout is also somewhat longer than that of black marlin in small specimens under 6 mm.



Text Fig. 9. Relation between snout length and standard length.
Black dots represent shortnosed spearfish ; crosses, sailfish ; circles, striped marlin ; black triangles, black marlin ; white triangles, white marlin.

Head spination and scaling: Presumably, there will be no marked difference, as compared with other species.



Text-Fig. 10. Larvae of *Marlina marlina.*

Fin-formation : The pectoral fin of the larvae over 3.5 mm is very unique in shape. In specimen of 3.5 mm in length, it stands out rigidly from the lateral side of the body at a right angle, and cannot be folded without breaking the joint. In specimen of 5 mm and thereabout, not only this characteristic in shape becomes more distinct, but also the fin is turned slightly counter-clockwise, because of the distortion of the base of the fin. Even in specimen of 23 mm in length, such transformation of the fin is not complete yet but

progresses to the extent sufficient to connect with the shape of the adult's. This species seems to be different from the other species in the shape of the dorsal fin too.

Pigmentation : Since specimens between 6 mm and 20 mm are not available, it is not possible to trace the process of the development of pigmentation all through their larval stage. However, it is presumed that there will be no substantial difference between white marlin and the other istiophorid species.

COMPARISON OF MORPHOLOGICAL CHARACTERS BETWEEN SPECIES

It is not easy to identify the larvae of different istiophorid species, because of their close resemblance with each other and of marked difference from their respective adults, generally speaking, in their morphological characteristics. This is particularly true with those of very early stage before the snout develops its specific characteristics. However, the specific separation of the larvae is possible throughout their entire range mainly on the basis of their head profile.

Following are the criteria for identification :

(1) *Larvae under 5 mm in length :* The characters, as shown in Table A, can be used for specific separation, although snout length does not provide a useful clue.

TABLE A

Summary of the prominent diagnostic characters of istiophorid larvae

Species characters	*Tetrapturus angustirostris*	*Istiophorus orientalis*	*Makaira mitsukurii*	*Eumakaira nigra*	*Marlina marlina*
Profile of head	Tip of snout is lower in level than center of eye.	Same to the left.	Tip of snout and centre of eye are on a nearly equal level.	Tip of snout is lower in level than center of eye.	Same to the left.
	Anterior edge of orbit does not project forward.	Same to the left.	Same to the left.	Anterior edge of orbit projects forward.	Anterior edge of orbit does not project forward.
Presence or absence of chromatophores on the branchiostegal membrane.	Present (*See* Fig. 1)	Absent Chromatophores generally present on the peripheral zone of lower jaw membrane.	Absent	Absent	Absent
Pectoral fins ...	Fins extend along the lateral side of the body and can be readily folded against the side of the body.	Same to the left.	Same to the left.	Same to the left.	Fins stand out from the lateral side of the body at a right angle and cannot be folded against the body without breaking the joint.

(2) *Larvae between* 5 *and* 10 *mm in length :* Besides the criteria given in Table A, snout length and size of eyes can be used. Black marlin larvae are recognized by their short snout (Fig. 5). The ratio of snout length to diameter of orbit is largest in sailfish, smallest in black marlin, and is between in shortnosed spearfish. More precisely, the ratio tends to be >1 in sailfish, <1 in black marlin, and $=1$ in shortnosed spearfish in specimens 7—8 mm length.

(3) *Larvae between* 10 *and* 20 *mm in length :* They are grouped into two on the basis of their snout length; the long snout group with shortnosed spearfish, sailfish and striped marlin, and the short snout group with black and white marlins. In the former, the snout length exceeds 1/5 of their body length, while in the latter, it does not. For the specific separation of the former group, Table A applies ; shortnosed spearfish is distinguishable by black chromatophores on branchiostegal membrane, while sailfish is separated from striped marlin by the difference of their head profile : Unlike striped marlin with a straight snout, sailfish has a beak-like snout. And because of this difference in the shape of the snout, they are separable by the difference of the location of snout in terms of the center of eyes. In sailfish, the center of eyes is above the tip of snout, while in striped marlin, they are on a nearly same level.

Separation of white marlin from black marlin can be made on the basis of the form of the pectoral fin.

(4) *Larvae over* 20 *mm in length :* On top of the criteria of Table A, the following characters, as listed in Table B, can be applied.

TABLE B

Diagnostic characters usable in distinguishing the istiophorid larvae more than 20 mm in standard length'

Species characters	*Tetrapturus angustirostris*	*Istiophorus orientalis*	*Makaira mitsukurii*	*Eumakaira nigra*	*Marlina marlina*
Number of first dorsal fin-rays.	More than 48	43—47*	Less than 45	Less than 45	Less than 45
Snape of first dorsal fin.	Anterior-high type.	Posterior-high type.	Anterior-high type.	Anterior-high type.	Anterior-high type (presumed)
Lateral line.	Single.	Single.	Single.	Complex-having branches.	Not single (?) ** (obscure).

* This range is estimated from a small number of materials examined, so it seems to become somewhat wider with an increase of materials.

** Lateral line pattern is not yet ascertained.

In addition to the above, the distance between anus and the first anal fin insertion works as a reference to discriminate shortnosed spearfish. The distance of the said species is larger, as compared with the other species.

The vertebral formulae are also useful tools for separation: the formulae of shortnosed spearfish, sailfish and striped marlin are all 12+12, while those of black and white marlin are 11+13.

Notes on the dubious specimens reported as Istiophorus larvae from the Pacific Ocean

The author re-examined specimens described and illustrated as *Istiophorus* larvae by Sun Tsi-Gen (1960) and found a few dubious specimens.

Among the specimens which he described and illustrated as *Istiophorus orientalis*, specimens No. 3 (Fig. 5c; 19.1 mm in total length) and No. 4 (Fig. 5d; 30.5 mm in total length) seem to be black marlin, *Eumakaira nigra*, because of their short snout. Furthermore, one specimen (Fig. 7), described and illustrated as juvenile of *Tetrapturus angustirostris*, will presumably be that of *Eumakaira nigra*, by the same reason.

GEOGRAPHICAL DISTRIBUTION OF LARVAE

Irrespective of species, areas of collection have been limited to the waters between 30° N and 30° S. In the tropical waters, they occurred throughout the year, while in the region between 20° and 30° in latitude seasonal variation was observed in their occurrence. In terms of surface temperature, their distribution appears to be limited by 24°C isotherm or thereabout. On the basis of the above information, it seems to be reasonable to conclude that the tropical and subtropical waters of the Indian and Pacific Oceans are their spawning grounds.

(1) *Shortnosed spearfish:* No collection has been reported from the Indian Ocean. In the Pacific Ocean, the occurrence has been reported from a very extensive area, as shown in Fig. 11, concentrating in the area between 10° N and 25° N. In terms of season, they were collected in May, June, July, August, October, November, December, January and February, or almost throughout the entire year. Accordingly, it seems quite logical to assume that their spawning takes place, in all four seasons, in the tropical and subtropical waters north or south of 25° latitude. This assumption is supported by the results of the gonad analysis of adults (Fig. 12). Their spawning seems to be more active in winter than in summer, because larvae are found in abundance from the waters close to 20° N in winter*.

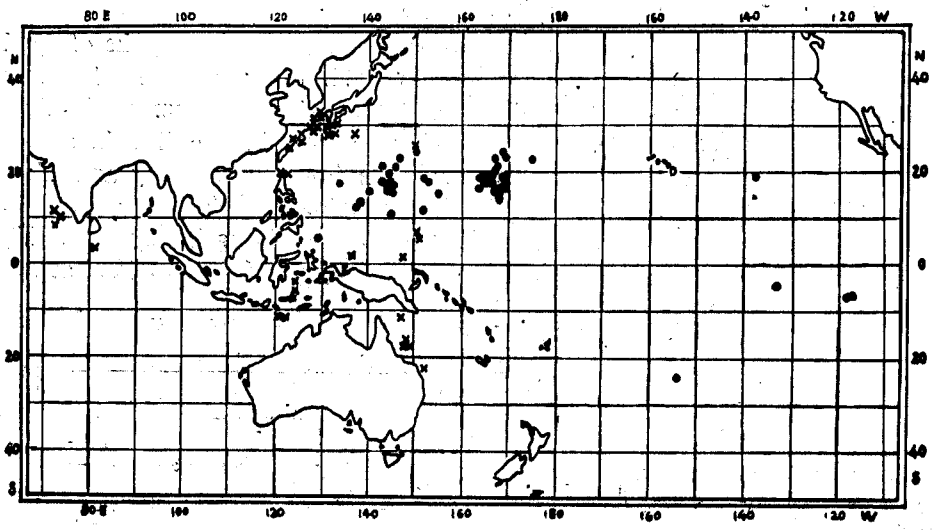
(2) *Sailfish:* Unlike shortnosed spearfish larvae, sailfish larvae are found mainly in the waters close to islands (Fig. 11)**. In the northwest Pacific, the occurrence in the Kuroshio current and its vicinities was most eminent.

These observations indicate that their main spawning grounds lie in the waters close to islands, although this does not rule out the possibility of their spawning in open sea. Months of collection were January, February and April in the Indian Ocean and Indo-Australian Archipelago area. October and November in the Coral sea, July and November in the equatorial waters of the Pacific Ocean, and May through September in the northwest Pacific Ocean. Although nothing conclusive can be stated regarding their spawning

* In the case of the other species, they are usually found in abundance in summer.

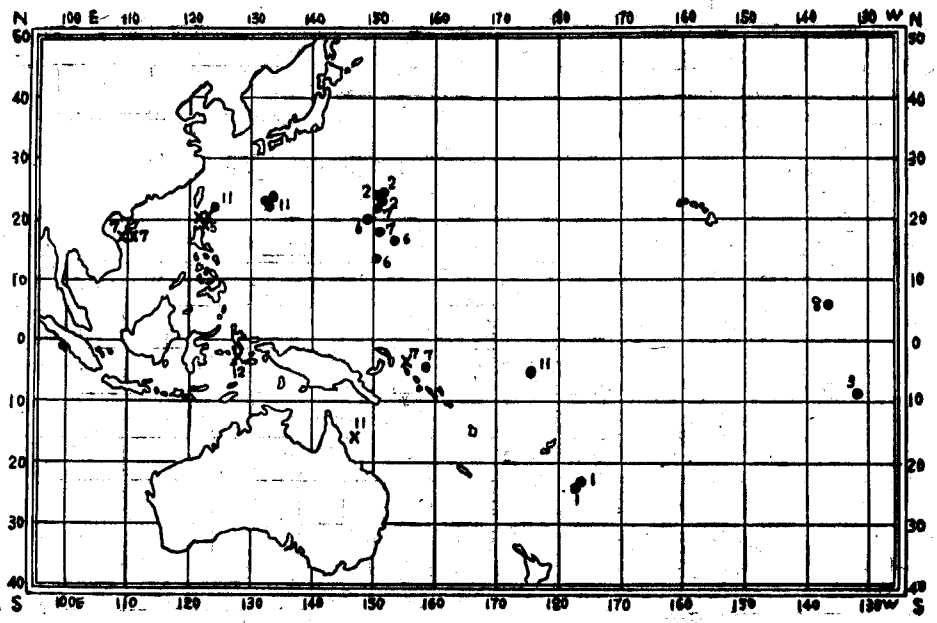
** Data of Jones (1959) are also included.

season because of the lack of sufficient data, the above knowledge seems to suggest that it will be summer in the northwest Pacific, southern summer in the South Pacific, and pre-



Text Fig. 11. Areas of capture of larval specimens. Black dots indicate shortnosed spearfish ; crosses, sailfish.

sumably throughout the year in the equatorial waters. This assumption is supported by the distribution of mature females (Fig. 12).

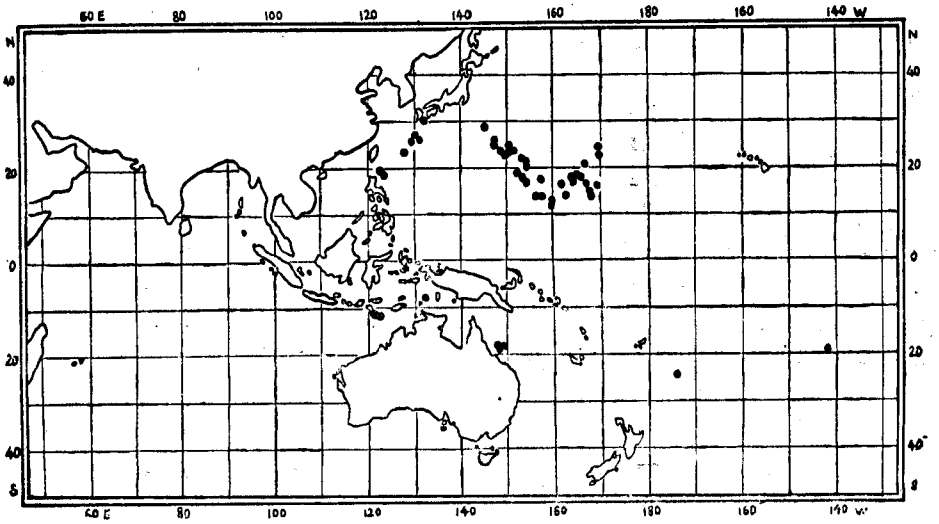


Text Fig. 12. Areas of capture of mature female. Black dots indicate shortnosed spearfish ; crosses, sailfish ; numerals, the month in which mature females were caught.

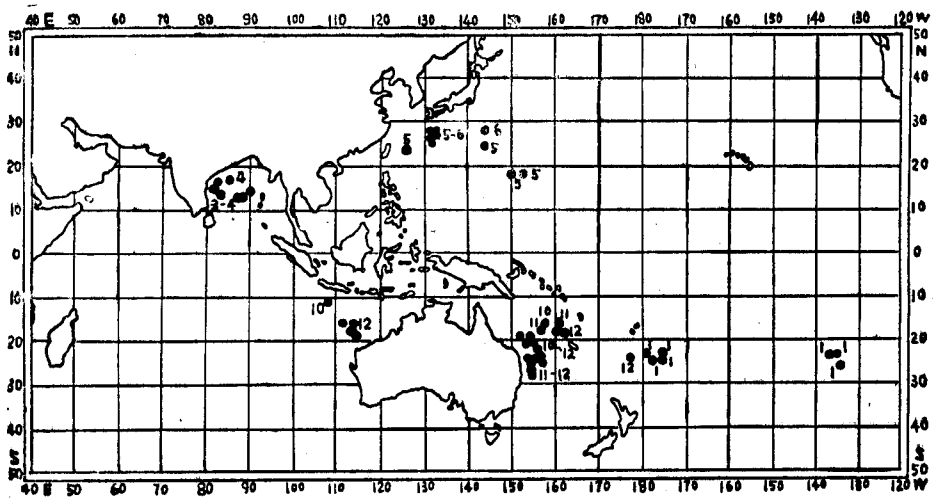
(3) *Striped marlin:* As summarised in Fig. 13, the area of larval striped marlin's occurrence is very extensive, and yet very specific. Their occurrence is limited to the waters between 10° N and 30° N in the North Pacific and around 20°S in the South Pacific and has

never been reported from the equatorial waters in between. The season of their occurrence varies between the North and South Pacific; May through June in the North Pacific and October through January in the South Pacific.

These characteristics on their occurrence indicate that the stocks of the North and South Pacific are separate and independent with each other and that their spawning season is early summer of the respective hemisphere. This is also in agreement with the occurrence of mature females (Fig. 14). The spawning season in the Banda and Timor Seas is assumed to be winter, because larvae have been found in January and February. In the Indian Ocean, the abundance of adult striped marlin, particularly of mature females, is known to increase March through May in the Ceylon—Bengal Bay area (Fig. 14). Accordingly it may be assumed that their spawning activity will be intensified at this time



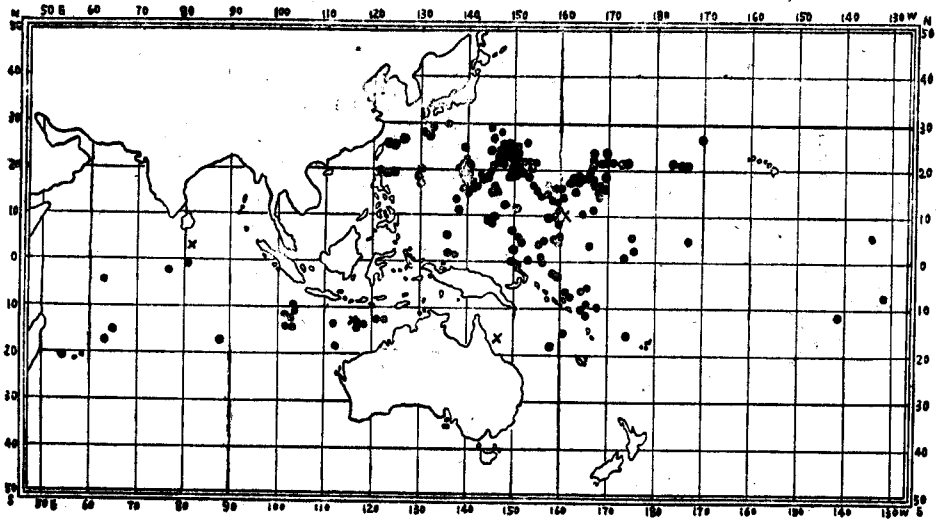
Text Fig. 13. Areas of capture of larval specimens of striped marlin.



Text Fig. 14. Areas of capture of mature females of striped marlin.
Numerals indicate the month in which mature females were caught.

of the year, although this assumption cannot be substantiated in the absence of reports on the occurrence of their larvae.

(4) *Black marlin :* Since the occurrence of black marlin larvae has been reported throughout the tropical and subtropical waters between 30° N and 20° S (Fig. 15), it is assumed that their spawning grounds also extend all over this entire area. The number of black marlin larvae collected far exceeded that of the other species. This indicates that the abundance of black marlin larvae is higher in oceanic waters than that of any other species. The season of their occurrence is shown in Table 2, which can be summarized that it extends almost throughout the year in the low-latitude waters of the Indo-Pacific, and that it tends to concentrate in summer north of 22°N of the north Pacific. (In the north Pacific, there has been only one exceptional report in October, presumably carried by the flow of the Kuroshio Current). On the basis of the above information, it is assumed that spawning takes place throughout the year in the low-latitude waters where the sea conditions are quite stable, and is limited to summer in the waters north of 20° N where the sea conditions are subject to seasonal fluctuations.



Text Fig. 15. Areas of capture of larval specimens. Black dots indicate black marlin (*Eumakaira nigra*) ; crosses, white marlin (*Marlina marlina*).

TABLE 2

Monthly occurrence of the black marlin larva by areas

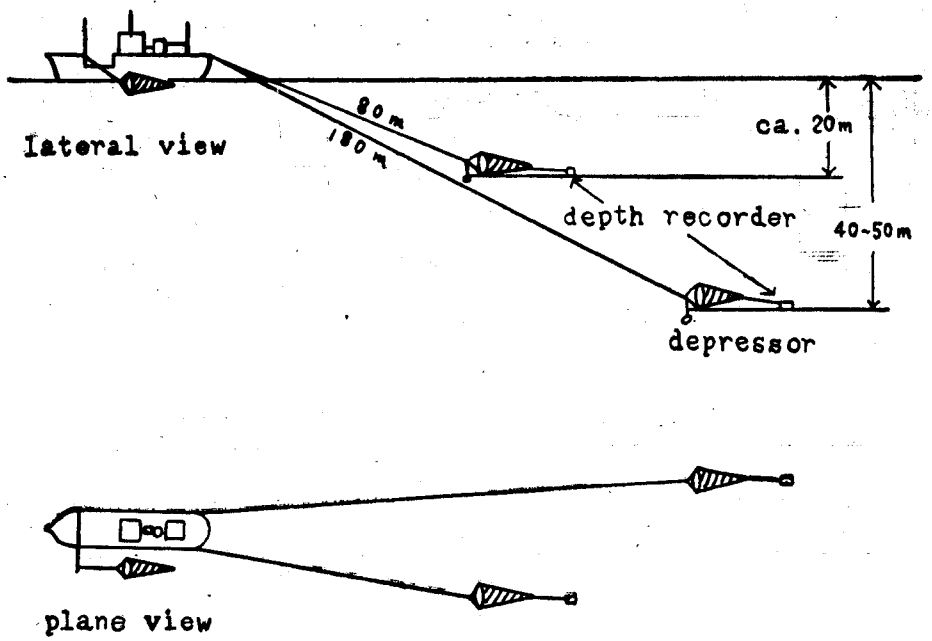
		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Indian Ocean		O	O	O		O	O	O				O	O
Pacific Ocean (22° N–20° S)				O		O	O	O	O	O	O	O	O
Pacific Ocean (North of 22°N).	A					O	O	O	O		O		
	B					O	O	O					

A..... Kuroshio Current Area. B..... Out of Kuroshio Current Area.

(5) *White marlin:* Information is very limited because of insufficient number of available specimens. However, on the basis of the distribution of their larvae (Fig. 15), it may be assumed that their spawning takes place in a vast area extending over tropical and subtropical waters as in the case of the other istiophorid species. It also seems that their spawning does not occur uniformly over the above mentioned area, but tends to concentrate in the Indo-Australian Archipelago area and be less active in oceanic waters, as indicated by the distribution of adults and the conditions of their gonads. In the coastal waters of the northeast Australia, which is presumed to be one of the most important spawning areas, white marlin larvae were collected in November. Results of the gonad analyses also indicate that October and November will be the peak of their spawning season.

VERTICAL DISTRIBUTION OF LARVAE

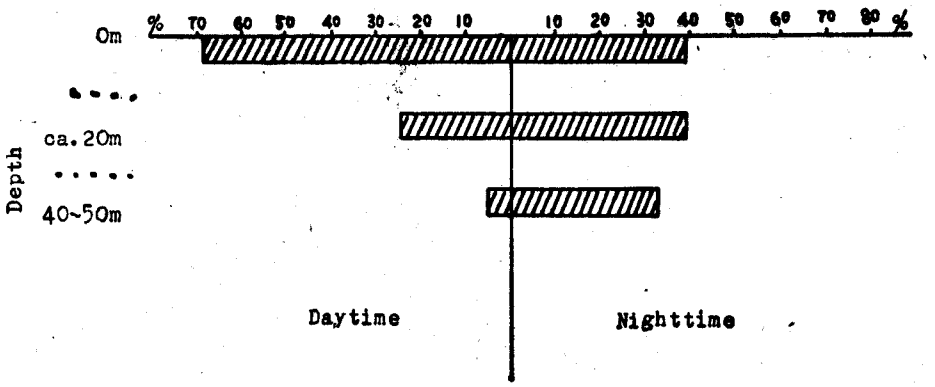
Since 1958, Shunyo-maru, 184 gross ton research vessel of NRFRL has made three cruises to the western Pacific (0°~25° N, and 135°~150° E) and conducted the survey on the vertical distribution of istiophorid larvae. The periods of the three survey cruises were November to December of 1958 and 1959, and July of 1960. Sampling was conducted by the three layer simultaneous horizontal towing with use of three non-closing larval nets, each 2 m in diameter (Fig. 16). Towing was made at the speed of 2 knots for half an hour, starting from 000, 400, 800, 1200, 1600 and 2000 hours. The results of the three cruises were summarized in Table 3 and Fig. 17, where daytime collection is the sum of the collections made at 800, 1200 and 1600 hours, and nighttime collection the sum of those made at 2000, 000, and 400 hours.



Text Fig. 16. Diagram illustrating the method of net towing used for studies of vertical distribution of larvae.

The results of the three survey cruises show that during the daytime istiophorid larvae are most abundant in the surface layer and that their abundance decrease with depth. During

the night, the distribution of the larvae are approximately equal at all depths sampled (down to 50 m.) suggesting that there has been a downward migration of the istiophorid larvae from day to night. The vertical distribution of the istiophorid larvae during the daytime samples suggests that they are not present in great numbers below 50 m.



Text Fig. 17. Vertical distribution of larvae showing. (*a*) Percentage number of tows from which larvae were captured. (*b*) Depth distribution with time.

TABLE 3

Comparison of numbers (and percentage) of tows from which istiophorid larvae were captured, showing the various depths and times of towing, in Western Pacific area

	Day		Night	
Total number of tows	32		31	
Depth in meters	No.	%	No.	%
0 ...	22	68.8	12	38.7
Ca. 20 ...	8	25.0	12	38.7
Ca. 40—50 ...	2	6.2	10	32.3

SUMMARY

1. The larvae of five istiophorid species distributed in the Indo-Pacific areas—short-nosed spearfish (*Tetrapturus angustirostris*), sailfish (*Istiophorus orientalis*), striped marlin (*Makaira mitsukurii*), black marlin (*Eumakaira nigra*), white marlin (*Marlina marlina*)—are

described from larval net tows and dipnetting collections obtained in a vast area of the Indian and Pacific Oceans.

2. The diagnostic characters suggested to be effective in the identification of the species are as follows :

(*a*) *Tetrapturus angustirostris* : Presence of chromatophores on the branchiostegal membrane.

(*b*) *Makaira mitsukurii* : On the profile of head, tip of snout and center of eye are nearly in equal level.

(*c*) *Istiophorus orientalis* : On the profile of head, tip of snout is lower level than center of eye and anterior edge of orbit does not project forward (eye is relatively small).

Of these three species, snout is markedly elongated (more than one-fifth of the standard length) in larvae above 10 mm. size.

(*d*) *Eumakaira nigra* : Snout is short (less than one-fifth of the standard length), eye is large and anterior edge of orbit projects forward.

(*e*) *Marlina marlina* : Short snout (similar to *E. nigra*); pectoral fin stands out from the lateral side of the body at a right angle and fin cannot be folded against the side of the body without breaking the joint between the fin and the shoulder girdle.

3. Judging from the diagnostic characters found, there are a few doubtful specimens in the larvae of *Istiophorus orientalis* reported (described and figured) by Sun Tsi-Gen (1960) from the western and central Pacific Ocean, and those specimens are suggested to be the larvae of *Eumakaira nigra*.

4. Larvae of istiophorid species occur generally in the tropical and subtropical lower latitudinal area from about 30° latitude (at temperature more than 24°C). For *Istiophorus orientalis* and *Marlina marlina*, abundance distribution of larvae is suspected to be high in waters in the vicinity of islands, whilst the other three species are found in the more oceanic areas. Larvae of *Tetrapturus angustirostris* were found to occur over a wide area between 25°N to 25°S lat. of the Pacific Ocean nearly in all seasons. Larvae of *Makaira mitsukurii* were not found to occur in the tropical area (10°N—10°S lat.) of the Pacific Ocean. From the occurrence of larvae and mature females, spawning of this species is presumed to take place during early summer season in the areas between 10°N to 30°N lat. of the North Pacific, and also during early (Southern) summer in the areas around 20°S lat. of the South Pacific. In the Indian Ocean, spawning probably takes place during March to May in Bay of Bengal and during January to February in the Banda Sea and adjacent seas of Timor Is. Larvae of *Eumakaira nigra* are the most abundant of the five species and found to occur over a vast area between 30°N and 20°S lat. in the Pacific Ocean and between 0° to 20° lat. in the Indian Ocean. From the seasonal occurrence of larvae, spawning of this species appears to take place throughout the year in the lower latitudinal area from about 20° latitude and during summer season in the higher latitudinal (20°N—30°N lat.) area. Indo-Australian Archipelago area seems to be the important spawning area for *Marlina marlina*.

5. Larvae appear to be distributed most abundantly in the surface layer and their abundance rapidly decreases with depth during the daytime. Vertical, diurnal migration seems to occur in the upper 50 meters of waters.

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APPENDIX

TABLE 1

Data of capture and measurements of the specimens selected for the description',—Shortnosed spearfish, *Tetrapturus angustirostris* (Tanaka)

Specimen No.	1	2	3	4	5	6	7	8	9	10	11
Date	1954 XII–13	1960 VII–10	1958 XII–9	1960 XII–5	1960 II–25	1960 II–25	1953 II–2	1960 II–25	1960 II–5	1960 II–25	1957 I–2
Locality	12°00′N 152° 13.5′E	19°51′N 144° 27′E	11°49.5′N 138° 11.5′E	15°26′N 145° 52.5′E	17°17′N 145° 10′E	17°17′N 145° 10′E	18°30′N 134° 30′E	17°41′N 145° 03′E	6°30′S 117° 16.5′W	17°41′N 145° 03′E	21°30′N 146° 26′E
Measurement in mm.—											
Total length	Ca. 2.5	3.8	4.7	6.2	8.5	11.8	19.3	22.2	30.5	Ca. 51	83
Standard length	Ca. 2.4	3.6	4.5	5.9	7.4	10.2	16.8	19.1	27.2	Ca. 46	76
V. F.—A. F. *	...	...	Ca. 1.2	Ca. 1.8	2.3	2.6	4.2	Ca. 4.7	6.3	Ca. 12.5	19
Snout length	0.10	0.23	0.55	0.9	1.43	2.2	5.1	5.7	10.2	20.5	32.7
Dia. of orbit	0.36	0.55	0.85	1.12	1.49	1.7	2.2	2.25	2.3	3.2	3.9
Dia. of eye	0.34	0.49	0.75	0.96	1.29	1.5	2.0	2.15	2.15	3.1	3.5
Postorbital length	0.23	0.42	0.59	0.78	1.09	1.6	2.0	2.35	2.7	3.8	5.8
Upper jaw length	0.44	0.59	1.18	1.85	2.8	3.8	7.1	7.9	12.4	24.0	35.8
Lower jaw length	0.45	0.62	1.16	1.82	2.7	3.5	5.3	5.6	6.2	10.0	13.8
Head length	0.69	1.18	1.95	2.7	4.0	5.5	9.3	10.3	15.2	27.5	42.4
Head depth	...	Ca. 0.9	1.38	1.7	Ca. 2.2	Ca. 2.5	3.1	3.3	3.6	4.9	6.0
Head width	0.37	0.68	1.12	1.4	1.82	2.1	2.6	2.7	2.9	3.5	4.2
Pterotic spine	...	0.25	0.78	0.8	...	1.0	0.9	1.15	0.9	0.8	Ca. 0.7
Preopercular spine	...	0.45	0.95	1.5	1.55	2.0	1.75	2.4	2.3	2.8	Ca. 2.6
Body height—											
at ventral fin origin	...	Ca. 0.9	Ca. 1.3	1.65	2.05	2.4	3.2	3.2	3.4	...	6.2
at anal fin origin	...	0.35	Ca. 0.6	...	...	1.7	2.35	2.0	2.2	...	3.0
Body width	..	..	Ca. 1.1	1.2	...	Ca. 1.5	2.5	Ca. 1.8	Ca. 2.2	...	Ca. 4
Pectoral fin ray length	Ca. 0.3	0.5	0.65	0.75	1.2	1.6	2.5	2.6	3.0	5.4	8.3
Ventral fin ray length	...	...	Ca. 0.1	Ca. 0.16	0.5	1.2	2.2	3.0	3.9	8.8	13.5
Anal fin ray length	...	...	...	...	..	...	...	Ca. 1.15	Ca. 1.3	2.1	3.3
Dorsal fin ray length—											
4th	..	..	...	...	...	...	...	Ca. 2.5	Ca. 3.4	5.5	Ca. 7
7th	...	...	...	...	...	...	...	...	4.7	9.5	15
10th	...	...	...	...	...	...	...	Ca. 4.0	5.0	11.0	16
13th	..	...	...	..	...	...	...	...	5.0	...	...
15th	...	...	...	...	...	..	...	...	5.0	...	16
17th	..	...	...	...	...	...	...	...	4.3	..	...
20th	...	...	...	...	...	...	...	...	3.6	7.0	13
Counts—											
No. of pectoral fin rays	...	...	...	..	..	...	17	17	17	..	18
No. of anal fin rays	..	...	...	...	...	...	...	25	25	..	..
No. of dorsal fin rays	...	...	...	...	...	...	...	...	57	55	55

* The distance from the ventral fin origin to the anal fin origin.

TABLE 2

Data of capture and measurements of the specimens selected for the description,—Sailfish, *Istiophorus orientalis* (J. & S.)

Specimen No.	1	2	3	4	5	6	7	8	9	10
Date	1949 V–26	1950 VIII–8	,,	1952 VIII–12	1949 V–26	1952 IX–13	1952 VII–10	1950 VIII–8	1953 I–21	1955 VII–18
Locality	26°23′N 126° 32′E	30°N 31°N 131° 132°E	,,	30°36′N 132° 17′E	26°23′N 126° 32′E	30°35′N 132° 17.5′E	31°06′N 131° 49′E	30°N–31°N 131°E 132°E	6°53′S 124° 06′E	32°30′N 132° 30′E
Measurements in mm.—										
Total length	3.4	5.4	8.9	11.2	11.9	18.6	23.5	23.5	37.6	Ca. 59
Standard length	3.3	5.1	7.8	9.7	10.5	16.5	19.8	20.3	33.2	Ca. 53
V. F.—A. F. *	...	Ca. 1.2	Ca. 2.5	2.8	Ca. 2.7	5.0	5.5	5.7	9.4	14.5
Snout length	0.2	0.6	1.4	2.1	2.2	4.1	5.4	5.8	11.0	18.6
Dia. of orbit	0.4	0.6	1.1	1.4	1.5	1.9	2.2	2.0	2.5	3.0
Postorbital length	0.4	0.7	1.1	1.4	1.5	2.3	2.7	3.2	3.5	5.0
Upper jaw length	0.54	1.1	2.7	3.5	3.8	6.0	7.8	8.2	13.7	21.8
Lower jaw length	0.5	1.0	2.3	3.1	3.3	5.1	6.0	5.9	8.0	10.0
Head length	1.0	1.9	3.6	4.9	5.2	8.0	10.2	10.9	17.0	26.0
Head depth	...	...	2.0	2.3	2.6	3.1	3.3	3.4	3.8	4.8
Head width	...	1.2	1.7	2.0	2.2	2.7	2.7	2.8	3.1	3.6
Pterotic spine	0.1	0.8	...**	...**	1.1	1.1	1.1	1.1	1.1	0.9
Preopercular spine	0.36	1.4	1.6	2.0	2.2	2.7	2.3	3.3	2.8	2.6
Body height—										
at ventral fin origin	0.85	1.2	2.0	2.2	2.5	3.0	3.6	3.4	4.5	5.0
at anal fin origin	...	0.8	1.5	1.5	1.5	2.0	2.3	1.9	2.9	3.7
Body width	0.7	0.9	1.5	1.7	1.9	2.4	1.9	1,7	2.3	2.3
Pectoral fin ray length	...	0.55	1.2	1.45	1.35	1.8	2.9	2.9	4.0	5.5
Ventral fin ray length	...	0.15	0.55	1.0	1.0	3.3	4.5	4.6	8.2	12.3
Dorsal fin ray length—										
4th	...	...	...	0.85	...	...	2.43	..	2.0	7.7
5th	...	...	...	1.0	...	...	3.06	...	4.1	9.6
13th	...	...	...	1.0	...	...	5.86	...	10.0	15.7
20th	...	...	...	...	...	...	4.51	...	8.7	13.5
Counts—										
No. of pectoral fin rays	...	...	...	...	...	...	...	20	...	...
No. of anal fin rays	...	..	...	..	...	...	...	23	26	23
No. of dorsal fin rays	...	...	...	...	...	...	...	49	..	..

* The distance from the ventral fin origin to the anal fin origin. ** Damaged.

TABLE 3

Data of capture and measurements for the specimens figured

Striped marlin, *Makaira mitsukurii* (J. & S.)

Specimen No.	1	2	3	4	5	6	7
Date	1958 XI–23	1953 V–5	1953 V–5	1953 V–5	1952 VIII–12	1952 V–21	1952 VI–25
Locaity	18°20′S 141°35′W	19°17′N 123°02′E	19°17′N 123°02′E	19°17′N 123°02′E	30°30′N 132°23′E	24°08′N 127°58′E	26°45′N 131°17′E
Measurements in mm.—							
Total length	3.03	3.23	Ca. 5.4	9.0	11.6	Ca. 20	Ca. 24
Standard length	2.9	3.1	5.0	7.9	10.0	17.6	21.2
V. F.—A. F. *	...	...	1.5	2.3	Ca. 2.6	5.1	Ca. 6.0
Snout length	0.25	0.30	0.80	1.7	2.15	4.2	5.2
Dia. of orbit	0.40	0.47	0.89	1.30	1.60	2.2	2.3
Postorbital length	0.31	0.40	0.81	1.25	1.55	2.4	2.6
Upper jaw length	0.60	0.68	1.65	3.1	3.7	6.4	7.6
Lower jaw length	0.57	0.66	1.58	3.0	3.5	5.3	5.9
Head length	0.96	1.16	2.5	4.25	5.3	8.8	10.1
Head depth	0.80	0.88	Ca. 1.5	2.1	2.3	3.2	3.5
Head width	...	...	1.2	1.8	Ca. 2.0	2.8	3.0
Snout extension	0.03	0.02	0.07	0.1	0.2	1.1	1.7
Pterotic spine	0.1	0.31	0.9	1.0	1.1	1.2	1.2
Preopercular spine	0.3	0.62	1.5	...	2.7	2.8	2.9
Body height—							
at ventral fin origin	...	...	...	Ca. 1.8	...	3.2	Ca. 3.5
at anal fin origin	..	..	...	Ca. 1.3	Ca. 1.2	2.3	Ca. 2.4
Pectoral fin ray length	0.45	0.4	Ca. 0.7	1.2	1.5	2.6	3.2
Ventral fin ray length	none	none	0.2	0.85	1.3	4.4	Ca. 6.0
Dorsal fin ray length—							
4th	...	...	...	...	1.0	2.3	2.7
10th	...	...	...	...	1.5	4.1	5.7
13th	..	...	..	...	..	4.0	5.7
15th	...	..	...	...	...	3.7	5.3
17th	...	...	...	...	...	3.3	4.8
20th	...	...	...	...	...	2.9	4.3
Anal fin ray length	..	...	...	...	0.7	1.4	1.7
Counts—							
No of pectoral fin rays	...	...	...	...	...	20	20
No. of anal fin rays	...	...	...	...	...	24	25
No. of dorsal fin rays	...	...	...	...	...	48	51

* The distance from the ventral fin origin to the anal fin origin.

TABLE 4

Data of capture and measurements for the specimens figured.
Black marlin, *Eumakaira nigra* Nakamura

Specimen No.	1	2	3	4	5	6	7	8	9
Date	1952 V–24	1953 V–20	1951 VIII–26	1953 V–20	1956 VI–5	1956 VI–5	1954 VI–21	1954 VI–21	1960 VII–18
Locality	20°02′N 124°24′E	19°20′N 122°50′E	0°49′N 155°11′E	19°20′N 122°53′E	10°24.5′N 145°15.5′E	10°24.5′N 145°15.5′E	10°21′N 159°35′E	10°21′N 159°35′E	14°55.5′N 139°56′E
Measurements in mm.—									
Total length	2.9	3.3	4.5	6.0	8.6	11.6	16.3	23.2	Ca. 31
Standard length	2.65	3.1	4.4	5.7	7.7	10.0	14.0	19.5	Ca. 26.8
V. F.—A. F. *	...	...	...	1.5	2.0	2.9	4.4	6.4	9.0
Snout length	0.09	0.13	0.43	0.74	1.18	1.7	2.5	3.4	4.2
Dia. of orbit	0.31	0.41	0.67	1.05	1.43	1.6	2.1	2.6	3.0
Dia. of eye	0.30	0.40	0.57	0.90	1.23	1.5	1.9	2.4	3.0
Postorbital length	0.29	0.35	0.53	0.82	1.07	1.56	2.0	3.1	3.5
Upper jaw length	0.34	0.48	0.90	1.71	2.45	3.2	4.55	5.9	6.8
Lower jaw length	0.34	0.48	0.88	1.6	2.25	2.9	4.2	5.5	6.2
Head length	0.78	0.95	1.65	2.58	3.7	4.8	6.6	9.0	10.7
Head depth	0.54	0.76	1.23	Ca. 1.65	1.95	2.5	3.0	3.9	4.5
Head width	0.51	0.71	1.06	...	1.7	2.1	2.6	3.3	3.5
Pterotic spine	..	0.14	0.61	0.92	1.0	1.15	1.2	1.2	1.1
Preopercular spine	..	0.29	1.1	Ca. 1.9	2.5	2.9	2.9	2.9	..
Body height—									
at ventral fin origin	Ca. 0.57	Ca. 0.76	1.15	Ca. 1.5	1.85	2.25	3.1	4.1	4.5
at anal fin origin	...	..	..	0.94	1.2	1.4	1.9	2.7	3.2
Pectoral fin ray length	0.37	0.48	0.65	0.8	1.3	1.7	2.3	3.4	4.0
Ventral fin ray length	...	...	Ca. 0.1	0.18	0.7	1.9	3.7	5.8	8.7
Dorsal fin ray length—									
4th	...	...	..	...	...	...	1.65	3.8	..
10th	...	...	...	...	...	...	3.2	6.4	...
13th	...	...	..	...	...	Ca. 0.9	3.3	6.6	...
15th	...	...	...	...	...	...	3.0	6.6	...
17th	...	...	...	...	...	...	..	6.1	..
20th	..	...	...	...	...	...	...	5.3	...
Anal fin ray length	...	...	...	...	0.82	1.2	1.3	1.9	...
Counts—									
No. of pectoral fin rays	...	...	...	...	...	Ca. 20	20	20	...
No. of anal fin rays	...	...	...	...	...	...	23	25	...
No. of dorsal fin rays	...	...	...	...	...	...	...	49	...

* The distance from the ventral fin origin to the anal fin origin.

TABLE 5

Data of capture and measurements for the specimens figured

White marlin, *Marlina marlina* (J. & H.)

Specimen No.	1	2	3	4	5
Date, Hour	I–1, 1958 1010–1025	XI–23, 1956 2342–2357	,,	IV–1, 1958 ...	VI–21, 1954 0720–0930
Locality	13°04.2′S 116°12′E	16°30.5′S 146°30.5′	,,	3°24′N 81°43′E	10°21′N 159°35′E
Method of capture	larvalnet surface tow	,,	,,	,,	dip-net
Measurements in mm.—					
Total length	Ca. 2.6	3.75	Ca. 4	Ca. 5.5	26.5
Standard length	2.5	3.6	3.83	Ca. 5.2	23.0
V. F.—A. F.*	...	...	...	...	7.7
Snout length	0.23	0.4	0.42	0.73	3.8
Dia. of orbit	0.4	0.6	0.62	1.00	2.8
Dia. of eye	0.39	0.52	0.51	0.86	2.55
Postorbital length	Ca. 0.3	0.42	0.56	0.75	3.3
Upper jaw length	Ca. 0.5	0.79	0.88	1.65	6.4
Lower jaw length	Ca. 0.5	0.8	0.9	1.55	5.8
Head length	Ca. 0.9	1.42	1.6	2.5	9.9
Head width	...	Ca. 0.9	0.93	1.3	3.4
Pterotic spine	Ca. 0.2	0.6	0.6	1.0	1.15
Preopercular spine	Ca. 0.4	...	1.0	1.7	2.85
Body height—					
at ventral fin origin		Ca. 1.0	Ca. 1.0	Ca. 1.3	4.1
at anal fin origin		0.55	0.55	Ca. 0.7	2.8
Body width		0.7	0.79	Ca. 1.2	2.65
Pectoral fin ray length ..	Ca. 0.3	0.5	Ca. 0.5	Ca. 0.7	4.0
Ventral fin ray length		0.1>	...	Ca. 0.15	6.9
Anal fin ray length		...	...	...	2.4
Dorsal fin ray length—					
4th		...	...	...	2.45
5th		..	...	...	4.3
6th		...	...	...	5.0
10th		..	...	...	3.4
Counts—					
No. of pectoral fin rays		....	...	...	21
No. of anal fin rays		...	...	...	23
No. of dorsal fin rays		...	...	...	Ca. 50

* The distance from the ventral fin origin to the anal fin origin.

ALBACORE STUDIES—VII. SURFACE WATER TEMPERATURE AND THE DISTRIBUTION OF ALBACORE IN THE LONGLINE FISHING GROUNDS OF THE NORTHWESTERN PACIFIC OCEAN

BY

AKIRA SUDA AND TOSHIO SHIHAMA

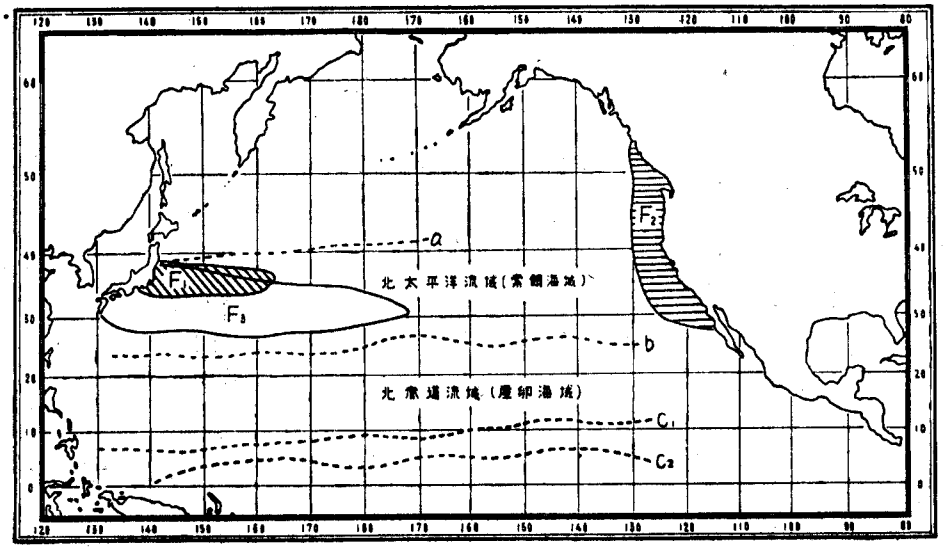
INTRODUCTION

It has been pointed out many times that each of the several current systems present in the oceans is a life territory having a different meaning for the tunas, and that this sort of ocean structure gives marked characteristics to the geographical distribution of the tunas. In this sense the current systems can be said to be the elements regulating the primary distribution. However, within the distributional territory of each species—within the current system—the distribution of the schools is by no means uniform, and at times it shifts according to rather clear laws. A knowledge of this pattern of distribution within the territory of distribution is necessary for understanding variations in the availability of the schools, for predicting fishing seasons and the positions of fishing grounds, and for evaluating the data of catch statistics. The present report is an attempt to analyze from this standpoint the laws of distribution within the distributional territories.

In the North Pacific, as shown in Figure 1, there are three important fisheries. Of these, the present study deals with the relationship between surface water temperature and the distribution of albacore in the longline fishing grounds which are formed from autumn through winter in the Northwestern Pacific Ocean (Figure 1. F 3). These fishes are the immature group (or feeding group) of the Pacific Northern Hemisphere population, and their distributional territory is the North Pacific Current area. The spawning group has as its distributional territory the North Equatorial Current area, its distribution being separated from that of the feeding group by the Subtropical Convergence ; in this study it will not be taken up directly. The data used in this study were made up of records of fishing vessels which operated on the longline grounds of Figure 1. F_3 (date of operation, position, surface water temperature, number of units of gear fished, number of albacore captured) and records of the length measurements of albacore landed by these boats at the fish markets. The period covered was the 3 years from the 1953 fishing season to the 1955 fishing season, and the period of operation in each year was from October to April.

There have already been many studies which have dealt with the relation between the distribution and catch of fishes and the water temperature on the fishing ground. However, there still remain at present problems which must be examined with regard to the manner of carrying on studies of this sort. In the way in which a given species adopts to its temperature environment the special characteristics of that species can naturally be detected, but ordinarily it is considered that such characteristics are fixed ones for the species, and not much attention is paid to the fact that there are

multifarious variations in response to the inner structure of the population. Neither has there been adequate treatment of the alterations which regulating factors other than water



Text Fig. 1.—The current systems and the Albacore fishing ground in the North Pacific.

a : Polar front ; b : Sub-tropical convergence c^1, c^2 : Boundary of Equatorial Counter Current.

F^1 : Japanese pole-and-line ground.

F^2 : Trowing and pole-and-line ground of U. S. A. and Canada.

F^3 : Japanese long-line ground.

temperature may be thought to cause in the pattern of albacore distribution with respect to the temperature environment. In this sort of alteration we consider the field water temperature and the result of interactions other than water temperature, but in many cases the regulating factors other than temperature are made a separate subject of study and are handled in isolation from water temperature. The pattern of distribution of the fish with respect to temperature is constantly changing form, depending on the structure of the population and the conditions of the environments, and if we do not regard this point seriously in our attempts to grasp the laws of this change of form, we cannot be said to have grasped them concretely. Actually, the course of this kind of variation can be said to be the reality of the relationship (water temperature-distribution). To look at the (water temperature-distribution) relationship from this kind of view point is the basic attitude of the author in this study. Furthermore, in this study the authors have tried to grasp the characteristics of the horizontal distribution of albacore as related to the surface temperature, and they do not deal with the watch temperature inhabited by the fish elf the method of carrying out the analysis itself is appropriate, it should be possible to gain much information and many hints concerning the actual conditions of adaptation to the temperature environment by dealing with just the surface temperature, and we think that it is not absolutely necessary to take up the temperature of habitation.

In Part I of this paper we will explain our methods of handling the data, and in Part II we will give a bird-view of the relation between water temperature and distribution.

In Parts III and IV the multifariousness of the structure of the (water temperature-distribution) relationship is explained. This multifariousness is formed by the compounding and alteration of the most basic (water temperature—distribution) relationship, which reflects the life-patterns of unit aggregations. An attempt to measure the effect of various factors on this compounding and alteration—particularly the latter-is found in Parts V and VI. Part VII is a discussion from several points of view of the results brought out in Parts III and IV.

PART I—PRELIMINARY DISCUSSION OF THE TREATMENT OF THE DATA

I—(1) Handling of the various elements affecting the temperature of occurrence.

It can be considered that in different fishing seasons or sea areas, even though there is no change in water temperature, there will be changes in the kind and degree of effect of the other factors which parallel water temperature in influencing the distribution of the fish. This sort of background change is probably constantly causing changes in the significance of water temperature as the distributional environment or in the predominance as a controlling factor. The pattern of changes in environmental conditions is complex and it is thought to be impossible to grasp it accurately just by taking up the changes in any single factor, such as salinity or the quantity of plankton (except in cases where that factor is known to be markedly predominant). Rather, it should probably be approached as a collection or group of elements of appropriate form. In the present study the data are arranged by squares of 10° and by months. It is true that this is mechanical, but it means that the group of factors causing changes to the distributional temperature of the albacore has been organized into a group of factors giving rise to areal changes and a group of factors producing seasonal changes.

There are changes in the distributional water temperature which arise not from the sort of changes in environmental factors discussed above but from the internal structure of the population. It is known that groups which differ in age (or size) show differences of distributional water temperature. In the present study importance is given to this point and the size of the fish taken is made one of the criteria for classifying the data.

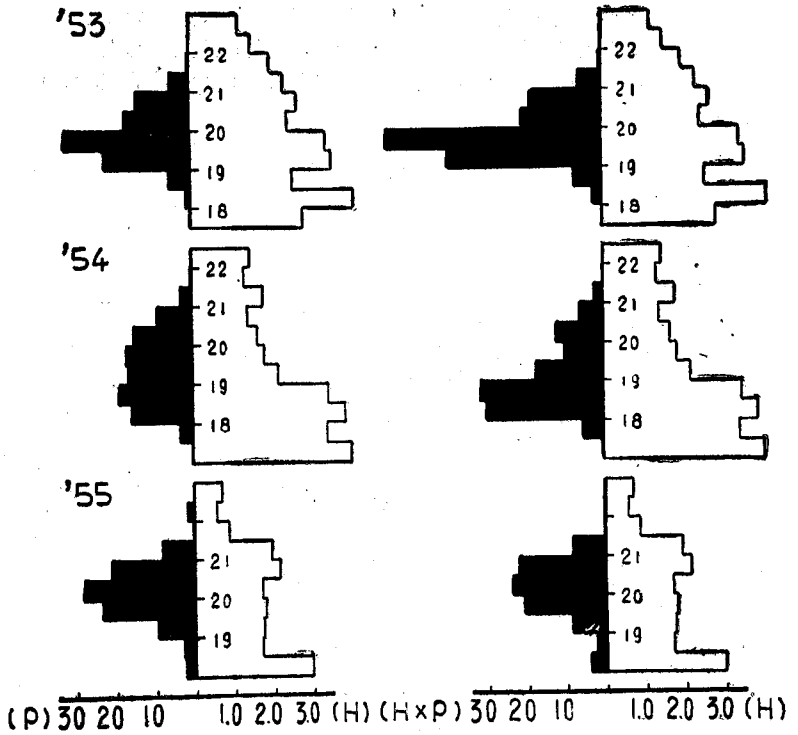
Thus, among the various factors which cause changes in the relationship of water temperature and distribution we have tried to deal with the group of factors causing seasonal and areal changes and with the size of the fish, however, other groups of factors which affect the (water temperature-distribution) relationship may be thought to exist. In order to check on their existence, we have sought the size of the variation in catch within levels set up taking into account the conditions of season, area and size of fish. However, in seeking the values of variations of this kind, it is not appropriate to use the total number N of fish caught at each temperature as an index of the quantity of fish occurring at that temperature. The reason is that variation in catch for each set of the longline cannot be shown by N. In the present study we use catch rate instead of N. This N will be further discussed in the next section.

I—(2) Indication of the quantity of the stock

The total number of fish caught N can be used as an index of the quantity of the stock, when the condition that the total amount of fishing effort expended does not change greatly with temperature is fulfilled. As is shown in Figure 2, the tendency for the amount of fishing effort expended (number of longline sets mode) to be concentrated in a

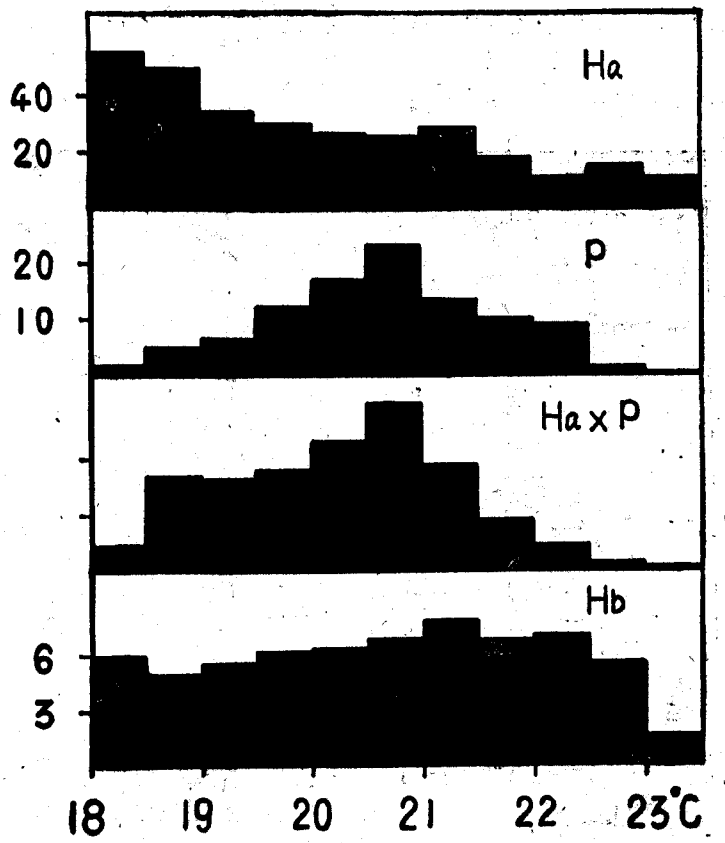
particular water temperature area is very strong. In this figure the product of catch rate by number of operations, shown by N^1, is an index which is proportional to N, that is, the total number of fish taken at each temperature. Since the fishing boats are extremely concentrated in a certain temperature area, N^1 also shows a conspicuous concentration in that area. The distribution of N and N^1 differs markedly from the distribution of the catch rates, which is broad and without clearly marked peaks.[1] The bias in the application of effort affects the N—θ curve in another form too. An example is shown in Fig. 3. In this case operations of the fishing boats are carried on with bigeye as their principal object. As a natural result the centre of operations is in the band of 20°–21°C., water temperature where the density of bigeye distribution is high, and away from the centre of albacore distribution. However, as a result of the concentration of operations in the centre of bigeye distribution, the peak of N^1 also appeals in the center of bigeye distribution, away from the center of albacore distribution. Because the bias in the distribution of the number of long-line sets has this sort of effect in the (N–θ) curve, in the present study the catch rate, which is not so affected, is used as an indicator of the abundance of fish.

Another reason for having used the catch rate is that it is possible, as noted in the preceding section, to check the variation in catch per longline set within a given class for example, within a certain band of water temperature. In actuality this variation is surprisingly large (Fig. 10). Within water temperature areas with a spread of 5° of longitude and



Text Fig. 2.—The comparison among the hooked-rate (H), percentage frequency of long-line operation (H.) and the index of catch amount (H×P) of Albacore in each water temperature (Jan. 1953–1955, 140°E–150°E).

[1] The failure of the catch rate peak and the peak of N^1 to coincide is probably due to the fact that the catch rate peak and the peak of number of fish caught (catch rate) X average weight of the fish caught X fish price per unit of weight do not coincide.



Text Fig. 3.—The comparison among the hooked-rate of Albacore (H_a) and Bigeye (H_b), percentage frequency of longline operation (P) and the catch amount of Albacore ($HaX_a \times P_o$) in each water temperature (Nov. 1955 170°E–180°E).

a 0.5°C. range of temperature, the coefficient of variation of catch rates reaches 70–80% (Table 3) off this large scatter of catches is not taken into consideration, there is a danger of postulating, a cause and effect character in what is simply an apparent relationship obtained by contraposing N and water temperature.

Section II—Outline of Albacore Distribution with Respect to Surface Water Temperature

Let us first consider very generally the relation between albacore catch and surface water temperature in this area. In Table 1 we have taken all of the operational data for north of 25°N- (this mechanical approach was used because it is not possible to determine from the operational records of fishing boats whether the points at which they fished were north or south of the Subtropical Convergence), ignoring differences of year and month and of area of operations, and have totalled up all of the longline sets which caught albacore. The lowest temperature at which catches were made is 16.1°C and the highest is 29°C. The temperature range in which more than 50% of the sets produced albacore is 16.6° C–22° C. This corresponds generally to the long east-west band of waters enclosed by two isotherms (60° F and 70° F) which is diagonally shaded in Figure 4. In the longline fishing season (October—March) the highest water temperature in the vicinity of the Subtropical Convergence is 25°–26° C., while the lowest temperature of the Kuroshio

Front in Japanese waters (144° 20' E) is 14°-15° C. (Table 2), so, stated in broad terms, fishing operations are carried on in the central part of the area comprised between the Subtropical Convergence and the Kuroshio Front.



Text Fig. 4.—Monthly changes in the distribution pattern of Albacore shown by hooked-rate.
Full-line : isotherms. Chain-line : boundary between currents.

TABLE 1

The accumulated number of fishing days by temperature, in the area north of 25° N and west of 175° W, and in the long line season (Nov.—May) of each year from 1953 to 1955

Temperature	Number of fishing days	Number of fishing days on which fish were caught	Percentage of fishing days on which fish were caught
15.1–15.5	13	0	0
15.6–16.0	11	0	0
16.1–16.5	15	1	7
16.6–17.0	42	21	50
17.1–17.5	530	483	91
17.6–18.0	1881	1770	94
18.1–18.5	4599	4353	95
18.6–19.0	6103	5621	92
19.1–19.5	5199	4579	88
19.6–20.0	4915	3858	78
20.1–20.5	4025	2970	74
20.6–21.0	3131	2142	68
21.1–21.5	1861	1124	60
21.6–22.0	1434	712	50
22.1–22.5	880	260	30
22.6–23.0	816	172	21
23.1–23.5	666	98	15
23.6–24.0	634	58	9
24.1–24.5	621	63	10
24.6–25.0	560	55	10
25.1–25.5	542	40	7
25.6–26.0	368	34	9
26.1–26.5	118	18	15
26.6–27.0	90	15	17
27.1–27.5	47	8	17
27.6–28.0	59	29	49
28.1–28.5	46	12	26
28.6–29.0	32	8	25
29.1–29.5	9	2	22

TABLE 2

The mean surface water temperature by month in the region of the Subtropical Convergence 14,15, and Kuroshio-Front 16

TABLE 2-A

The mean latitudinal location and the surface water temperature of the Subtropical Convergence

(1) Latitudinal location (°N)—

Longi.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.
145°E	30	30	27.5	26	22	22	23	25.5	27.5	28	28.5	30
155°E	30.5	30	28	26	22	23	24	26	28	30	29	32.5
165°E	29.5	30	27	25	22.5	23	24	26	28	29.5	31	30.5
175°E	30	30	26	26	23	23	24.5	27	26.5	29.5	31.5	30.5
175°W	30	29	25.5	26.5	24.5	24	25	28	27.5	29.5	31	33
Mean	30.0	29.8	26.8	25.9	22.8	23 0	24.1	26.5	29.5	29.3	30.2	31.1

(2) Surface water temperature (°C)—

Longi.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.
145°E	27.5	26.4	24.7	23.9	24.5	24.2	23.4	22.8	22.5	23.9	27.0	27.5
155°E	27.0	26.4	24.7	24.2	24.7	23.9	22.2	22.8	22.2	23.6	26.7	26.4
165°E	27.0	25.6	25.0	24.5	24.2	23.9	22.2	22.8	22.5	23.4	25.3	27.0
175°E	25.9	24.6	25.0	23.9	23.6	23.9	21.7	21.7	23.6	23.4	24.7	25.6
175°W	25.6	24.2	24.7	22.8	23.1	22.5	22.0	21.1	22.5	23.9	23.9	24.7
Mean	26.6	25.4	24.9	23.9	24.0	23.7	22.4	22.2	22.7	23.6	25.5	26.2

TABLE 2-B

The surface water temperature of the Kuroshio-front

Longi.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.
144°E	...	...	19.9	...	...	14.0	...	—	...	...	...	24.8

However, the patterns of distribution of albacore within the individual water temperature areas change markedly from one month to another. Figure 5 shows catch rates for a temperature area 0.5°C. broad by months and for each degree of longitude. Concentrated distributions of albacore are not simply fixed in a certain temperature area but show the following kinds of shifts with the passage of the seasons :

(1) October-November (first part of the albacore fishing season): The areas where catch rates rise to 1% or higher are where the water temperature is 24° C. or lower between

160° E. and 175° W., the east-west breadth being comparatively narrow. The band of water temperatures of 24° C. or lower does not exist only in the area between 160° E. and 175° W., but continues farther to the east and west. Nevertheless, it is noted that the fish appear only between 160° E. and 175° W.

(2) December–January (peak fishing season): The maximum temperature in areas showing catch rates of 1% or more becomes 22°C., somewhat lower than at the beginning of the season. The 1% band has extended remarkably to the west, and the position of its centre has shifted west as compared with the start of the season.

(3) February–March (end of the fishing season): The area of dense distribution inclines markedly to the west and at the same time becomes narrower, and the upper limiting water temperature of the 1% zone falls to 21° C.

What is noted in the above outline of the distribution is:

(1) The range of water temperatures in which albacore are densely distributed is rather broad; in terms of the temperature zone in which the proportion of days on which albacore were caught is 50% or more it is 5° - 6° C., in terms of the range of the zone of catch rates of 1% or greater it is 6° – 7° C.

(2) Within any water temperature zone the distribution of albacore is not uniform but biased. Furthermore, the central position of the distribution and its extent change with the season.

(3) The upper limiting water temperature of the area of distribution changes from month to month. The upper temperature limit of the 1% catch rate zone shows a drop of 2° – 3°C. from 23° – 24°C. at the beginning of the fishing season to 21° C. at its close. Judging from this, it can be considered that at least the relation between the surface water temperature and albacore distribution presents many changes and that these changes extend to many aspects.

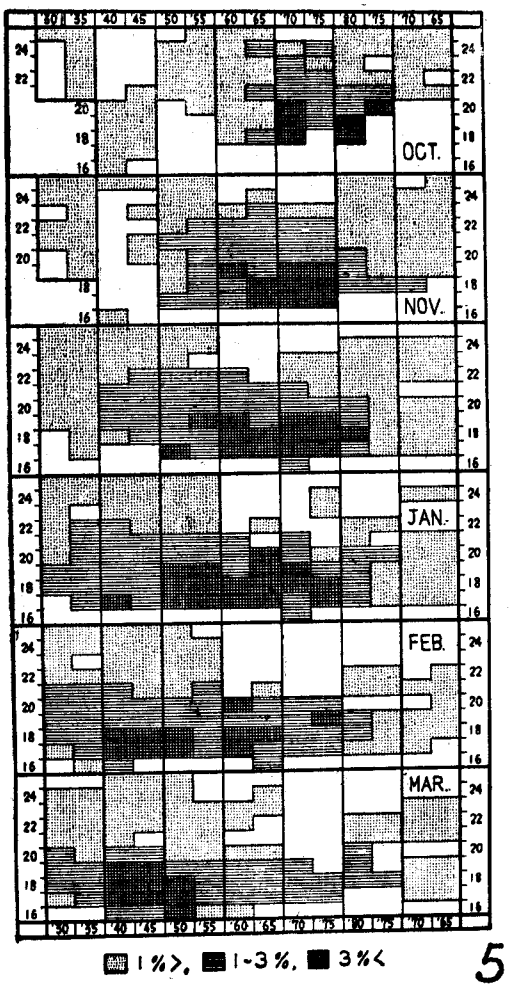
Section III—Multifariousness of the Relationship between Albacore Distribution and the Surface Water Temperature on the Fishing Grounds

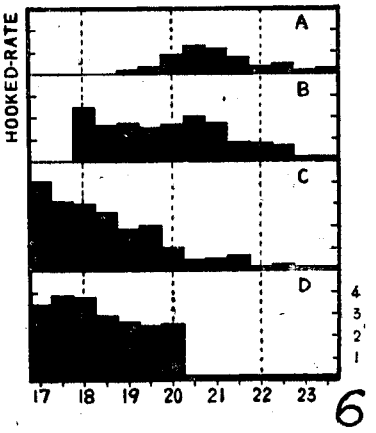
III—(1) Seasonal and areal changes in the distributional temperatures

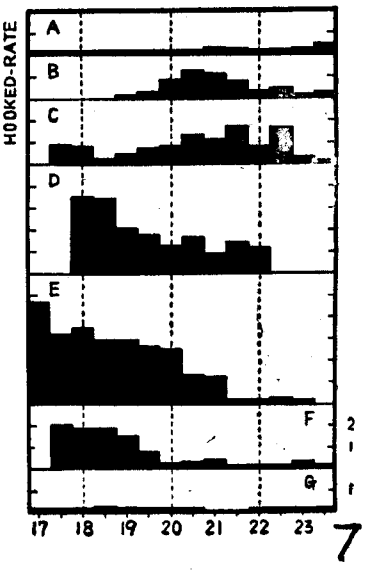
Part 1.

As is shown in figure 5, the range of water temperatures in which albacore are found distributed changes markedly depending on the longitude of the fishing ground and on the season. Let us examine this situation while holding constant either season or area. Figure 6 is an example of how the catch rates at different temperatures change from month to month in the same area (1955, 140°E – 150°E). Figure 7 shows how the catch rates in each water temperature band change with area within the same month (December 1955). These figures show that the range of water temperatures in which albacore occur changes markedly with season and area. The seasonal and areal changes shown in these two figures, which are basically of very similar type, are as follows. The distribution is not a simple matter of the albacore's having a simple optimal temperature around which the schools gather. Multiple bands of water temperatures of catch rate maxima appear, and their combinations change with season and area. For example, as we see in Figure 6, the catch rate peak which appears in the first half of the fishing season disappears in the

latter half, when a peak appears in a different water temperature band. Furthermore, the peak in the early half of the fishing season appears in the high temperature band, but later in the season it is at a lower temperature. The shift in position of the peak is not continuous : the peak remains in one water temperature band for 1 to 3 months, and then a separate peak appears in a lower water temperature band. Sometimes the







Text Fig. 5.—The hooked-rate in each temperature zone shown by 5 degrees of longitude and month. The ordinate represents surface water temperature, and the absissa represents longitude. The figures added to the temperature class and longitudinal class represent the lower limit of each class.

Text Fig. 6.—The monthly changes in the distributing temperature of albacore in the fixed areas, 140°E–150°E, without consideration of the size of fish. A, B, C, D represents Dec. Jan. Feb. Mar., in 1955, respectively.

Text Fig. 7.—The longitudinal changes in the distributing temperature of Albacore in the fixed month, Dec. 1955, without consideration of the size of fish.

A : 130°E–140°E B : 140°E–150°E C : 150°E–160°E D : 160°E–170°E
F : 170°E–180° F : 180°–170°W G : 170°W–160°W

original peak fades out, as if replaced by the new peak, but sometimes both persist together for a while. At times three peaks may appear simultaneously for a time. Judging from these types of development, it may be thought that the (water temperature-distribution) relationship of the albacore is an overlapping distribution of several peaks, each of which has its own peculiar significance.

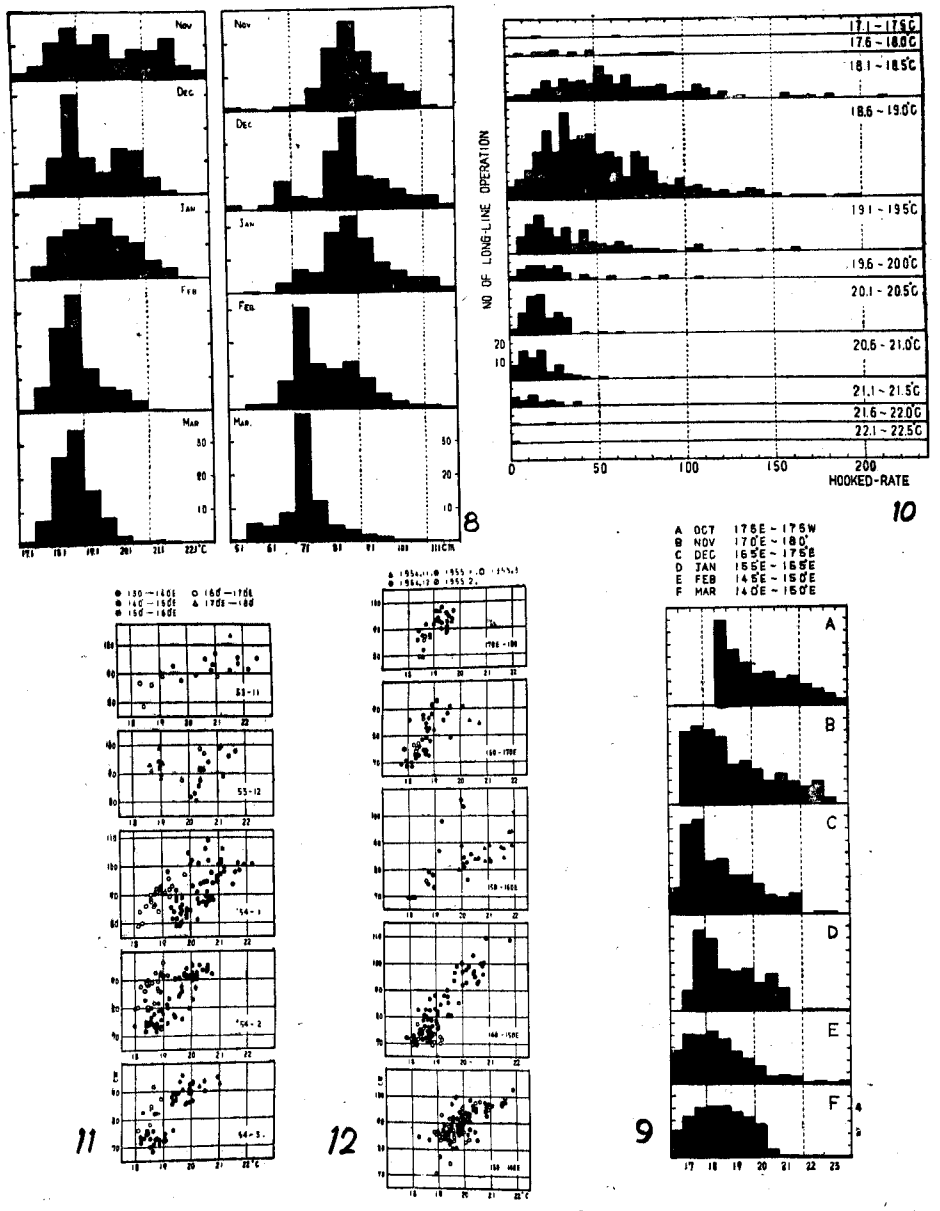
III—(2) Size of fish and distributional temperature.

As a rule the catch rate maximum appears in the high water temperature band early in the fishing season and shifts to a lower temperature band as the season progresses, as in Figure 6. At the same time, the size of the albacore taken gradually becomes smaller as the season passes (4) (5). These two parallel phenomena are an important clue for understanding the significance of the water temperature areas in which albacore occur. Figure 8 is presented in order to show more clearly the anticipated relation between the seasonal changes in the size of albacore caught and the seasonal changes in the water temperature of occurrence. On the left side of the figure is shown, by months, the number of fish caught in each temperature band, while on the right side is shown the length composition of the catch at the corresponding time. When large fish are numerous, more of the catch is made in high water temperature zones, and when the catch at lower temperatures increases, the proportion of smaller fish in the catch increases. Thus in correspondence with the size of the fish the distributional temperature of the schools changes, the large fish occurring in the high-temperature areas and the small fish in the low-temperature areas. The seasonal and areal changes in the temperature of occurrence, as shown in Figures 6 and 7, are both strongly correlated with changes in the sizes of fish with season and area. In seasons or areas where large fish are numerous, the schools appear in areas of high water temperature, while on the contrary, at seasons or in areas where small fish are numerous the schools occur in areas of low temperatures. When the number of size groups appearing in the catch is large, the range of temperatures in which the schools appear becomes broader. These seasonal and areal changes in the temperature of occurrence which arise together with seasonal and areal changes in the size composition are called Type I changes to distinguish them from the Type II changes described in Section II-(4).

It is also shown in Figure 6 and Figure 7, but except for the first part of the fishing season, in general the distribution of catch rates with respect to water temperature is as shown in Figure 9. The maximum value of stock abundance appears at a point near the limit on the low side. The farther from this point, the lower the catch rate falls. This decline is extremely, sharp on the low temperature side of the maximum, but on the high temperature side it is gradual and irregular. The fact that the catch rate maximum appears very close to the lower limit of range of temperatures of occurrence can be explained by the relation between fish size and distributional temperature. In actuality the stock of fish in the sea (meaning, of course, the stock of fish which have reached the post-recruit phase) as a rule contains larger numbers of the younger fish. Since the younger the fish, the lower the water temperatures at which they occur, it is considered natural that the catch rate should be higher in the lower temperature sector.

III—(3) Variation in catch within areas of uniform surface temperature.

There are also problems to be noted in the changes in catch rate on the high-temperature side of the catch rate maximum in Figure 9. Within this temperature area the albacore



Text Fig. 8.—The relationship between the fishing temperature and the size of fish. The left histogram represents the per mileage frequency of fish caught in each temperature range, and the right histogram represents the frequency of body length of Albacore caught in the water temperature condition shown in the left histogram.

Text Fig. 9.—Relationship between the hooked-rate and the water temperature in the central region of distribution of Albacore by month.

Text Fig. 10.—The frequency distribution of catch number of Albacore per 1,000 hook occurred in the area of 0.5°C of temperature range and 5-degrees of longitudinal range (Feb. 1954, 140°E–150°E).

Text Fig. 11.—The changes in the fishing temperature of given size Albacore, by the difference of fishing area.

Text Fig. 12.—The change in the fishing temperature of given size Albacore by the difference of fishing month.

catch rate declines gradually and irregularly from lower to higher temperatures. As the index A in Table 3 shows, when the water temperature rises 0.5°C., the catch rate drops about 20–25%. We shall try comparing these changes of catch rate based on a change of 0.5°C.

TABLE 3

The comparison between Index A and Index B

Index A is the ratio of the change (the percentage of the change to the original value) in the mean hooked-rate in the area of longitudinal range of 5 degrees, caused by the change of 0.5°C in the average fishing temperature.

Index B is the coefficient of variation of hooked-rate in the area in which temperature range is 0.5°C. and longitudinal range is 5 degrees.

	Index A	Index B
Less than 20%	160	...
21–40	79	...
41–60	31	41
61–80	5	51
81–100	4	28
101–120	1	13
121–140	2	3
141–160	2	3
161–180	1	...
Total	285	139
Mean	23.67	75.43

in water temperature with the variation in catch rates within a temperature area having a breadth of 0.5°C. The latter is Index B in Table 3, and it amounts on the average to 75%. The variation in catch rates within a temperature range of 0.5°C is more than 3 times greater than the changes in catch rate which arise with a temperature change of 0.5°C. Consequently the following can be said. " Even though the water temperature changes, the average catch rate (or the total quantity of fish present) does not change so greatly. This being so, the distribution of the fish is definitely not uniform, and even within an area of uniform temperatures they show, conspicuous aggregations which are, apparently at any rate, unrelated to water temperature ". Figure 10 shows marked variations in catch within zones of uniform temperature. This frequency distribution is either of negative binomial type or nearly so.

TABLE 4

The comparison between the frequency distribution of catch per 1,000 hooks in each 0.5°C range of temperature and critical Negative Binomial Distribution (Feb. 1954 140°E–150°E)

Catch per 1,000 hooks	18.1–18.5		18.6–19.0		19.1–19.5		19.6–20.0		20.1–20.5		20.6–21.0	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
0– 4	2	0.5	7	3.3	...	7.0	2	4.7	3	3.5	8	7.5
5– 9	3	2.2	11	11.6	9	11.4	6	6.7	12	13.7	16	15.5
10– 14	3	4.4	16	20.0	16	12.8	8	6.6	21	19.4	12	15.5
15– 19	6	6.7	26	26.8	21	12.8	8	6.0	22	17.7	16	12.0
20– 24	11	8.7	38	31.6	14	12.1	6	5.3	9	14.0	4	8.2
25– 29	7	10.3	26	34.3	9	11.2	8	4.5	12	9.4	8	5.2
30– 34	12	11.5	48	35.4	14	10.2	4	3.7	9	5.7	3	...
35– 39	10	12.0	33	35.2	5	9.1	...	3.0	...	3.2	2	...
40– 44	11	12.3	35	34.0	13	8.0	3	2.4	1	...	1	7.8
45– 49	8	12.2	36	32.0	6	6.9	1	1.9	...	4.4	...	...
50– 54	19	11.9	25	29.7	5	6.2	...	...	1	...	1	...
55– 59	14	11.4	26	27.1	3	5.4	2	...	...	...	...	...
60– 64	9	10.7	23	24.4	6	4.7	...	...	1	...	...	...
65– 69	14	9.9	12	21.8	4	4.0	...	8.2	...	...	...	...
70– 74	7	9.1	26	19.2	2	3.4	...	...	...	...	...	...
75– 79	7	8.3	23	16.9	2	3.0	1	...	...	...	...	...
80– 84	7	7.5	15	14.7	2	2.7	...	...	...	...	...	...
85– 89	8	6.7	8	12.7	1	2.3	2	...	...	...	...	...
90– 94	3	6.0	7	10.9	1	2.0	...	...	...	...	...	...
95– 99	4	5.3	11	9.4	...	1.6	...	...	...	...	...	...
100–104	4	4.6	6	8.0	2	1.3	...	...	...	...	...	...
105–109	8	4.1	7	6.8	4	1.1	1	...	...	...	...	...
110–114	6	3.5	5	5.8	1	...	...	...	...	...	...	...
115–119	2	3.1	3	4.9	...	...	...	...	...	...	...	...

TABLE 4—(*Contd.*)

The comparison between the frequency distribution of catch per 1,000 hooks in each 0.5°C range of temperature and critical Negative Binomial Distribution (Feb.–1954 140°E–150°E)—(*Contd.*)

Catch per 1,000 hooks	18.1–18.5		18.6–19.0		19.1–19.5		19.6–20.0		20.1–20.5		20.6–21.0	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
120–124	4	2.7	4	4.1	...	...	...	...	...	...	...	...
125–129	1	2.3	2	3.4	1	...	...	...	...	...	...	...
130–134	2	2.0	3	2.9	...	5.8	...	...	...	...	..	...
135–139	...	1.7	5	2.4	...	..	...	...	..	...	...	..
140–144	...	...	4	2.0	1	...	...	...	...	...	...	...
145–149	...	...	1	1.7	...	..	...	...	...	..	...	...
150–154	...	...	2	...	2	...	1	...	...	...	...	...
155–159	2	...	...	...	...	...	...	...	...	...	...	...
160–164	1	...	1	8.0	...	...	1	...	...	...	..	...
165–169	1	...	1	...	1	...	...	...	...	...	...	...
170–174	2	9.5	1	...	...	...	...	...	...	..	...	...
175–179	...	...	1	...	...	...	...	...	...	...	...	...
180–184	2	...	...	...	...	...	...	...	...	...	...	...
185–189	...	...	1	...	...	...	...	...	...	...	...	...
190–194	...	...	1	...	...	...	...	...	...	..	...	..
195–199	...	...	1	...	..	..	...	...	...	...	...	...
200–204	...	...	...	...	...	...	...	...	...	...	...	...
205–209	...	...	...	...	...	...	...	...	...	...	...	...
210–214	1	...	...	...	...	...	...	...	...	...	...	...
215–219	...	...	...	...	...	...	...	...	...	...	...	...
D. F.	11		20		9		2		2		2	
Quai-square	8.0377		26.3564		14.6200		5.1399		1.8313		2.3955	

(*a*) The actual frequency distribution of catch per 1,000 hooks in each 0.5°C range of temperature,

(*b*) The critical frequency distribution of Negative Binomial.

The extent of the variation of catch rates within areas 2 degrees square, taken mechanically without any consideration of water temperature, is in C. V. about 50% (6)(7), so that the value of 75% given in Table 3 is larger. Judging from the pattern of distribution of isotherms in average years (Table 5), the surface water temperature changes roughly 0.5°C. with each 0.7°C./sic/ of latitude. Consequently, areas with a temperature spread of 0.5°C. and a longitudinal spread of 5° can be regarded roughly as areas having a spread of 5° in the longitudinal direction and of 0.7°C. in the latitudinal direction. This is a smaller extent than that of the areas of 2 degrees of latitude and longitude. Nevertheless, it is noted that the variation of catch rates within areas having a temperature spread of 0.5°C. and an east-west breadth of 5° compares with that in the areas 2 degrees square. Furthermore, the value of 75% includes the effects of differences in fishing gear structure, bait, and the skill of the fishermen. Most of the effects of such differences in technical level should appear as differences in the average catch rates as between voyages. Therefore, in order to eliminate this type of influence, it is appropriate to use the variation between operations within the

TABLE 5

The latitudinal location of the 60°F and the 75°F isotherms in the North West Pacific for every month 14, 15.

(A) 60°F (15.6°C)-isotherm—

Longi.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
135°E	...	...	...	33.5	33	...
145°E	40.5	39	37	34.5	34	35
155°E	41.5	39.5	37	35.5	33.5	34
165°E	42	39.5	37.5	34.5	34	33.5
175°E	41.5	39.5	37	34.5	33.5	34
175°W	41	38	36.5	34	33	32.5

(B) 75°F (23.9°C)-isotherm—

Longi.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
135°E	33	26.5	24	21	21.5	21.5
145°E	34	29	25.5	23	22.5	22.5
155°E	34	30	26.5	24	22.5	22.5
165°E	33.5	30	25	23.5	23	22.5
175°E	31	28.5	24.5	22	23	23
175°W	29.5	27	24.5	22	23	22.5

(C) Latitudinal degrees between 60°F and 75°F isotherms—

Longi.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
135°E	...	...	...	12.5°	11.5°	...
145°E	6.5°	10.0°	11.5°	11.5°	11.5°	12.5°
155°E	7.5°	9.5°	10.5°	11.5°	11.0°	11.5°
165°E	8.5°	9.5°	12.5°	11.0°	11.0°	11.0°
175°E	10.5°	11.0°	12.5°	12.5°	10.5°	11.0°
175°W	11.5°	11.0°	12.0°	12.0°	10.0°	10.0°

(D) Latitudinal degree which causes the change of 0.5°C in surface water temperature.

135°E	145°E	155°E	165°E	175°E	175°W	Mean
0.72°	0.64°	0.62°	0.64°	0.68°	0.67°	0.662°

same voyage as a measure of catch rate variation within an area of uniform temperature. One or two examples of the variation among operations of the same trip are shown in Table 6 as the Index C. Its extent is, in terms of a coefficient of variation, about 40%.

TABLE 6

The frequency of the co-efficient of variation in hooked-rate, calculated by each fishing cruise carried out in the range of 0.5°C of water temperature in the areas from 135°E to 140°E and from 140°E to 145°E (Index C)

Co-efficient of variation (%)	Feb. 1955 135°E–140°E 19.1–19.5°C	Feb. 1954 140°E–145°E 18.6–19.0°C
1–10 ...	1	...
11–20 ...	6	1
21–30 ...	2	7
31–40 ...	8	4
41–50 ...	7	8
51–60 ...	4	7
61–70 ...	1	2
71–80 ...	1	1
Mean ...	36.7%	42.7%

Thus the fact that of the three Indices A, B and C, A is smaller and B and C are larger means, as will be explained later, that even if a suitable fishing ground is selected on the basis of water temperature, it is unreasonable to expect that the catch will always be stabilized.

III—(4). Seasonal and areal changes in the temperature of occurrence—2

It was stated in III-(2) that since the central water temperature of occurrence differs depending on the size of the fish, seasonal and areal changes in the size composition bring about seasonal and areal changes in the range of water temperatures at which albacore occur (these are called Type I seasonal and areal changes). If we look carefully we can find Type II seasonal and areal changes, which differ in kind from those based on changes in the size composition. Let us consider in Figure 11 how the water temperature at which albacore are caught differs with area when season and fish size are kept constant. It is seen that there is a comparatively clear areal difference, and that albacore of the same size are caught in lower water temperature zones in the more easterly areas than they are in westerly areas.

Figure 12 shows how within the same area fish of the same size change their water temperature of capture with the season. In some areas (Figure 12 is 150°E.–170°E.) the seasonal difference in temperature of capture is fairly clear, but there are areas where seasonal changes can hardly be detected. For all areas the differences in temperature of capture between months for the period January–March are very unclear. The seasonal and areal changes of Type II indicate the existence of [water temperature-distribution] relationships peculiar to each area and season respectively, and they differ greatly in character from the Type I seasonal and areal changes, which take place annually and which are based on annual variations in the size composition.

PART IV—INTERRELATIONSHIPS OF THE VARIOUS FACTORS INVOLVED IN THE DETERMINATION OF THE TEMPERATURE OF OCCURRENCE

In the foregoing part we have looked at the relation between surface water temperature and the distribution of albacore. It is indicated that these two are not simply connected by a single relationship but that the relationship is determined by the interaction of a group of factors, such as (1) the fishing season, (2) the position of the fishing ground, (3) the size (or age) of the fish, and (4) other factors which cannot be concretely described but which cause clumping of the distribution of the schools of fish within the same water temperature zone. Perhaps factors of other kinds might be brought out, depending on the manner in which the data were processed.

Let us consider how these various factors combine to contribute to the determination of the temperature of occurrence. The first that must be considered is that the water temperature which the albacore inhabit differs with age (size of fish). This means that what is generally called the relation of water temperature to albacore distribution is a composite of as many separate relationships as there are size groups (age groups). This composite situation is constantly changing with the season. The changes of this composite situation are the seasonal and areal changes of Type I. At the same time, the separate [water temperature-distribution] relationships of the different ages are subject to seasonal and areal changes of Type II depending on the environmental conditions peculiar to the respective seasons and areas. Through this kind of process the basic [distribution-water temperature] relationships of each size (age) undergo their peculiar compounding and changes according to the season and the area.

This may be thought of as follows. At a given time, in a given area, there is a particular distribution *vis-a-vis* temperature for each size (age), and this shows the most basic relation between water temperature and distribution. The result of compounding these distributions by size (age), with the specific weight of each reflecting the size (age) composition of

the season and area, is the actual distributional relationship of [distribution and water temperature] for the albacore.

PART V—MEASUREMENT OF THE INFLUENCES OF THE VARIOUS FACTORS INVOLVED IN THE DETERMINATION OF THE WATER TEMPERATURE OF OCCURRENCE

In Part IV we reviewed the relationships among the elements determining the temperature of occurrence of the albacore. In this section we shall attempt to find quantitative scales for the effects of the individual factors on the albacore's temperature of distribution. As we set forth in Parts III and IV, the size (age) of the fish and the seasonal and areal effects of Type II are the fundamental group of factors determining the temperature of occurrence of the albacore, and it is they which are the main objects of the measurements discussed in the section.

Part V—(1) Changes in the distributional temperature accompanying changes in the size of the fish

The objective of this section is not to find the central temperature of occurrence of a given size group (age group) but to find out how much the temperature of occurrence changes with change in the size of the fish. First we will calculate the average temperature of capture and the average length of the fish by cruises for each year, area (each 10 degrees of longitude), and month. Next we find the regression coefficient, using this value, for the average fish length at the average temperature of capture for each year, season, and area. This regression coefficient b_1 is the amount of change in the temperature of capture for a unit of change (5 cm) in body length, and it is taken as a scale for measuring the effect of fish size on water temperature. The frequency distribution of the regression coefficient b_1 is shown in Table 7. The average value is +0.33, and an increase in fish size brings a raising of the water temperature of capture. As the amount of growth in the albacore in one year is somewhat more than 10 cm., this means that for schools differing one year in age the temperature of occurrence will differ by about 0.7°C.

TABLE 7

The frequency of the increase in distributing temperature of Albacore in given month and area, by the increase of 5cm. in body length (Index b^1)

Range of Index b^1	Frequency
-0.2–0.1 ...	...
-0.1–0.0 ...	2
0.0–0.1 ...	3
0.1–0.2 ...	6
0.2–0.3 ...	15
0.3–0.4 ...	17
0.4–0.5 ...	7
0.5–0.6 ...	2
0.6–0.7 ...	2
0.7–0.8 ...	1
0.8–0.9 ...	1
0.9–1.0 ...	1

Mean value of Index b^1 is calculated as 0.33.

Part V—(2) Changes in the temperature of occurrence with changes in location of the fishing ground (temperature of capture)

One of the reasons for this is that there are conspicuous differences between areas in the size composition of the catch. Since the temperature of occurrence differs depending on the size of the fish, the temperature of occurrence will change if the age composition of the catch changes. This is an areal change of Type I. The effect of this type of areal change is naturally not fixed. It changes from year to year, depending on variations in the size composition, and its effects can be considered in relation to the changes in temperature of occurrence in response to changes in fish size discussed in the preceding section.

Let us next look at the areal changes of Type II. We will calculate by areas (for every 10° of longitude) the water temperature of capture for the same month and for fish of the same size and using these values will get the regression coefficient b_2 for catch location (catch longitude) and temperature of capture. The frequency distribution of this b_2 is shown in Table 8. If we take its average value as an indicator of the influence of areal changes of Type II, it means that for every 10° of longitude that we move to the east the temperature of occurrence drops by 0.35°C. As a result, as between 135°E. and 175°E., for the same month and for fish of the same size, there is a difference in the temperature of occurrence of $(175-135)\div 10\times 0.35°C.=1.40°C.$

TABLE 8

The frequency of the decrease in distributing temperature for given size of fish in a given month, by 10 degrees of eastward shift in longitude (Index b^2)

Range of Index b^2	Frequency
0.19–0.10 ...	...
0.09–0.00 ...	1
-0.01–0.10 ...	4
-0.11–0.20 ...	11
-0.21–0.30 ...	8
-0.31–0.40 ...	7
-0.41–0.50 ...	4
-0.51–0.60 ...	6
-0.61–0.70 ...	1
-0.71–0.80 ...	...
-0.81–0.90 ...	...
-0.91–1.00 ...	...
-1.01–1.10 ...	3
-1.11–1.20 ...	1
-1.21–1.30 ...	...

Part V—(3) Changes in distributional temperature with fishing season

In this case too, of course, seasonal changes of the so-called Type I, that is, changes in the temperature of capture accompanying seasonal changes in the age composition of the catch, also appear, but their effect can be measured using b_1. In order to show the effects of seasonal changes of Type II, we found the difference in average temperature of capture for adjacent months by year and area. The frequency distribution of these values and their average are shown in Table 9. The temperature of capture drops monthly from November on, is at its lowest from February to March, and begins to rise again in April. There is a difference of more than 1°C. in the temperature of capture as between November and February.

TABLE 9

The frequency distribution of the difference of distributing temperature of albacare of given size between successive two months, in given area

Difference (°C)	Nov.–Dec.	Dec.–Jan.	Jan.–Feb.	Feb.–Mar.	Mar.–April
+ 1.0	...	...	...	...	2
+ 0.5	2	...	6	9	3
0.0	5	9	14	14	7
— 0.5	6	9	15	19	2
— 1.0	2	7	2	...	...
— 1.5	1	2	...	...	...
— 2.0	...	1	...	...	...
Mean	— 0.356	— 0.611	— 0.181	+ 0.016	+ 0.236

PART VI—ESTIMATION OF THE CENTRAL WATER TEMPERATURE OF DISTRIBUTION OF THE ALBACORE

From Part III to Part IV we have seen that the relationship between albacore distribution and surface water temperature has a diverse structure. It is a composite of the basic [water temperature-distribution] relationships of each size group (age group). The way in which they are compounded is determined by the age composition at each season and in each area, and is not due to any way of distributing in response to the temperature environment peculiar to the albacore. The characteristics of the albacore's adaptation to the temperature environment appear superposed on the temperature-distribution relationships of the separate age groups (size groups). In this sense the central temperature of occurrence or distribution spoken of in this section is the average temperature of occurrence of the size groups (or age groups). Furthermore, the [distribution-water temperature] relationships of the several size groups are always changing with season and area. It is always necessary to apply to the central water temperature of occurrence corrections which reflect the peculiarities of the season and the area. Thus, a central temperature of occurrence which can be applied to the albacore as a whole, as a value peculiar to the species, does not exist.

In V-(1)—V-(3) we have evaluated the effects of (1) size (age), (2) catch location, and (3) season on the temperature of capture. Now we have:

(1) With every increase of 5 cm. in fish length, the temperature of capture rises 0.33°C. and with every decrease of 5 cm. it falls by 0.33°C.

(2) With a shift of the position of the fishing ground 10° of longitude to the east, the temperature of capture drops 0.35°C.

(3) The temperature of capture drops month by month, 0.35°C. from November to December, 0.61°C. from December to January, and 0.18°C. from January to February. From February to March the temperature of capture is at its lowest. In April it turns back upward and becomes 0.24°C. higher than in March.

These three elements working together determine the central temperature of occurrence. With T as the surface temperature at which albacore of a given size (x cm) are captured in a given month (Z month) on a given fishing ground (Y°E), and with T_0 as the reference temperature of capture of albacore X_0 cm. long at Y_0°E. in O month, formula [1] shows the central temperature of occurrence for each season and area for albacore X cm. long.

$$T=T_0+(X-X_0)/5\times 0.33-(Y-Y_0)/10\times 0.35+(C_Z-C_O) \quad \ldots\ldots[1]$$

$C_Z - C_O$ is the difference in temperature of occurrence between the base month and Z month. If T_0, X_0, Y_0, and Z_0 are determined, one can actually find the average temperature at which albacore of a given size are captured on a given fishing ground in a given month. Here we take X_0=90 cm., Y_0=135°E., and ($C_Z - C_O$) as the difference in temperature of capture between February and Z month. The following procedures are followed in calculating T_0. First we derive the average temperature of capture (T) for fish having an average length (X) of 85–95 cm., without particularly limiting the fishing ground (Y) to 130°-140°E. and the fishing season (Z) to February. Next we enter T, X, Y and Z in formula [1] and get an estimate of T_0. The frequency distribution of deduced values of T_0 is shown in Table 10. Their average is 19.93°C., and using this we can rewrite formula [1] as follows.

TABLE 10

Frequency distribution of estimate of To in equation (2)

T is the mean distributing temperature of Albacore of 90 cm length, in February, in the area from 130°E to 140°E

Temperature	Frequency
18.6–18.7	1
18.8–18.9	...
19.0–19.1	...
19.2–19.3	1
19.4–19.5	3
19.6–19.7	6
19.8–19.9	7
20.0–20.1	2
20.2–20.3	3
20.4–20.5	2
20.6–20.7	...
20.8–20.9	1
21.0–21.1	1

Mean value is calculated as 19.93°C.

$T=19.93°C.+0.33\ (X-90)/5°C.-0.35\ (Y-135)/10°C.+(C_z-C_o)$.....[2]

The values of $C_z - C_o$ are as shown in Table 11. The central temperatures of occurrence of albacore of various sizes as found by formula [2] are shown in Table 15.

TABLE 11

The table of (Cz-Co) of the equation (2)

(Cz-Co) is the difference of the mean distributing temperature between each month and February.

Nov.	Dec.	Jan.	Feb.	Mar.	April
1.15	0.79	0.18	0.00	002	0.25

PART VII—DISCUSSION OF RESULTS—THE SIGNIFICANCE OF DISTRIBUTIONAL WATER TEMPERATURES

VII—(1) Range of temperatures of occurrence and central temperatures of occurrence for albacore

The relationship [water temperature-distribution] which is observed in the albacore is not of a character which allows it to be explained as a characteristic value corresponding to the species. It is a composite of the basic [water temperature-distribution] relationships of the different sizes (ages), and it is altered by the peculiarities which each season and area has. This composite character of the structure of the distribution arises fundamentally from the internal structure of the albacore *population*. The albacore *population* can be divided into a spawning group and a food-seeking group, differing markedly in their *sexual activity*, and each of these is composed of a number of size groups (age groups). (4) It may be thought that each of these unit groups has its own peculiar life-pattern. Therefore, there probably exists for each group a [water temperature-distribution] relationship corresponding to this sort of life-pattern.

When it comes to the area of distributional water temperatures of the albacore as a species, it is naturally extremely broad, because the spreads of temperatures of occurrence of the feeding group in the North Pacific current area and of the spawning group in the North Equatorial Current area are compounded. According to Table 1, it appears that they hardly occur at all in temperature zones below 16°C., but above this level they occur up to quite high temperatures. The data used in this study were all from operations in waters north of 25°N., however, even so we find catches recorded in water temperatures of 29°-30°C. The waters north of 25°N. are mainly the area of distribution of the food-seeking group. However, seasonally (around October, within the range of our data) the Subtropical Convergence is located considerably north of 25°N. (Table 2), so there is a possibility that at this season the temperature of capture also includes that of the spawning group. The proportion of productive fishing operations at each temperature, shown in Table 1, is minimum at 24°-26°C., and this temperature coincides with the surface temperature observed on the Subtropical Convergence. Judging from this, the peak of productive operations seen in the temperature range of 16°-24°C. probably corresponds to the life territory of the *feeding group* north of the Subtropical Convergence. The life territory of the spawning group is the area of the North Equatorial Current, and in that area temperatures of

around 30°C. are often observed. Consequently, the surface water temperature area of occurrence as a species must be considered to be 16°C.-30°C. The temperature of occurrence area of the *feeding group*, shown in Table 1 as 16°C.-24°C., is in general agreement with the 16.3°C.-22.8°C. which Inoue (1958) calls the zone of temperatures suitable for habitation and with Uda's (1957) *optimum water temperature* of 15°C.-22°C.

The range of temperatures at which the *feeding group* occurs is, if we inquire into its origins, formed by the composition of several ranges of distributional temperatures of unit size groups (or age groups). The annual growth of albacore is slightly over 10 cm., so if we make our estimate from the value of b_1, the discrepancy between the central temperatures of occurrence for groups 1 year apart in age will be about 0·7°-0·8°C. Because at least six groups having this degree of difference in their temperature of occurrence appear in the fishing grounds (Suda, 1954), the displacement of their central temperatures of occurrence alone would give about 4°-5°C., and adding to this the seasonal and areal changes of Type II and the *latitude* which individuals have, it is thought that the range of temperatures of occurrence for the feeding group as a whole would amount to 16°-24°C. These differences in distributional temperatures associated with the size of the fish have frequently been pointed out in other studies (Inoe, 1958 and Suda, 1958), The fact that large fish occur in the high-temperature parts and small fish in the low-temperature parts of the fishing ground means that large fish are more abundant in the southerly portions of the fishing ground, while small fish are more abundant in the more northerly portions. According to Table 5, the change of surface water temperature with 1° of latitude is about 0.8°C., and consequently for each change of 1° of latitude there is a change of about 1 year in the average age of the fish in the catch. Inoue (1958) thinks that the principle of differential habitation can be applied to this sort of displacement of the temperature of occurrence.

Looking in this way at the spread of temperatures of occurrence, as a species or as feeding groups and spawning groups, we cannot find any reason for regarding the albacore as a stenothermal species. However, this sort of spread in the temperature of occurrence is not something that shows the area of adaptation of the individual. If the concept of stenothermicity or of eurythermicity is concerned with the breadth of the adaptability of the individual or of a unit size group, then it is rather narrow. Because of the kind of data which we are using, we cannot directly get the spread of the temperature of occurrence of the individual, but we can get a general idea by deriving the discrepancy of 4°-6°C. in the central temperatures of occurrence among the six age groups represented in the 8°C. spread of temperatures of occurrence in the feeding group. If we make the estimate by this method, the spread in the temperature of occurrence for an individual is about 3°-4°C. This value is the sum of the individual's *latitude* with respect to temperature and the seasonal and areal changes of Type II in the central temperature of occurrence of the unit age group (or the unit size group). At the present stage we are unable to determine how these two elements are interrelated.

In the foregoing we have discussed the range of temperatures of occurrence of albacore, and next we will consider the central temperature of occurrence. The central temperature of occurrence for the species, or for the feeding group and the spawning group, is determined by each year's size composition (or age composition), and it is not of such a nature that it can be regarded as a fixed and characteristic value for the species or for the set of age groups.

The central temperature of occurrence is a characteristic value which must be defined for each single age group (unit size group). Furthermore, as we have seen in Parts III-IV, the individual character of the *field* (the season and the area) has an extremely important role in the determination of the central temperature of occurrence. The actual central temperature of occurrence is the result of interaction between each age group's characteristic response to the temperature environment and the conditions of the *field*. In other words, the peculiarities of the *field* are very strongly reflected in what are called the suitable fishing temperature (also called the suitable water temperature) and the fishing center temperature (the most suitable water temperature), and these are not just values characteristic of the respective groups. This point must be fully borne in mind when this value is discussed hereafter. The authors feel that this water temperature should not be dealt with simply as "the suitable water temperature for such-and-such a species of fish" but that the conditions of the fishing ground and the fishing season should be clearly noted. Central temperatures of occurrence by size, calculated by formula [2], are shown in Table 15.

VII—(2) Seasonal and local changes in the area of distribution and the seasonal migrations of the fish.

The range of the temperature of occurrence for the feeding group is 16°-24°C., or about 8°C., however, it is not a case of the schools' being distributed equally all over this temperature area. East of the line of 175°W., whatever temperature range we consider, there are hardly any examples of concentrated catches of albacore on longlines(Nakamura and Yamanaka 1959 and Naskai Reg. Fish. Res. Lab. 1959). Although albacore catches on longline are very few in this area, there are very outstanding catches of bigeye. The vicinity of 175°W. corresponds to the vicinity of the boundary of the Northwest Pacific Central Water Mass and the Northeast Pacific Central Water Mass (Hidaka 1950), and perhaps this difference in water systems may contribute to the formation of a boundary between the *field* of the albacore and the *field* of the bigeye.

Even within the area of temperatures of occurrence of albacore east of 175°W. the distribution of the schools is not uniform. As was shown in Figures 5 and 6, the schools have the western edge of their distribution at different longitudes in different months, and it shifts from east to west as the season progresses.

If we depict schematically the areas of distribution of the albacore which are fished in the longline fishing season, it takes the form shown by Suda(1958) and Nakamura and Yamanaka(1958). Of course, the southern edge and the northern edge of this territory correspond to the upper and lower limits of the distributional temperature area of the feeding group, that is, approximately the 24°C. and the 16°C. isotherms. The 75°F. (23.9°C.) and 60°F. (15.6°C.) lines, as explained in Part V, are respectively the water temperatures of the Subtropical Convergence and slightly inside of the Kuroshio Front (the side nearer the center of the North Pacific Current), so it may be said that the southern and northern edges of this distributional territory are the Subtropical Convergence and the Kuroshio Front. The eastern edge of the territory of occurrence, as already stated, corresponds approximately to the area of contact of the Northwest Pacific Central Water and the Northeast Pacific Central Water. In the North Pacific Current area, where the surface isotherms run east and west, the eastern edge, which runs north and south, must be unrelated to the surface temperature. The same thing can be said of the western edge of the territory of occurrence. The changes in density of the schools at the western edge are

much slower than at the other three edges. However, its position (in the longitudinal sense) shows very clear seasonal changes, and these are repeated every year quite regularly. Of the four fringe areas surrounding the area of occurrence of the feeding group, the western one has the most obscure oceanograpic character.

The distributional territory is defined as above, however, its (1) southern and northern edges (the Subtropical Convergence and the Kuroshio Front) show marked seasonal changes in a north-south direction, and (2) its western edge moves seasonally east and west, so the life territory itself changes its position and extent with the seasons. That is to say, the albacore change the center of their distribution and its extent markedly with the season.

The westward shift of the center of occurrence is particularly conspicuous. Its position is around 170°E.-180°E. in November, 165°E.-175°E. in December, 155°E.-165°E. in January, and 140°E.-155°E. in February. Because the position of occurrence changes thus, it is of interest to see how the effects of seasonal and areal changes of Type II appear in the water temperature at the center of the population. Taking the 80 cm. group as an example and estimating the water temperature at the center of this group by means of formula (2), we get about 19°C. in November, 18.8°C. in December, 18.5°C. in January and 18.9°C. in February. The central temperature of occurrence shows hardly any seasonal change, and the difference between November and January is thought to be about 0.5°C. Since the southward migration of the albacore begins in August-September, the change in water temperature at the center of the population during the whole period of southward movement is estimated to be about twice the temperature difference between November and January, that is, perhaps 1°C. This value is extremely small in comparison with the seasonal change in surface temperature of about 10°C. (Table 12) at a given point of fixed latitude and longitude in the area within the range of movement of the central portion of the North Pacific Current, that is, between 28.5°N. and 36.5°N. (Table 13). It must be considered that the albacore have a rather strong tendency to shift the center of their distribution in pursuit of a definite water temperature area. Or, changing the point of view, it can be considered that the seasonal and areal changes of Type II and the movements of the population have meshed together smoothly so that there has been hardly any change in the surface water temperature at the center of the distribution. It is rather difficult to estimate the seasonal change of surface water temperature at the latitudinal center of the North Pacific Current, which moves considerably north and south with the season. This is because, although the position of the Subtropical Convergence, which is its southern edge, can be determined from current charts, it has not been possible to deduce satisfactorily the position of the Kuroshio Front. We estimate the position of the Kuroshio Front in the following way. As was explained in III-(2) in regard to Figure 9, the albacore are distributed densely as far as their northern fringe, and there the density drops sharply. Therefore, there is a possibility that one can infer the Kuroshio Front using as a clue the northern edge of the distribution, or in other words, the sharp drop in the density of occurrence. From this point of view, the position of the northern edge of the distribution as shown in the Atlas of Average Year's Fishing Conditions in the Tuna Longline Fishery(1959), is considered to be the position of the Kuroshio Front in that month. According to Table 13, the range of the seasonal change in surface water temperature at the latitudinal centre of the North Pacific Current is about 5°C., or about one-half the amount of annual temperature change at a point fixed in latitude and longitude. However, this 5°C. is large in comparison with the amount of seasonal temperature change, 1°C., experienced at the center of the population. Consequently, one may think

TABLE 12

Seasonal changes in the surface water temperature at each station located in the North West Pacific 14,15

Lat.	Longi.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	D.	M. D.
25°N	135°E	21.7	20.6	21.4	22.5	25.0	26.4	28.1	28.4	28.1	27.5	25.3	23.6	7.78	...
„	145°E	22.5	22.0	21.1	23.6	24.7	26.7	27.8	28.1	27.8	27.8	26.1	23.9	6.95	...
„	155°E	22.5	22.8	22.0	23.4	25.0	26.1	27.5	28.1	28.1	27.5	26.7	24.6	6.17	...
„	165°E	22.5	22.5	22.0	23.1	23.9	26.7	27.0	27.8	27.8	27.2	25.9	23.6	5.84	...
„	175°E	22.5	22.2	22.2	23.1	23.6	25.6	27.0	27.0	27.5	27.2	25.6	23.6	5.28	...
„	175°W	22.5	22.2	22.2	22.2	23.1	25.0	26.1	26.4	27.0	26.1	24.7	23.6	4.73	6.12
30°N	135°E	19.5	18.6	18.9	19.7	22.2	24.7	27.2	28.1	27.5	25.6	22.2	21.4	9.45	...
„	145°E	18.9	18.6	18.1	19.7	20.6	23.4	26.4	27.5	27.2	26.1	23.1	21.1	9.45	...
„	155°E	18.9	18.3	18.1	19.2	21.1	23.4	26.7	27.0	27.0	26.1	23.9	22.0	8.90	...
„	165°E	19.5	18.3	18.1	19.2	21.1	22.8	25.9	27.0	26.7	25.9	23.9	21.1	8.90	...
„	175°E	18.6	18.3	18.1	19.2	21.1	22.8	25.3	25.9	25.9	24.7	22.8	20.3	7.78	...
„	175°W	18.6	17.8	17.8	18.6	20.6	22.8	24.5	25.3	25.6	23.9	21.7	19.7	7.78	8.71
35°N	135°E	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	145°E	15.0	14.5	15.6	16.4	18.6	21.1	24.7	25.9	25.3	22.8	20.0	17.8	11.40	...
„	155°E	15.8	14.5	14.5	15.8	17.2	20.0	23.9	25.3	25.3	23.1	20.3	17.5	10.84	...
„	165°E	15.0	14.7	14.2	16.1	16.7	18.9	22.8	24.2	24.7	22.5	20.9	18.3	10.56	...
„	175°E	15.0	14.5	14.5	15.8	16.7	17.8	22.5	23.9	22.8	21.4	19.5	17.0...	9.45	...
„	175°W	14.7	14.5	14.2	15.3	16.4	18.6	22.2	24.2	23.1	20.6	18.3	16.7	10.01	10.45
40°N	135°E	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	145°E	6.1	7.8	4.4	6.7	8.6	15.0	18.6	22.0	20.9	16.1	12.2	8.9	17.51	...
„	155°E	8.9	8.3	8.3	8.9	11.4	13.9	17.8	22.2	20.3	18.3	14.7	11.7	13.90	...
„	165°E	10.0	10.0	8.9	10.0	10.6	12.8	17.2	20.6	19.5	18.6	15.0	12.8	11.68	...
„	175°E	11.1	10.0	10.6	11.1	11.7	13.6	17.2	21.1	19.5	17.2	15.0	12.5	11.12	...
„	175°W	11.1	10.6	10.6	11.4	12.2	13.9	19.5	21.4	19.2	17.0	13.9	11.7	10.84	13.01

Remarks : D. is the difference between the highest and lowest temperature at each station.
M. D. represents the mean of D.

TABLE 13

The seasonal change in surface water temperature at the latitudinal center of North Pacific Current area 4,14,15

Month	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Monthly latitudinal position of the Subtropical Convergence.	31	30	30	27	26	23	23	24(°N)
Monthly latitudinal position of the northern limit of Albacore distribution.	42	41	41	40	39	36	34	3(°3N)
Estimated position of the latitudinal center of the North Pacific Current.	36.5	35.5	35.5	33.5	32	29.5	28.5	28.5(°N)
Surface water temperature at the latitudinal center of the North Pacific Current.	24.1	24.0	22.0	21.1	19.5	19.1	19.5	19.3(°C)

of this as follows. Of the 10°C. of seasonal temperature change which must probably be experienced in case it is postulated that the albacore do not move at all, one half, or 5°C., is cancelled out by the seasonal north-south movement of the distributional territory itself. Of the remaining 5°C., about 4°C. of temperature change is cancelled out by other kinds of movements of the population, and in the end only 1°C. remains as the amount of seasonal change in the water temperature which is experienced by the population itself.

As examples of such movements of the population we can think of (1) the advance westward, and (2) an active southward movement of the population separate from the southward shift of the distributional territory. Looking first at the westward movement (1), we can think of two cases. The first is that case where there is no great difference between the surface water temperature and the temperature at the level where the albacore are swimming in the westerly and easterly portions of the distributional territory. At this time it is thought that in this area, where the surface isotherms run almost east and west, this movement has very little effect in cancelling out the seasonal changes in the water temperature. Case number 2, on the contrary, is that where there are marked changes in the vertical temperature distribution, and in this case the areal changes of Type II seen in the temperature of occurrence would be merely apparent changes in the surface temperature. According to Table 14, the possibility of the second case is thought to be almost nil. Probably the westward migration is something other than an adaptation to the temperature environment, and in order to keep the water temperature at the center of the population uniform, the effect of the southward movement (2) is operating. The southward movement (2) is considered to be a migration in pursuit of suitable temperatures, and it takes place within the life territory. As a result of this movement, albacore which were accumulated in the comparatively northern portion of the distributional territory at the beginning of the fishing season accumulate in the comparatively southerly portions at the end of the fishing season.

TABLE 14

Difference in temperature between surface and 50m depth, and between surface and 100m depth in albacore longline ground

(A) Difference between surface and 50m.—

Longi.	Dec.	Jan.	Feb.	Mar.
130°E–140°E	0.09(23)	— 0.10(61)	0.13(64)	0.18(30)
140°E–150°E	0.34(21)	0.22(35)	0.08(46)	0.13(60)
150°E–160°E	0.02(11)	— 0.28(12)	0.03(12)	0.15(15)
160°E–170°E	0.13(7)	...	— 0.40(2)	0.28(9)
170°E–180°	0.24(19)	— 0.22(24)	0.00(12)	0.48(23)

(B) Difference between surface and 100m.—

Longi.	Dec.	Jan.	Feb.	Mar.
130°E–140°E	0.34(23)	0.14(62)	0.28(64)	0.40(30)
140°E–150°E	0.47(20)	0.46(36)	0.46(46)	0.50(60)
150°E–160°E	0.03(11)	— 0.36(12)	0.17(12)	0.40(15)
160°E–170°E	2.28(6)	...	— 0.30(2)	0.89(9)
170°E–180°	1.12(19)	0.60(22)	0.63(12)	1.15(22)

Figures in brackets represent the number of oceanographical observations, which were carried out in the area in which the range of surface water temperature was from 16°C to 22°C in December and January, and from 16°C to 21°C in February and March.

Looked at in this way, the seasonal migrations of the albacore can be analyzed into the following kinds of components:

(i) southward movement arising from a southward shift of the life territory itself .....this can cancel out 5°C. of water temperature change;

(ii) southern movement within the life territory, as a migration in search of suitable temperatures.....this can cancel out 4°C. of water temperature change;

(iii) westward migration.....it is difficult to regard this as a response to temperature change.

Directly linking the fact that throughout the fishing season the temperature change experienced by the central part of the population is extremely small with the conspicuous seasonal migrations of the schools, one gets the impression that the seasonal migrations of the albacore are nothing more nor less than a migration in pursuit of suitable water temperatures. In fact, the seasonal migrations of the albacore meet the conditions of a migration in search of suitable water temperatures, however, on the other hand (*a*) they play a role which has an ecological significance other than that of a temperature-regulated migrations, and (*b*) of the actual movements of the population, those which correspond to a temperature-controlled migration are a portion of the southward movement, while the other parts of the southward movement and the westward migration (which makes up the greatest part of the albacore's seasonal movements) could be caused by other things.

Here let us examine the migration in pursuit of suitable temperatures from another aspect. As is shown in Figure 4, the east-west extent of the population is extremely broad, and the areas with catch-rates of 1% or higher extend over 2,000–2,500 miles. If we consider areal and seasonal changes of Type II and the *latitude* which the individual fish have, the range of temperatures of occurrence of a unit size group should be fairly large. In VII—(1) that range was estimated at about 3°C.-4°C. This is approximately equivalent to the temperature change of 4°C. which was thought to give rise to the migration of the albacore in pursuit of suitable temperatures. This means that although data are available from which it can be judged that a 4°C. temperature difference causes a seasonal change in the center of distribution of the albacore, on the other hand it is determined at the same time that as individuals the albacore ordinarily adapt to a temperature difference of the same degree. Consequently, although the water temperature at the center of the population is very uniform, that cannot be taken to indicate the rigorousness of the albacore's adaptation to temperature.

VII—(3) Surface water temperature and scouting for fishing grounds

In Parts III-V we have explained how the relationship between albacore distribution and surface water temperature is determined by the interrelationships of fish size, season (month), and area (longitude of the fishing ground). When these three elements are given, it should be possible to determine temperature of capture T by means of formula (2). Thus Table 15 shows values of T for various X, Y and Z. However, the practical difficulty is in determining these three elements, that is, fish length (X), fishing ground temperature (Y), and the month of operation (Z), and particularly X and Y.

Let us first consider X. The problem is that even supposing that formula (2) is given and the season and area are indicated, this formula can only give in a parallel fashion the central distributional temperatures for a number of size groups (or age groups), providing no clue as to which of them to select as the operational temperature. The selection of the temperature of operation is an adaptation to the seasonal and areal changes of Type I, and in this a knowledge concerning the composite picture of size groups or age groups is required. This raises the problem of the age composition of the population which has migrated into the fishing ground or that of forecasting the amount of annual recruitment. At the present stage, however, the forecasting of recruitment has not reached a satisfactory level. As Suda (1958) has pointed out, much attention should be paid to the fishing conditions in the spring pole-and-line fishery. This is because a strong connection has been detected between the spring pole-and-line fishery and the autumn longline fishery, so

TABLE 15

The mean distributing temperature of albacore of each length in the North Pacific Current area, shown by longitude and month

Longi.	Month	60cm.	70cm.	80cm.	90cm.	100cm.	110cm.
130°E–140°E	Nov.	19.10	19.76	20.42	21.08	21.74	22.40
„	Dec.	18.74	19.40	20.06	20.72	21.38	22.04
„	Jan.	18.13	18.79	19.45	20.11	20.77	21.43
„	Feb.	17.95	18.61	19.27	19.93	20.59	21.25
„	Mar.	17.97	18.63	19.29	19.95	20.61	21.27
„	April	18.20	18.86	19.52	20.18	20.84	21.50
140°E–150°E	Nov.	18.74	19.40	20.07	20.73	21.39	22.05
„	Dec.	18.38	19.04	19.71	20.37	21.03	21.69
„	Jan.	17.77	18.43	19.09	19.75	20.41	21.07
„	Feb.	17.59	18.25	18.91	19.57	20.03	20.89
„	Mar.	17.61	18.27	18.93	19.59	20.05	20.91
„	April	17.84	18.50	19.16	19.82	20.48	21.14
150°E–160°E	Nov.	18.39	19.05	19.71	20.37	21.03	21.69
„	Dec.	18.03	18.69	19.35	20.01	20.67	21.33
„	Jan.	17.42	18.08	18.74	19.40	20.56	20.72
„	Feb.	17.24	17.90	18.56	19.22	19.88	20.54
„	Mar.	17.26	17.92	18.58	19.24	19.90	20.56
„	April	17.49	18.15	18.81	19.47	20.13	20.79
160°E–170°E	Nov.	18.04	18.70	19.36	20.02	20.68	21.34
„	Dec.	17.68	18.34	19.00	19.66	20.32	20.98
„	Jan.	17.07	17.73	18.39	19.05	19.71	20.37
„	Feb.	16.89	17.75	18.21	18.87	19.53	20.19
„	Mar.	16.91	17.57	18.23	18.89	19.55	20.21
„	April	17.14	17.80	18.46	19.12	19.78	20.44
170°E–180°E	Nov.	17.69	18.35	19.01	19.67	20.33	20.99
„	Dec.	17.33	17.99	18.65	19.31	19.97	20.63
„	Jan.	16.72	17.38	18.01	18.70	19.36	20.02
„	Feb.	16.54	17.20	17.86	18.52	19.18	19.84
„	Mar.	16.56	17.22	17.88	18.54	19.20	19.86
„	April	17.69	17.45	18.11	18.77	19.43	20.09

that the year classes which predominate in the spring fishery may be expected to predominate in the fall fishery too.

Next, let us consider Y. As was set forth in VII—(2), the westward migration of the albacore is something other than an adaptation to water temperature change, and the central longitude of distribution of the population is thought to be determined by conditions other than water temperature. Therefore, here too, even supposing that the distributional temperatures by longitudes are given, there is the problem that this is not a clue to the selection of the longitude of operation. At the present stage there is no recourse but to use past data and find the central longitude of distribution empirically from the average catch rates and take this as a criterion for fishing ground selection.

Even supposing that the operational water temperature is determined in the above way, there is no guarantee that there will invariably be good fishing in the designated temperature zone. This is because even within a given water temperature area the fish will be hit or missed to a greater or lesser extent depending on changes in conditions other than temperature. The size of the catch variability caused by this sort of hit and miss factor is the *index* — *C* shown in Table 6, and as shown by C. V. it is about 40 per cent. It may be possible to reduce this variance by taking into consideration other physico-chemical factors (*e. g.*, the pattern of distribution of the isotherms) and other biological elements. However, for most of these a large intelligence network for the gathering of information is considered necessary. In areas where there is no assurance of profitable operations, or in other words, in areas where there are hardly any fishing boats working, it is extremely difficult and unpromising to expect such an intelligence network. The writers consider it more realistic to treat information on fishing conditions not as a key to the selection of fishing grounds but to study and plan how to use it for evaluating the durability and movements of fishing grounds which have already formed or been discovered.

VII—(4) Fishing ground temperatures and the interpretation of data on fishing conditions

One of the authors, Suda (1959), has given by the following formula the amount of recruitment into the fishing ground by year of hatching.

$$S_i = P_{4.i+4}\,\bar{X}_{i+4} + P_{5.i+5}\,\bar{X}_{i+5} \quad \text{.....[3]}$$

i.....year of hatching

$P_{4.i+4}$..... the proportion of 4-year-old fish in the longline catch of $i+4$ year

$\bar{X}_{i+4}$.....catch rate of albacore in year $i+4$

$P_{5.i+5}$.....proportion of 5-year-old fish in the longline catch of year $i+5$

$\bar{X}_{i+5}$ .....albacore catch rate of year $i+5$

This is based on the idea that (i) the time when the recruits join the stocks that are fished in the North Pacific is mainly from the latter part of their 3rd year to the first part of their 4th year, and (ii) since the 4-year-old group and the 5-year-old group are the ages taken in the greatest numbers during the longline fishing season, our information on these two groups is most complete. However, although these two groups are the most important

objects of fishing effort, the degree to which fishing effort is centered on these two groups, and consequently the degree of their predominance over other groups is not necessarily the same from year to year. These changes in the *availability* of the groups of fish introduce a bias into the estimate of $P_{4.i+4}$, $P_{5.i+5}$, $\overline{X}_{i+4}$ and $\overline{X}_{i+5}$. If the fishing grounds and fishing seasons can be thoroughly stratified, this bias becomes smaller. For the calculation of $\overline{X}_{i+4}$ and $\overline{X}_{i+5}$ this treatment is possible to some extent. However, this kind of stratification is impossible in the calculation of $P_{4.i+4}$ and $P_{5.i+5}$. We estimate the size composition (or age composition) of the albacore from the fish landed at the market from the fishing boats, and such landings comprise all of the fish taken on one voyage. The scope of the area fished by one boat on one trip is rather broad and may *cover* an area of several degrees of latitude and longitude. Consequently, as far as the age composition of the catch is concerned, the size of the strata which we can establish is at least this large. However, if we take several degrees as the north-south extent of our classes, as was set forth in VII—(1), several age groups' distributional territories will be taken in at once. In other words, within these strata the age composition is very heterogeneous, and even the very setting up of the strata is almost without meaning. Therefore, at present in the calculation of Si the fishing grounds are just divided up by 10° of longitude and no division by latitude is made. The calculation of Si is done on the assumption that the variability from year to year in the *availability* of the stock is of a negligible degree. There is room for *bias* to be introduced arising, from the variability of *availability* of the stock in the Si estimated by formula (3) with these methods of calculation.

In order to eliminate the influence of such fluctuations in *availability*, it is a good idea to extract just the operational data from within the distributional temperature of 4-year-old and 5-year-old fish and to carry out the calculations with that. The following two methods are possible.

Let us look at the first method. In this formula 3 is used for calculating Si, but in each section of the calculations only data from those operations are used which were within the temperature area where 4-year-old and 5-year-old fish predominate. The water temperature ranges in which fish of these ages predominate can be approximately figured out from Table 15. Because the average length of 4-year-old fish is about 80 cm and that of 5-year-old fish is about 90 cm, it is sufficient to look for the water temperature range where fish from 75 to 95 cm long predominate. The lower limit of this temperature area is the average value of the central distributional temperatures of the 70-cm and 80-cm. classes, and its upper limit is the average value of the central distributional temperatures of the 90-cm and 100-cm classes. In Table 16 are shown these temperature areas by month and region. Using the operational records from cruises for which the average temperatures of capture fall within the water temperature range shown in the above chart, X_{i+4}, X_{i+5}, $P_{4.i+4}$, and $P_{5.i+5}$ may be calculated.

In the second method there is no information on the size composition, and consequently the idea is to find Si without using formula (3). In this case, if the average catch-rate in the water temperature area where 4-year-old fish predominate is $H_{4.i+4}$ and the average catch-rate in the water temperature area where 5-year-old fish predominate is $H_{5.i+5}$, then Si is as shown in formula [4].

$$Si = H_{4.i+4} + H_{5.i+5} \quad \text{.....(4)}$$

TABLE 16

The water temperature range in which (IV + V) age group is most dominant, shown by month and area (Unit °C)

	130°E–140°E	140°E–150°E	150°E–160°E	160°E–170°E	170°E–180°E
Nov.	20.09–21.41	19.74–21.06	19.38–20.70	19.03–20.35	18.68–20.00
Dec.	19.73–21.05	19.38–20.70	19.02–20.34	18.67–19.99	18.32–19.64
Jan.	19.12–20.44	18.76–20.08	18.41–19.73	18.06–19.38	17.71–19.03
Feb.	18.94–20.06	18.57–19.80	18.23–19.55	17.98–19.20	17.53–18.85
Mar.	18.96–20.08	18.60–19.82	18.25–19.57	17.90–19.22	17.55–18.87
April	19.19–20.51	18.83–20.15	18.48–19.80	18.18–19.45	17.78–19.10

However, in actuality this $H_{4.i+4}$ and $H_{5.i+5}$ are not respectively composed only of 4-year-old and 5-year-old fish. As has already been stated, the individual has a rather wide *latitude* with respect to the temperature of occurrence, so that even in areas with temperatures where 4-year-olds and 5-year-olds predominate, members of older and younger groups should be present at the same time. Consequently, depending on the *population-size* of the immediately preceding and following age groups, it must be thought that $H_{4.i+4}$ and $H_{5.i+5}$ will be considerably affected. This method probably has value in cases where hardly any information is available on the size composition. Table 17 shows the water temperature areas in which 4-year-old and 5-year-old fish predominate.

TABLE 17

The water temperature ranges for IV age group and for V age group in which each age group is most dominant (Unit °C)

(A) IV age group—

	130°E–140°E	140°E–150°E	150°E–160°E	160°E–170°E	170°E–180°
Nov.	20.09–20.75	19.74–20.40	19.38–20.04	19.03–19.69	18.68–19.34
Dec.	19.73–20.39	19.38–20.04	19.02–19.68	18.67–19.33	18.32–18 98
Jan.	19.12–19.78	18.76–19.42	18.41–19.07	18.06–18.72	17.71–18.37
Feb.	18.94–19.60	18.58–19.19	18.23–18.89	17.98–18.59	17.53–18.19
Mar.	18.96–19.62	18.60–19.21	18.25–18.91	17.90–18.56	17.55–18.21
April	19.19–19.85	18.83–19.49	18.48–19.14	18.13–18.79	17.78–18.44

(B) V age group—

	130°E–140°E	140°E–150°E	150°E–160°E	160°E–170°E	170°E–180°
Nov.	20.75–21.41	20.40–21.06	20.04–20.70	19.69–20.35	19.34–20.00
Dec.	20,39–21.05	20.04–20.70	19.68–20.34	19.33–19.99	18.98–1,64
Jan.	19.78–20.44	19.42–20.08	19.07–19.73	18.72–19.38	18.37–19.03
Feb.	19.60–20.26	19.19–19.80	18.89–19.55	18.59–19.20	18.19–18.85
Mar.	19.62–20.08	19.21–19.82	18.91–19.57	18.56–19.22	18.21–18.87
April	19.85–20.51	19.49–20.15	19.14–19.80	18.79–19.45	18.44–19.10

As shown above, it is possible to heighten the accuracy of estimates or to eke out the inadequacy of the data by introducing *information* concerning the water temperature of occurrence.

Let us add one more possibility. Basically there is a strong tendency for the operations of fishing boats to be concentrated on the most economical size groups. Consequently it is to be thought that those size groups appear with an unrealistically great emphasis in the catch. By comparison, as explained in III — (2), the catch rates by different water temperatures given in Figure 9 are thought to be a good deal closer to the actual age composition of albacore in the sea. If we could grasp the *latitude* of the individual with respect to the temperature of occurrence, it would probably become possible to make a rather accurate estimation of the age composition and the survival rate.

In ending this paper, I wish to express my thanks, first of all to Director, Nakamura and Pelagic Resources Branch Chief Yabe for their guidance, to the members of the staff of the Pelagic Resources Branch, and particularly to Technical Officer, Yamanaka for serving as my constant consultant.

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