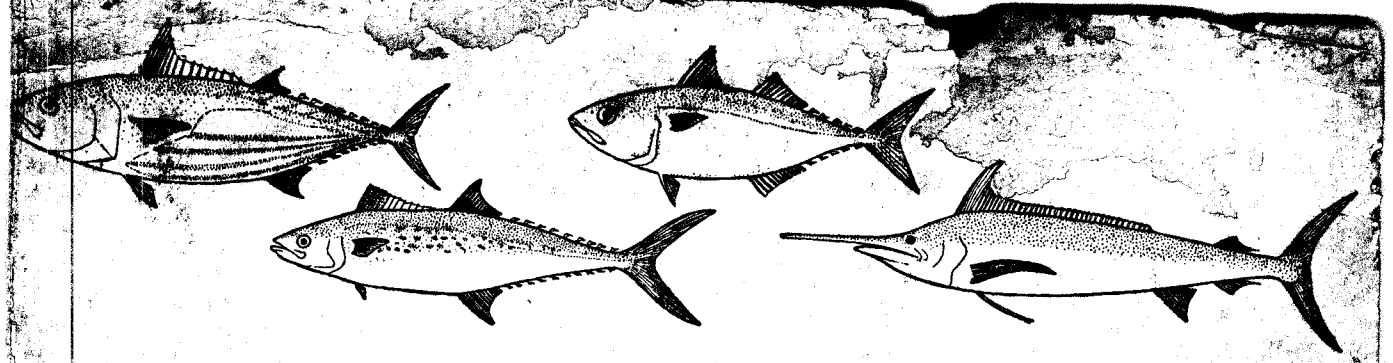
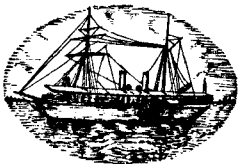


SYMPOSIUM ON SCOMBROID FISHES

PART I



MARINE BIOLOGICAL ASSOCIATION OF INDIA
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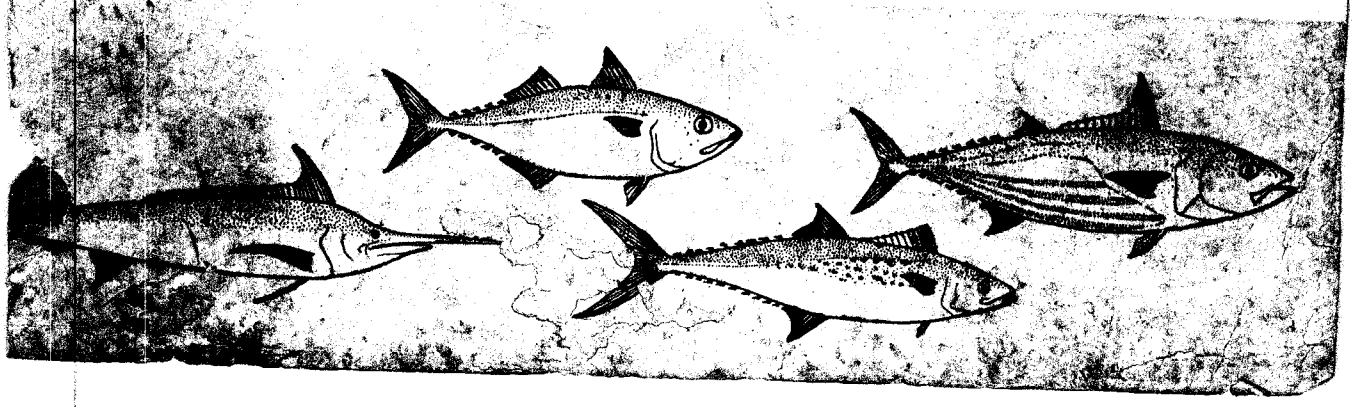
S. INDIA



PROCEEDINGS OF THE

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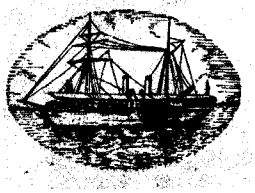
SCOMBROID FISHES

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

PART I



SYMPOSIUM SERIES 1
MARINE BIOLOGICAL ASSOCIATION OF INDIA
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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

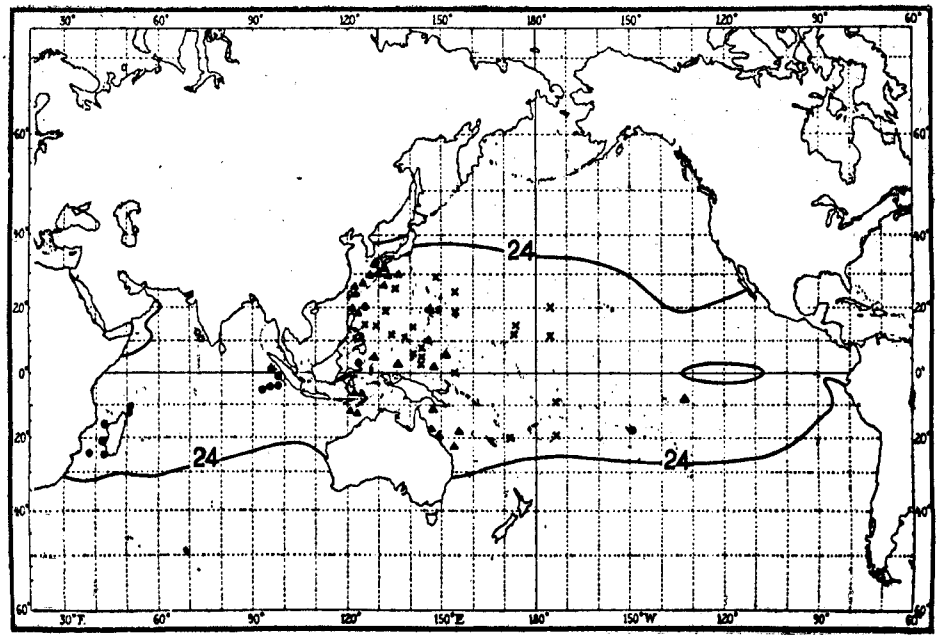
I. gladius is widely distributed from the coast of Union of South Africa and across the entire Indo-Pacific to the coast of California in the north to Peru in the south.

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

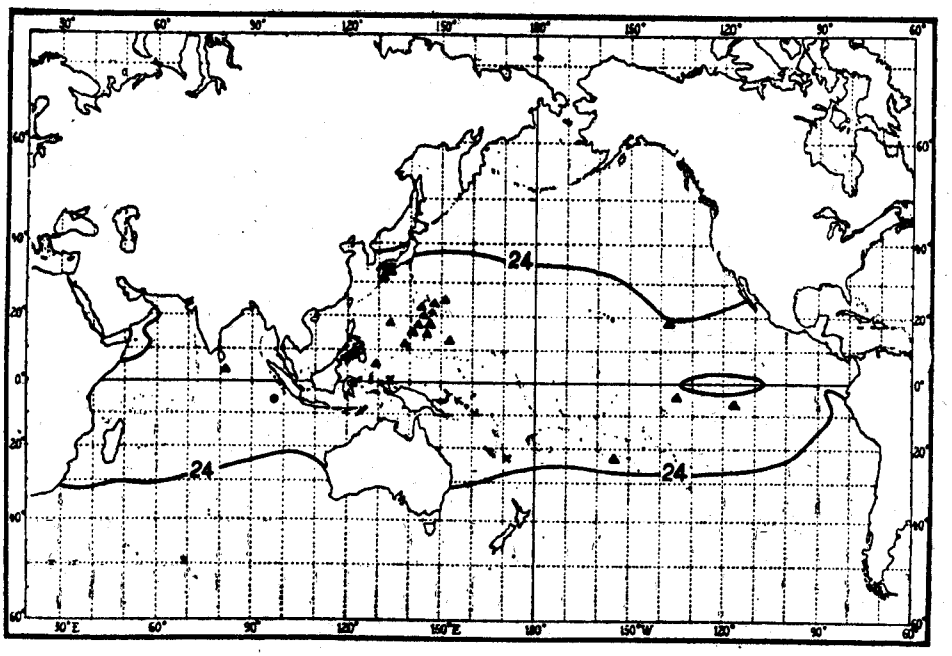
Marlina marlina Hirasaka and Nakamura

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.

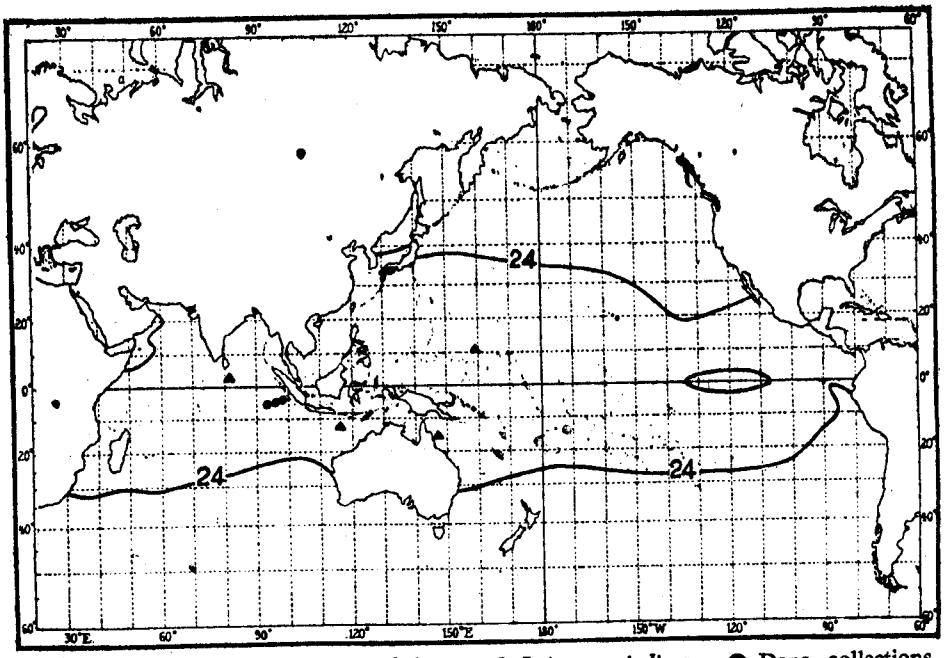


Text Fig. 2.—Records of capture of larvae of *Tetrapturus* angustirostris. ● Dana collections, × Vityaz collections, ▲ Japanese collections.

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

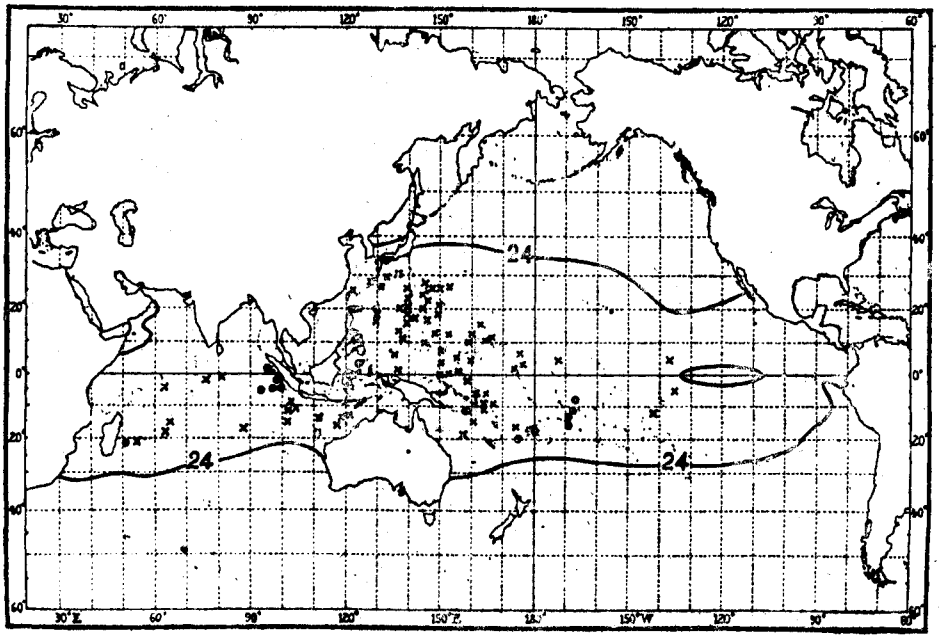
Istiompax howardi Whitley

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

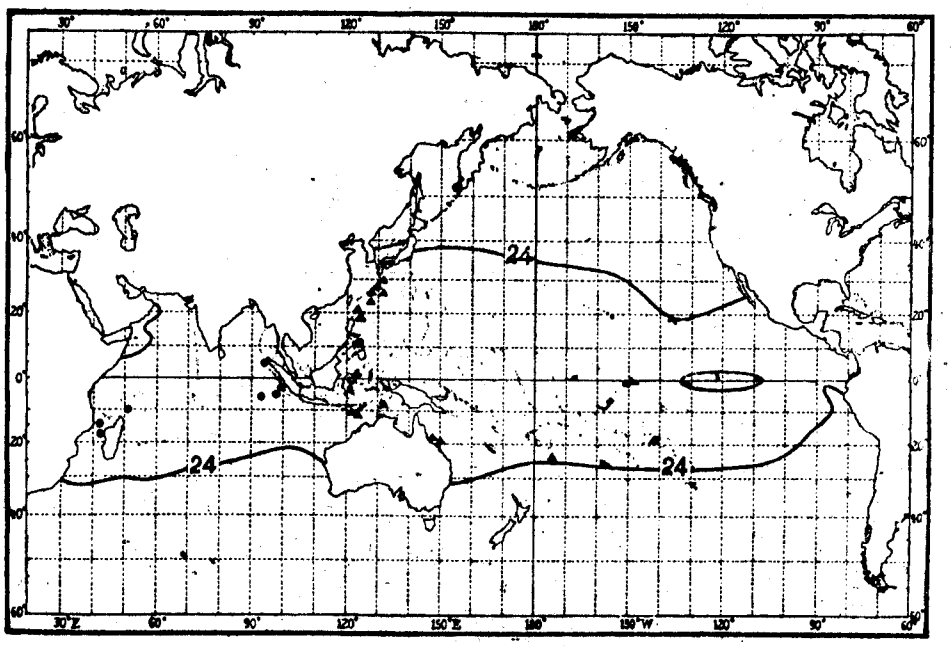
Distribution

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

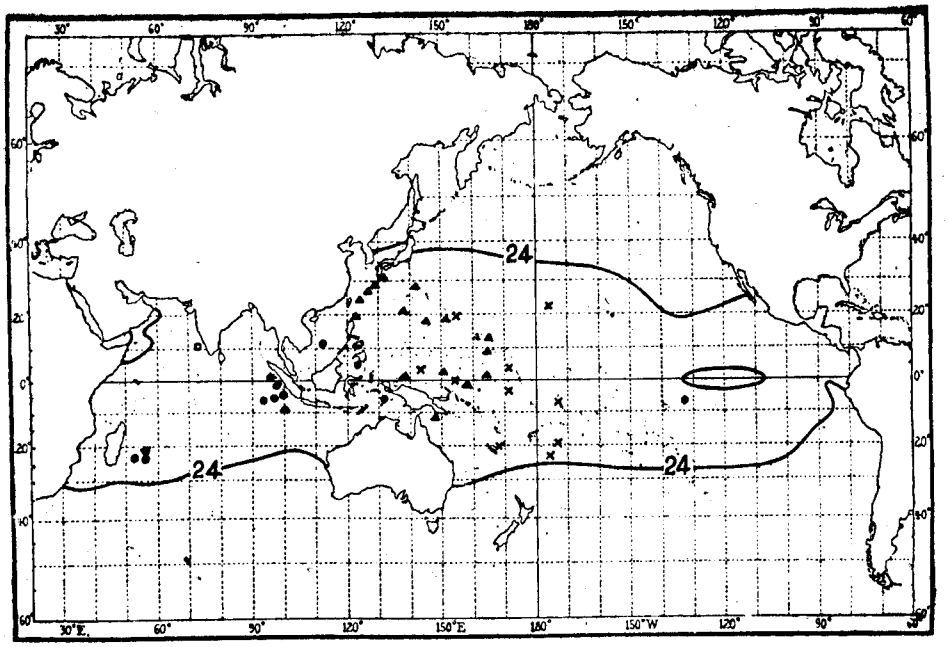
February to August with the peak from March to June and that in the equitorial region spawning might take place throughout the year. From the Laccadive Sea one postlarva measuring 16.27 mm. was collected in February (Jones, 1958). The swordfish larvae collected by the *Dana* have been worked out in detail 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

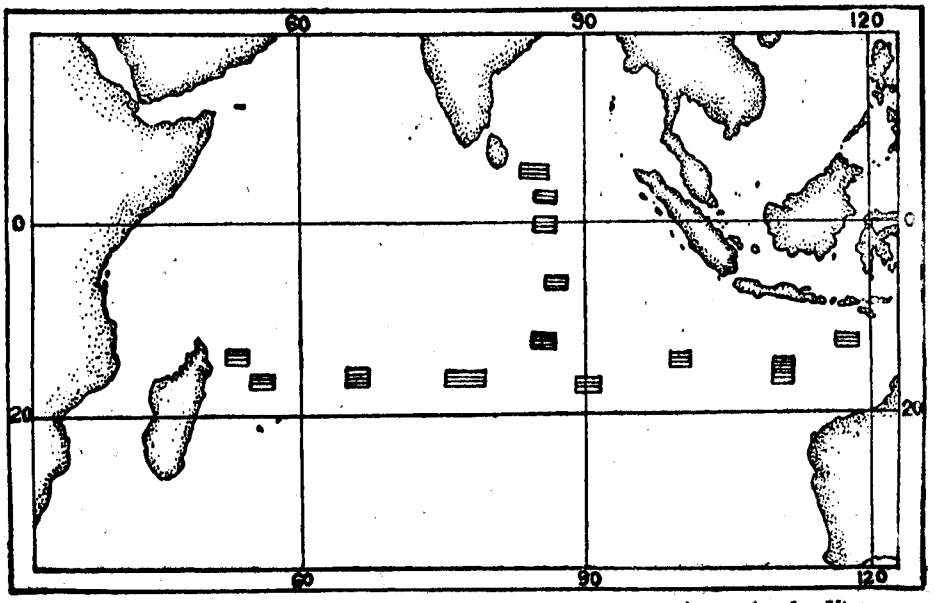
* Inclusive of specimens worked out by Tåning (1955).



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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