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GEOGRAPHICAL DISTRIBUTION OF SURFACE-MIGRATING MYCTOPHID FISHES (GENUS *MYCTOPHUM*) IN THE TROPICAL AND SUBTROPICAL PACIFIC AND INDIAN OCEANS*

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Many species of myctophid fishes have been known to migrate vertically into surface waters at night. These species, surface migrants, belong to certain restricted genera of the family Myctophidae : *Symbolophorus*, *Myctophum*, *Hygophum*, *Loweina*, *Gonichthys*, *Centrobranchus*, and *Tarletonbeania*. In other words, this pattern of diurnal vertical migration seems to be an ecological character of the fishes of these genera. The daytime habitats of these fishes have been hardly studied, since they avoid the net effectively during daytime, probably through a well-developed visual sense. However, judging from the depth at which the fishes are sometimes caught during the daytime and from their bright shining body, which is assumed to be an adaptation to the environment of dim light, it may be postulated that the center of their daytime distribution is in the 200—500 m layer, i.e., the twilight zone.

These fishes are very abundant in the open sea and have been reported to compose a considerable part of the diet of commercially important oceanic fishes and marine mammals such as salmon, scombroid fishes, squids and dolphins. Thus, it is important to study the ecology of these fishes, especially their geographical and vertical distributions, and the modes of their diurnal vertical migration. The taxonomy and geographical distribution of *Hygophum*, *Loweina*, *Tarletonbeania*, *Gonichthys*, and *Centrobranchus* were studied in detail in the Pacific and Indian Oceans by Bekker (1964, 1965). However, the fishes of *Myctophum* have not been studied as extensively, although they are the most common among the surface migrating myctophid fishes (Fig. 2).

This paper deals with the geographical distribution of *Myctophum* in the Pacific and Indian Oceans. Although the taxonomic confusion of these fishes has been partially cleared (Gibbs, 1957 ; Nafpaktitis and Nafpaktitis 1969 ; Wisner, 1970), there remain some problems such as the *Myctophum spinosum-lychnobium* complex and the uncertainty of the presence of *M. cuvieri*. The present study will serve not only to understand their ecological

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importance in the open sea, but also to contribute toward the clarification of the taxonomic problems.

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METHODS AND MATERIALS

All of the specimens were collected during the investigation on the spawning grounds, and the distribution and development of larvae of the commercially important scombroid fishes (*Thunnus, Euthynnus, Auxis,* etc.) and billfishes. The investigation was conducted during the years 1966—68 by the Division of Pelagic Resources, Far Seas Fisheries Research Laboratory of Japanese Fisheries Agency with the cooperation of 30 vessels of the fisheries experimental stations and fishery high schools of the local governments.

Towing methods were standardized for all of the collections. A Maruchi-type larva net was used for all the tows. The dimensions and construction details of the net are shown in Fig. 1. Towing speed was regulated at about 2 knots so as to keep one-third of the mouth diameter of the net appearing above the sea surface. All tows were made at night for a duration of 15 minutes at the side of ship. The samples were fixed in 10 percent Formalin. Larvae and postlarvae of myctophid fishes were not examined, since their identification is difficult at the present stage of study.

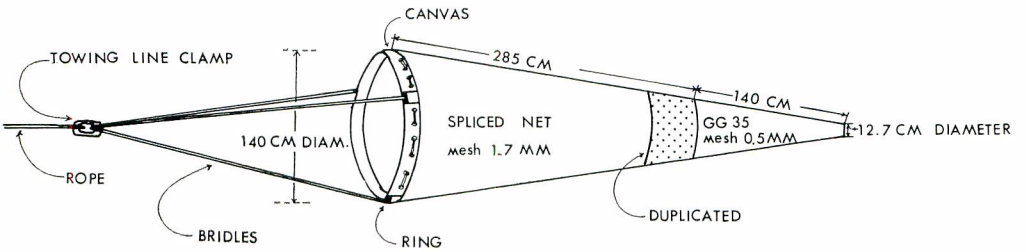

Fig. 1. Dimensions and construction detalis of MARUCHI-type larva net.

Sampling stations are plotted in Fig. 4. In the Pacific, most of the sampling stations were located in the tropical area between the Tropic of Cancer and Capricorn, although a considerable amount of sampling effort reached northward to lat. 30°N between long. 130°E and 150°W. Density of sampling stations was rather low in the eastern part, especially in the eastern South Pacific. Off the west and east coasts of Australia, samples were also obtained in the area south of lat. 30°S. These areas are defined as the western South Pacific south of lat. 30°S and the eastern South Indian Ocean south of lat. 30°S, respectively

Table 1. Number of sampling stations by month and areas in the Pacific and Indian Oceans during the years 1966—1968.

areas \ month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tropical Pacific east of 180°*	29	33	21	24	115	144	52	7	18	15	29	26	513
Tropical Pacific west of 180°*	78	71	38	32	69	140	99	68	85	134	62	32	908
Tropical Indian Ocean*	43	83	29	10	1	0	0	6	30	44	28	0	274
Western South Pacific south of 30°S	1	15	3	0	0	0	0	0	0	0	0	0	19
Eastern South Indian Ocean south of 30°S	0	0	0	0	0	0	0	0	2	14	0	0	16

* The areas between 20°N and 30°N and between 20°S and 30°S are partly included.

(Table 1). The number of samples is small in these areas. In the Indian Ocean, most of the stations are located in the area between the equator and lat. 20°S. The number of samples in each month and area is shown in Table 1.

In the figures showing the geographical distribution of each species, stations are expressed as a dot in a one degree latitudinal and longitudinal square. Positive stations (stations where specimens were caught) are indicated by large dots, and negative stations (stations where specimens were not caught) by small ones. In a square where both positive and negative stations are present, a larger dot is plotted. Some reliable records were cited from the literature.

THE DOMINANCY OF FISHES OF THE GENUS *MYCTOPHUM*

A total of 20,346 specimens belonging to nine genera, *Myctophum*, *Symbolophorus*,

Table 2. Generic composition of surface migrating myctophids collected at different areas of the Pacific and Indian Oceans.

Genus \ areas	Tropical Pacific east of 180°*	Tropical Pacific west of 180°*	Tropical Indian Ocean*	Western South Pacific south of 30°S	Eastern South Indian Ocean south of 30°S	Total No. of Individual
Myctophum	5,382	6,334	2,616	57	0	14,389
Symbolophorus	1,567	1,772	473	14	0	3,826
Centrobranchus	276	492	292	6	0	1,066
Hygophum	332	290	101	6	1	730
Loweina	0	1	0	0	0	1
Gonichthys	138	25	0	27	4	194
Electrona	0	0	0	1	20	21
Diaphus	1	1	0	1	0	3
Lampanyctus	116	0	0	0	0	116

* The areas between 20°N and 30°N and 20°S and 30°S are partly included.

Table 3. Species composition of the fishes of genus *Myctophum* collected at different areas of the Pacific and Indian Oceans.

Species \ areas	Tropical Pacific east of 180°*	Tropical Pacific west of 180°	Tropical Indian Ocean*	Western South Pacific south of 30°	Eastern South Indian Ocean south of 30°S	Total No. of individual
M. spinosum	2,551	3,155	736	0	0	6,442
M. nitidulum	1,584	565	1,175	1	0	3,325
M. obtusirostrum	863	1,198	415	0	0	2,476
M. asperum	357	1,399	280	19	0	2,055
M. phengodes	0	13	0	37	0	50
M. aurolaternatum	27	4	10	0	0	41

* The areas between 20°N and 30°N and between 20°S and 30°S are partly included.

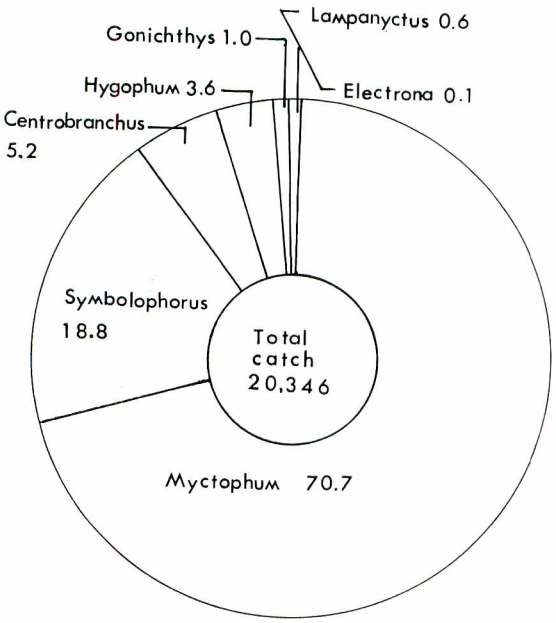

Fig. 2. Generic composition of myctophid fishes collected in the tropical and subtropical Pacific and Indian Oceans.

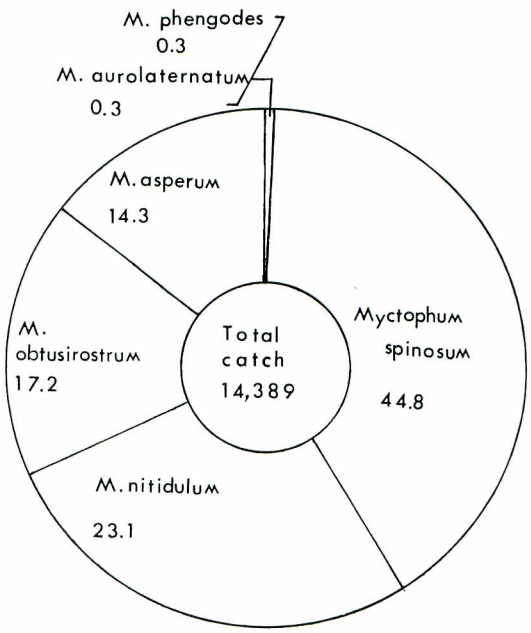

Fig. 3. Species composition of fishes of the genus *Myctophum* collected in the tropical and subtropical Pacific and Indian Oceans.

Centrobranchus, *Hygophum*, *Gonichthys*, *Electrona*, *Loweina*, *Lampanyctus*, and *Diaphus*, was found in the samples examined (Table 2). Of these, the fishes of *Myctophum* composed 70.7 percent of the total catch as shown in Fig. 2. Most of the species of the genera, *Diaphus* and *Lampanyctus*, do not usually appear in the surface waters at night. The 116 specimens of *Lampanyctus* in the tropical eastern Pacific were all *L. omostigma*. Beebe and Vander Pyl (1944) also reported the species from the surface in the same area. But at the present stage of our study, it is uncertain whether or not *L. omostigma* is the

surface-migrating *Lampanyctus*. Excepting this species, the appearance of *Diaphus* and *Lampanyctus* into the surface water at night is thought to be rare or negligible in the area under investigation.

Six species of *Myctophum* were identified in the samples. The species composition of *Myctophum* at different areas is shown in Table 3. In terms of numbers, *M. spinosum* and *M. nitidulum* accounted for 68 percent of the total catch of *Myctophum*.

GEOGRAPHICAL DISTRIBUTION

Myctophum spinosum Steindachner, 1867

(Fig. 5)

"Ibara-hadaka" (Japanese name)

Positive samples 1,048 ; total catch 6,442 individuals (15—95 mm in standard length).

The species is widely distributed in the tropical and subtropical waters of the Pacific and Indian Oceans as shown in Fig. 5. Though sampling locality of the type described by Steindachner (1867) is presented simply as "from China (Von China)", this species probably occurs in the South China Sea. Other previous records (Brauer, 1906 ; Sarenas, 1954 ; Nafpaktitis and Nafpaktitis, 1969) agree well with the present result.

This species is distinguished from the closely related *Myctophum lychnobium* Bolin in having the SAO_2 instead of the SAO_1 over or nearly over VO_4 (Bolin, 1946 ; Sarenas, 1954). Some of our specimens were intermediate between *M. spinosum* and *M. lychnobium* in the relative position of $SAO_{1,2}$ and VO_4 photophores. This is thought to support Sarenas (1954), who noted that "*Myctophum lychnobium* is very close to *Myctophum spinosum* and may actually prove to be conspecific".

Myctophum nitidulum Garman, 1899

(Fig. 6)

"Susuki-hadaka" (Japanese name)

Positive samples 468 ; total catch 3,325 individuals (15—75 mm in standard length).

The species was very widely distributed in the tropical and subtropical waters of the Pacific and Indian Oceans. The distributions of this species and *M. spinosum* widely overlapped in the area under investigation. However, the northern limits of both species seem to be different in the western North Pacific. The collection from the area between long. 130° and 155°E shows that the northern limit of the range of *M. nitidulum* lies near 42°N, whereas that of *M. spinosum* is near lat. 33°N (Hattori, 1964. Note : Hattori identified *M. nitidulum* as *M. affine*). Also with regards to the total catches of both species in the collection of Hattori (1964), 1,332 individuals of *M. nitidulum* from 197 samples greatly exceed the 4 individuals of *M. spinosum* from 4 samples in the western North Pacific.

The species differs from the closely related *M. affine* in having cycloid scales and an angulated upper opercle (Gibbs, 1957).

Myctophum obtusirostrum (Täning, 1928)

(Fig. 7)

"Hisa-hadaka" (new Japanese name)

Positive samples 54 ; total catch 2,476 individuals (15—75 mm in standard length).

This species occurred in the tropical part of the Pacific and Indian Oceans. Their occurrence in waters off Hawaii is thought to be due to the presence of the northward branch of the North Equatorial Current. In spite of the great sampling efforts, *M. obtusirostrum* has not been recorded from off Japan (Ogawa, 1961 ; Hattori, 1964).

Myctophum asperum Richardson 1844—48

(Fig 8)

"Ara-hadaka" (Japanese name)

Positive samples 317 ; total catch 2,055 individuals (15—75 mm in standard length).

The species occurred in the waters of the North and South Equatorial Currents and the Equatorial Countercurrent of the Pacific and Indian Oceans. It is noticeable that the density of positive stations was very low in rather stagnant waters such as North Pacific Central Water area southeast of the Kuroshio and the water around the Celebes Island which are not influenced by a warm current. In other words, the range of this species may be related to warm currents. The species appeared southward to lat. 40°S off the east coast of Australia, which is influenced by a warm current. Though no collection was made in the Kuroshio region in the present study, Ogawa (1961) and Hattori (1964) reported that *M. asperum* was very abundant in the Kuroshio region west of long. 150°E and south of lat. 40°N.

M. asperum differs from other species of *Myctophum* in having four gill rakers on the upper limb of the first arch, the lowest number in the genus, although *M. aurolaternatum* rarely has four gill rakers.

Myctophum phengodes (Lütken, 1892)

(Fig. 9)

"Chikame-hadaka" (new Japanese name)

Positive samples 14 ; total catch 50 individuals (15—50 mm in standard length).

This species was found only in the western South Pacific between lat. 20° and 40°S in the present study. Other records, however, show that *M. phengodes* is distributed also in the central South Pacific between 35° and 38°S and in the Indian Ocean between 22° and 34°S (Brauer, 1906 ; Nafpaktitis and Nafpaktitis, 1969). These facts indicate the range of the species coincides with the warm waters of the South Pacific and the South Indian Ocean, between lat. 20° and 40°S.

Myctophum aurolaternatum Garman, 1899

(Fig. 10)

"Hikari-hadaka" (Japanese name)

Positive samples 25 ; total catch 41 individuals (15—95mm in standard length).

The species was widely distributed in the waters of the North and South Equatorial Currents and the Equatorial Countercurrent in the Pacific and Indian Oceans (Fig. 10). The northernmost record from off Japan By Kamohara (1959) indicates that the northern extent of the range of *M. aurolaternatum* is influenced by the Kuroshio. It is noticeable that this species showed a very sparse distribution in warm waters, though the occurrence is rather frequent in the eastern tropical Pacific as shown in Fig. 10.

This species has the slenderest body of the species of *Myctophum*; the body depth is less than 20.5 percent of the standard length in *M. aurolaternatum*, whereas it is more than 21 percent in other species.

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インド・太平洋の熱帯・亜熱帯海域における夜表性ススキハダカ属（*Myctophum*）魚類の地理分布

川口弘一・池田博美・田村真道・上柳昭治

要　　約

インド・太平洋の熱帯・亜熱帯海域におけるマグロ類の産卵調査のために行なわれた稚魚網表面曳による稚仔採集調査で得られたハダカイワシ科魚類のうち，ススキハダカ属6種の地理分布について報告する。

1） 1966年から1968年にかけて得られたハダカイワシ科魚類の全採集標本20,348個体は，9属すなわちススキハダカ属（*Myctophum*），ナガハダカ属（*Symbolophorus*），ブタハダカ属（*Centrobranchus*），ドングリハダカ属（*Hygophum*），*Gonichthys* 属，*Electrona* 属，*Loweina* 属，トンガリハダカ属（*Lampanyctus*），コビトハダカ属（*Diaphus*）の魚類により構成されていたが，このうちススキハダカ属が全体の約70%と卓越した割合を示し，夜表性ハダカイワシ類のうち量的に最も重要な位置を占めている。（Fig. 2）。

2） ススキハダカ属の出現種は，イバラハダカ（*M. spinosum*），ススキハダカ（*M. nitidulum*），ヒサハダカ（新称）（*M. obtusirostrum*），アラハダカ（*M. asperum*），チカメハダカ（新称）（*M. phengodes*），ヒカリハダカ（*M. aurolaternatum*）の6種で，2種に新和名を与えた。

3） チカメハダカをのぞく各種はいずれも熱帯海域を中心に分布するが，亜熱帯・温帯域への出現頻度に種による若干の差異がみられた。（Fig. 5～10）。イバラハダカ，ヒカリハダカは熱帯・亜熱帯海域を中心に分布する。この2種は黒潮などの暖流と関係して分布域を北にのばし，温帯域へも出現するが，その量は極めて少ない。また，ヒカリハダカは，出現頻度は低いが広汎な海域に分散して出現するのが特徴的である。ヒサハダカは熱帯海域にのみ出現した。この種はイバラハダカなどと同様に暖流に乗って亜熱帯・温帯海域にも出現する可能性があるが，量的には極めて少いと推定される。

ススキハダカ，アラハダカは，熱帯，亜熱帯海域に広く出現した。温帯海域での既往の研究結果も含めて考察すると，これら2種は温帯海域にも多く分布し，その北限，南限はそれぞれ40°N および40°S 附近にあると推定される。温帯海域にも多産する点で前述の3種と異なっている。

チカメハダカは南半球の 20°S～40°S の海域にのみ出現した。既往の採集報告も本種が南半球の温帯・亜熱帯海域にのみ分布することを支持している。

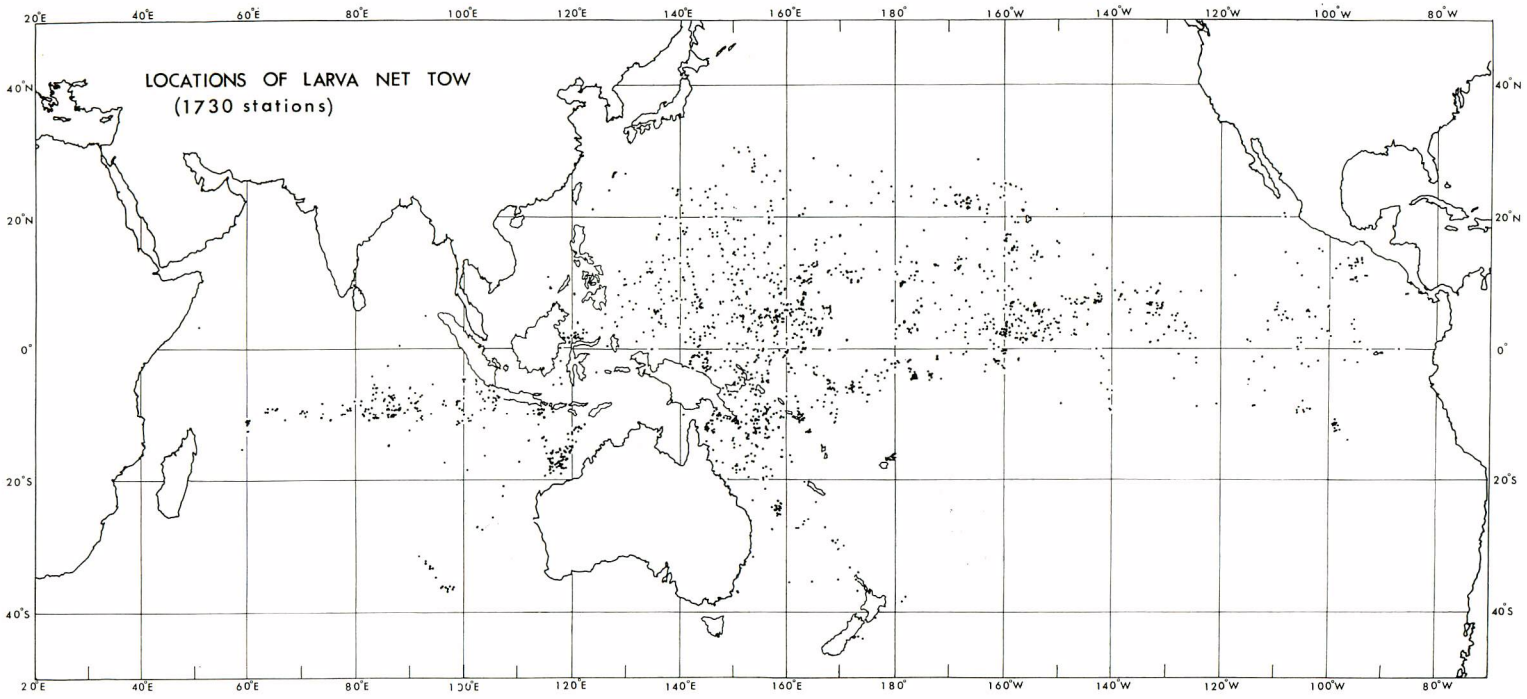

Fig. 4. Location of the sampling stations for myctophid fishes in the Pacific and Indian Oceans. Samples were collected during the years 1966—1968. Each dot represents a station.

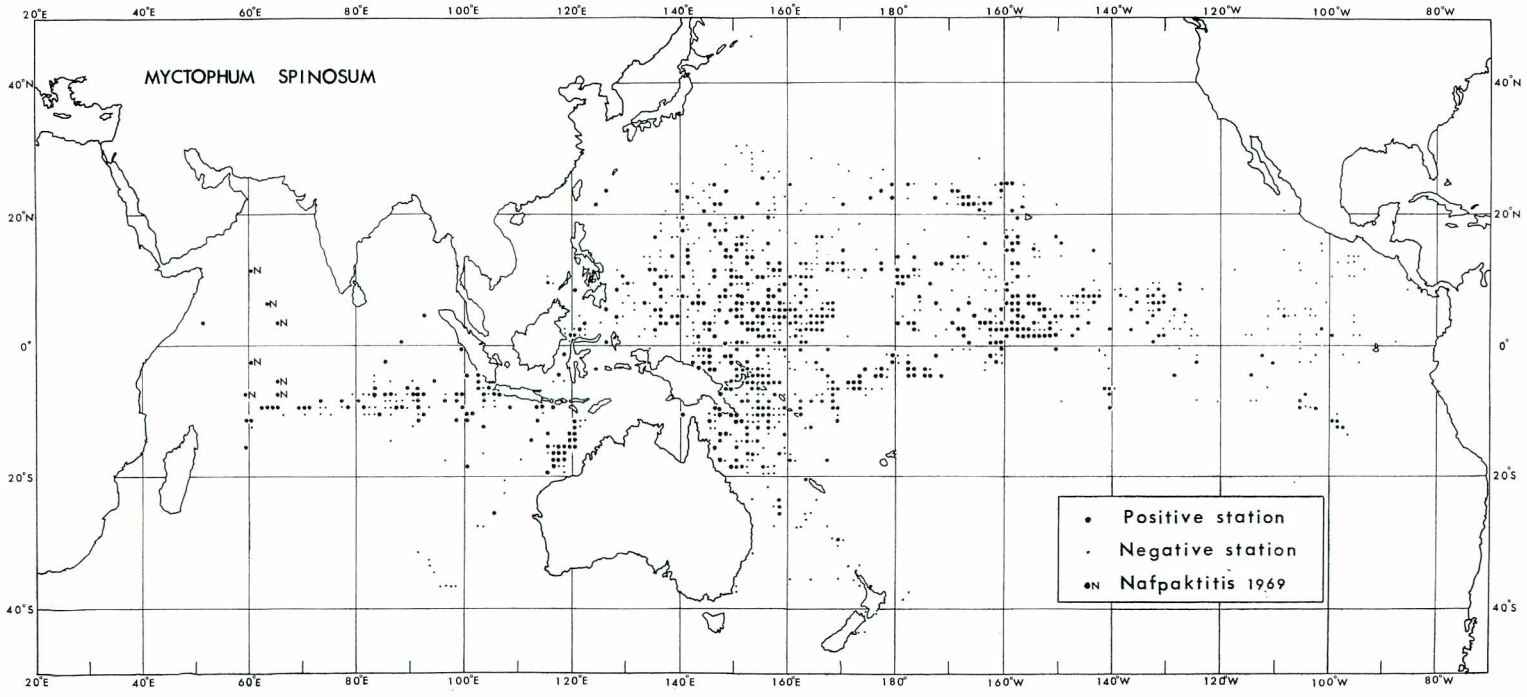

Fig. 5. Occurrence of *Myctophum spinosum*
In cases where there are two or more sampling stations within a one-degree square area, they are indicated by one dot. In such squares, a large dot shows the presence of at least one positive station. Stations are plotted in the same way in the following Figs. 6—10.

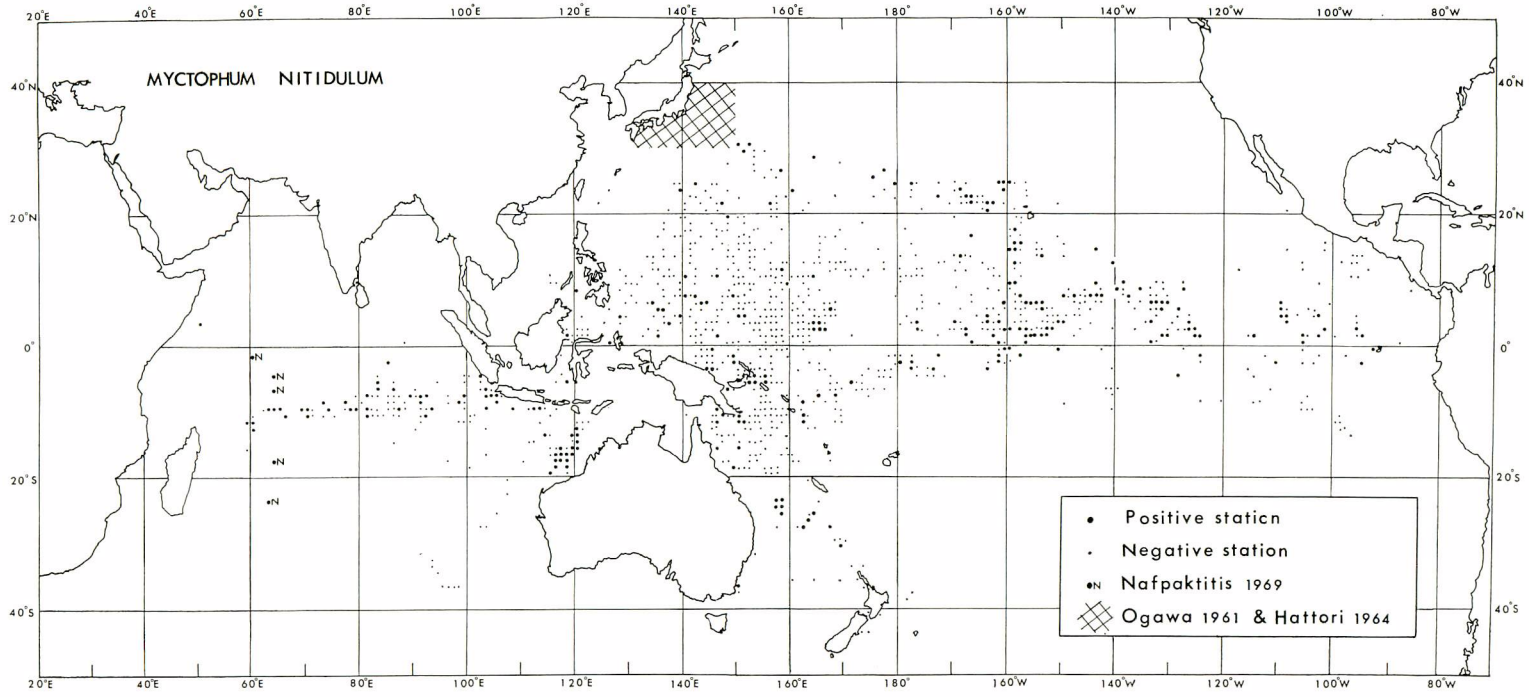

Fig. 6. Occurrence of *Myctophum nitidulum*

In cases where there are two or more sampling stations within a one-degree square area, they are indicated by one dot. In such squares, a large dot shows the presence of at least one positive station.

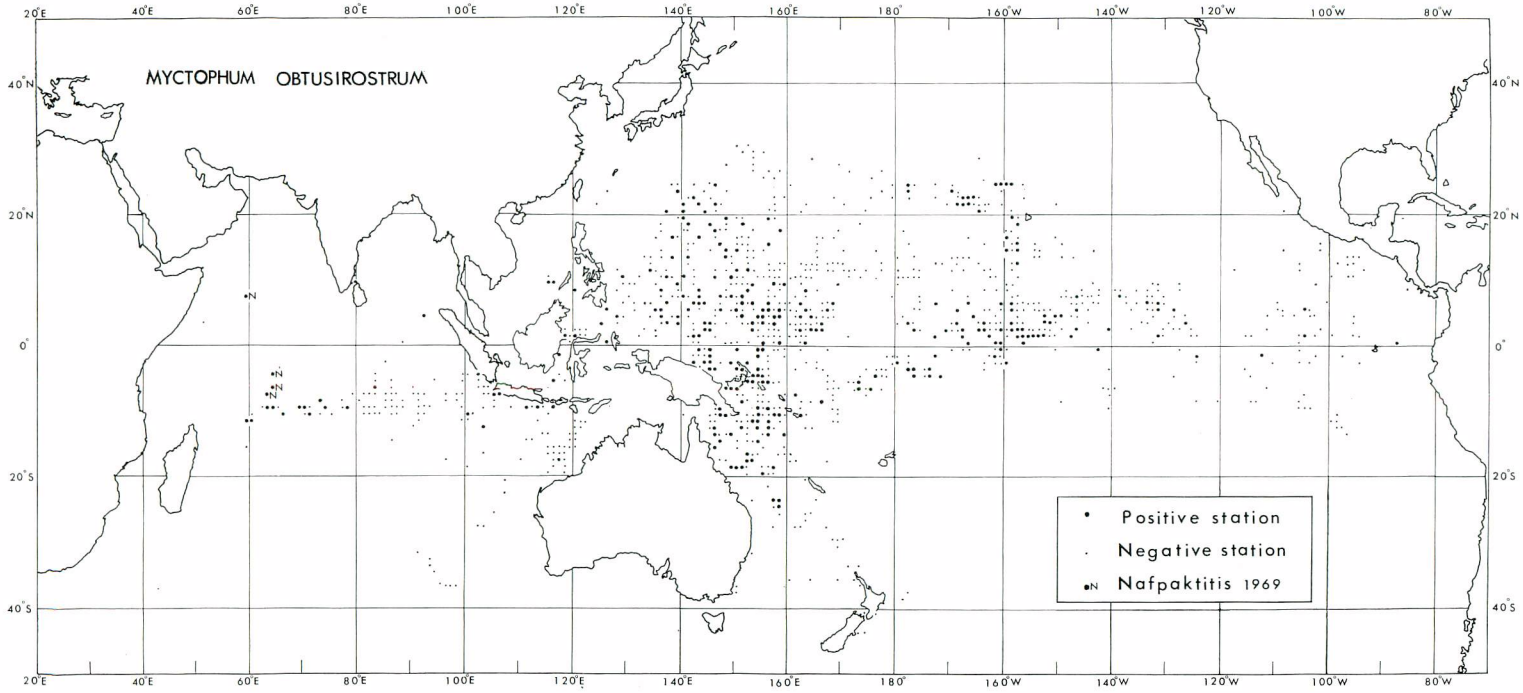

Fig. 7. Occurrence of *Myctopum obtusirostrum*
In cases where there are two or more sampling stations within a one-degree square area, they are indicated by one dot. In such squares, a large dot shows the presence of at least one positive station.

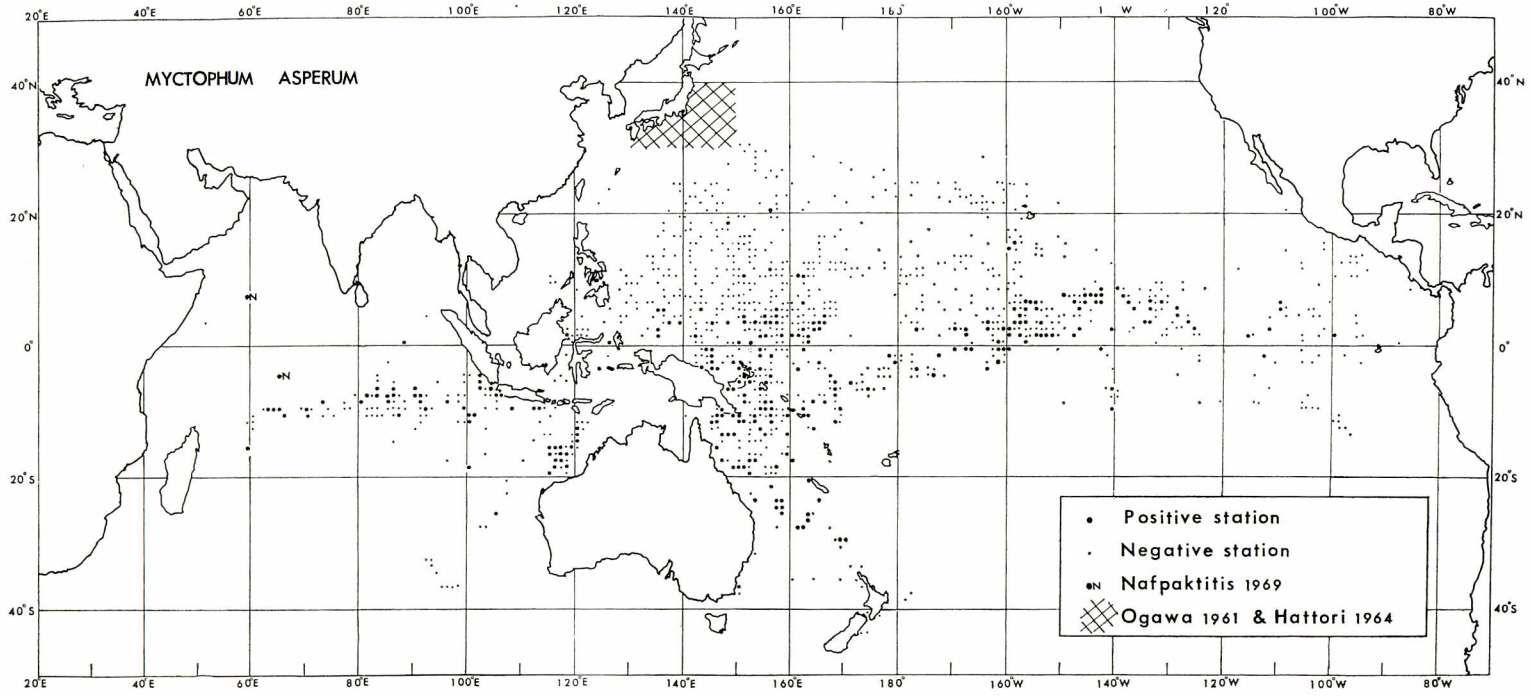

Fig. 8. Occurrence of *Myctophum asperum*

In cases where there are two or more sampling stations within a one-degree square area, they are indicated by one dot. In such squares, a large dot shows the presence of at least one positive station.

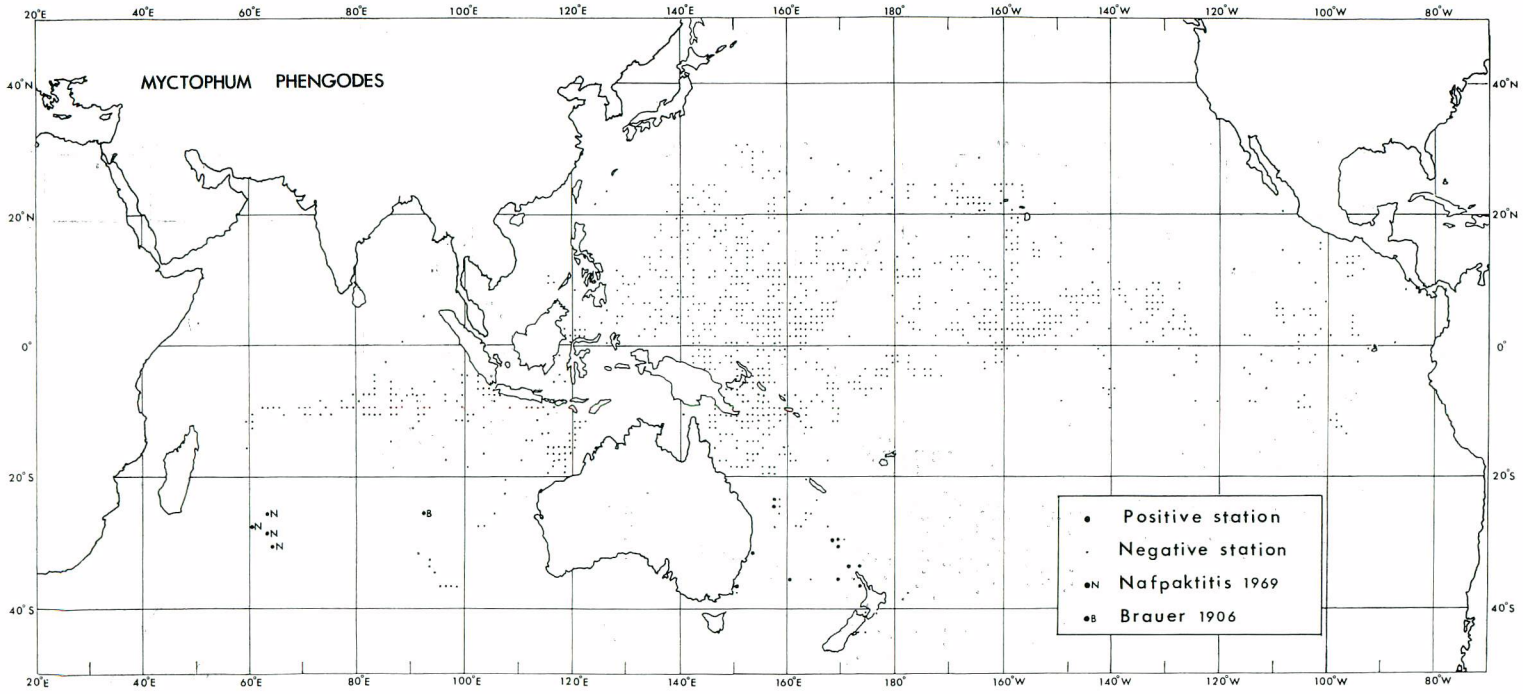

Fig. 9. Occurrence of *Myctophum phengodes*

In cases where there are two or more sampling stations within a one-degree square area, they are indicated by one dot. In such squares, a large dot shows the presence of at least one positive station.

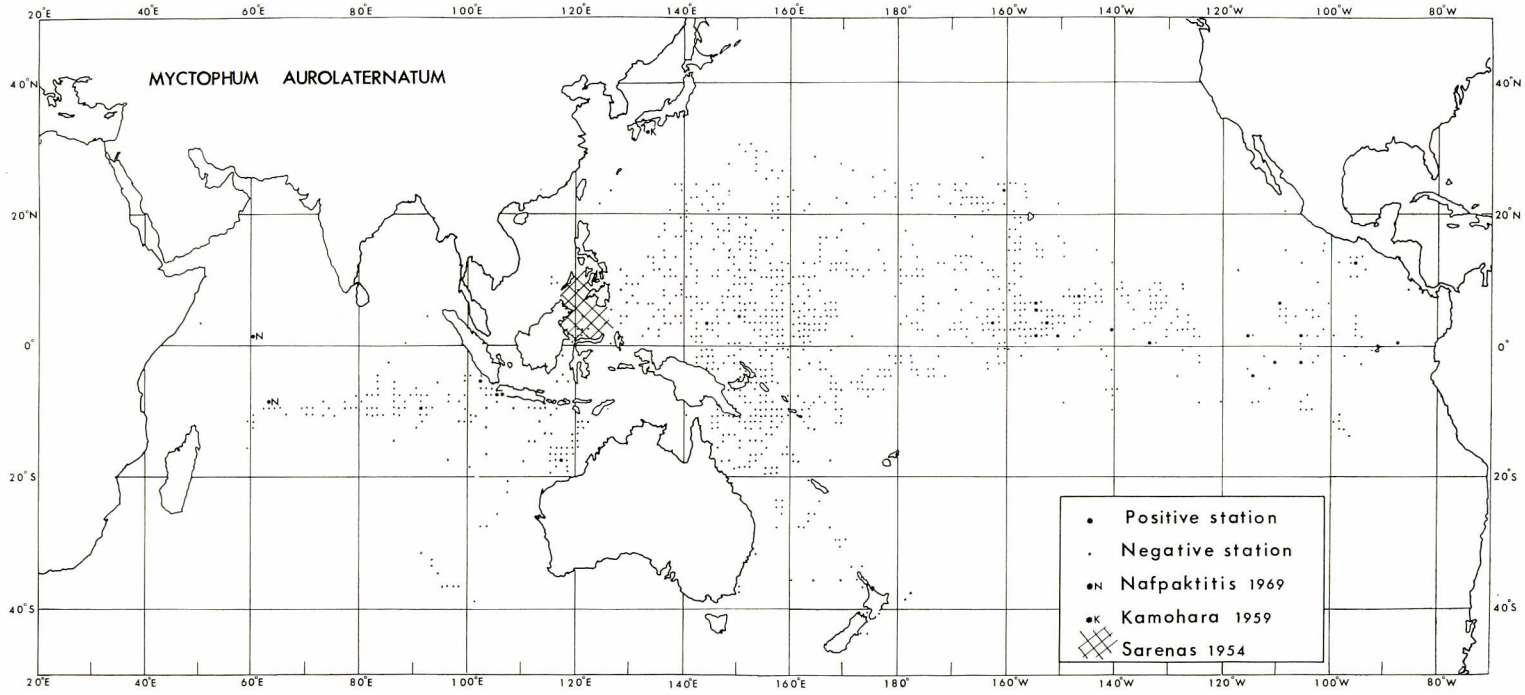

Fig. 10. Occurrence of *Myctophum aurolaternatum*

In cases where there are two or more sampling stations within a one-degree square area, they are indicated by one dot. In such squares, a large dot shows the presence of at least one positive station.