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SEASONAL DISTRIBUTION OF THE PLANKTON IN SINGAPORE STRAITS

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ABSTRACT

The physical and chemical characteristics of the environment in Singapore Straits are described. Mention is also made of the currents and drift throughout the year. The general distribution, both qualitative and quantitative, of the phytoplankton and zooplankton is given. At the same time the main genera of phytoplankton which contribute to the phytoplankton calender are highlighted. The interrelationships between phytoplankton, zooplankton and fish in Singapore Straits are briefly discussed.

INTRODUCTION

Singapore Straits is a narrow stretch of water situated a little over 1 north of the equator and bounded by Singapore in the north and the Rhio and Lingga Archipelago in the south. At the eastern end it is connected with the South China Sea, whilst at the western it is connected with the Durian Straits and the Straits of of Malacca. In the south it is connected with Java Sea through the maze of channels in the Rhio and Lingga Archipelago. In view of its geographical position, the plankton of Singapore Straits may be expected to have many forms which are common in the South China Sea and the Java Sea. The plankton of Singapore Straits was first studied by Tham (1953) and later by Wickstead (1961). After the establishment of the Fisheries Biology Unit at the University of Singapore in 1963, the study of various groups of planktonic organisms was carried by research students of the Fisheries Biology Unit under the supervision of the author. With the establishment of the Regional Marine Biological Centre at Singapore in 1968, the study of the plankton of Singapore Straits including total counts of the samples taken was carried out by members of the staff.

Physical and Chemical Environmental Characteristics

The climate of Singapore is characterised by two monsoons, the south-west monsoon from May to September and the north-east monsoon from November to March the following year, with two inter-monsoon periods of about eight weeks each during which weather conditions are changeable and windforce is at a minimum. On the whole the north-east monsoon brings more rain than the south-west monsoon. Usually the wettest months are from November to January the following year and the driest months are July and August, although in some years this pattern may not be followed. On the average the total annual rainfall is of the order of 237.5 cm, but it could be as much as 300.0 cm during certain years.

In Singapore Straits there are, generally speaking, one high water and one low water, succeeded by a second high water and low water of lower range, during each day. During neap tides the difference between the heights of this inferior high and low water may be only a few inches. The range between two consecutive low waters is generally greater than the two consecutive high waters.

According to Berlage (1927) and Wyrtki (1961), the general direction of the currents in the South China Sea during the north-east monsoon is south-west. At the eastern entrance to Singapore Straits this stream bifurcates—one branch flowing westwards into Singapore Straits and then northwards through Malacca Straits and the main stream flowing through Gaspar and Carimata Straits into the Java Sea. During the south-west monsoon the currents from the Java Sea filter through the Rhio and Lingga Archipelago into Singapore Straits, after which the bulk of the water leaves Singapore Straits through its western entrance and flows into Malacca Straits. From the studies carried out by Robinson *et al.* (1953) and current meter readings carried out in Singapore Straits recently it would appear that the general drift in Singapore Straits during the months of June to August is from west to east. This is confirmed by the movement of an oil slick in Singapore during the latter part of June 1972. Recent studies carried out with current meters in Singapore Straits indicate that the current directions in the territorial waters of Singapore in Singapore Straits form a very complex picture because of the large number of small islands to the south of Singapore and there is much turbulence during certain states of the tides.

The general pattern of water temperature fluctuations in Singapore Straits during the years 1948 and 1949 was shown by Tham (1953) to be characterised by a minimum (around 27° C) during December/January, with the temperature rising to a maximum (around 30°C) during April/June and then receding to another minimum (around 29°C) during August/September, thereafter rising slightly in October and then receding to the minimum in December/January.

From the records of the Meteorological Department the monthly average number of hours of sunshine per day for the different months of the year varies from 4.5 to nearly 7, with lower figures during November/December and higher figures during February/March and May/August. There does not appear to be a statistically significant correlation between the sunshine data and the water temperature data, but Tham (1953) found a statistically significant inverse correlation between the windforce data and the water temperature data.

Tham and Hon (1969) in their recent study of light penetration in Singapore waters found that near the middle of Singapore Straits off Raffles Lighthouse the percentage penetration of visible light around 11 a. m. in September 1967 was about 50% at a depth of 2 metres, about 22% at 5 metres and 7% at 10 metres, with a deck cell reading of around 20,000 lux of visible light. These results are in line with those obtained for tropical coastal waters in other parts of the world (cf. Raymont, 1963).

The dissolved oxygen content of the sea water in the middle of Singapore Straits at the surface and down to a depth of 2 metres is between 5 and 6 cc. per litre. The value decreases as one approaches the shore.

The general pattern of salinity fluctuations in Singapore Straits during the years 1948 and 1949 was shown by Tham (1953) to be characterised by a minimum of around 30%*o* during December/January, thereafter rising to a maximum of 31.5%*o* from February to April. From May the salinity decreases to a minimum of about 28.5%*o* during July/August, thereafter rising again to a maximum of between 30.5%*o* and 31.5%*o* from September to November. This general pattern was confirmed by Robinson *et al.* (1953) and Ommanney (1961).

The fluctuation of dissolved inorganic phosphate content in the surface layer down to 2 metres in Singapore Straits was studied by Tham (1953) during 1948 and 1949. The results showed that throughout the two years the values fluctuated between 5 mg P_2O_5/m^3 and 20 mg P_2O_5/m^3, except from January to March 1948 when the values were 81, 28 and 40 mg P_2O_5/m^3 respectively. This was due to land drainage resulting from the abnormally heavy rainfall (24 inches) during January 1948.

PHYTOPLANKTON

The study on the phytoplankton in Singapore Straits was carried out by Tham (1953) in 1948 and 1949 by pumped hauls. It was found that there were two major blooms and one minor bloom in 1948. The major blooms occurred in February and April whilst the minor bloom was in November 1948. In 1949 the pattern was more or less similar but there was an additional bloom in July, whilst the major blooms occurred in January and May and the minor bloom in December 1949. The January/February blooms were due mainly to *Coscinodiscus* spp. whilst the April/May blooms were due mainly to *Chaetoceros* spp. The November 1948 bloom was due mainly to *Rhizosolenia imbricata* and *Coscinodiscus* spp., whilst the December 1949 bloom was due mainly to *Coscinodiscus* spp. and *Chaetoceros* spp. The July 1949 bloom was due mainly to *Chaetoceros* spp. with *Coscinodiscus* spp., *Biddulphia sinensis* and *Ditylum sol* being present in fairly large numbers. Species of the genera *Coscinodiscus, Hemidiscus, Biddulphia, Ditylum, Chaetoceros, Bacteriastrum, Thalassiothrix* and *Rhizosolenia* were found in the plankton in most months of the year, although sometimes only in small numbers.

The pigment content in Harvey units has been determined. High values of about 1,300 Harvey units were found for February and May 1948 and values of about 1,000 Harvey units were found in October and November 1948. These high values correspond with the blooms noted in 1948. However, in 1949 high values correspond with the blooms noted in 1948. However, in 1949 high values of 2,350, 1,100 and 920 Harvey units were found in May, August and October respectively so that except for the bloom in May 1949 there does not seem to be such close correspondence between the blooms and the high values of pigment content. In spite of this there is a statistically significant correlation between the phytoplankton count and the pigment values in Harvey units for the data of the two years taken as a whole.

In 1968 and 1969 a further study was carried out by Tham *et al.* (1972) by means of horizontal surface hauls with a muslin net at a station in Singapore Straits further inshore than the 1948/49 station. There was much turbulence at the 1968/69 station because of its proximity to a number of small islands immediately to the south of Singapore. The specific composition of the phytoplankton was found to be different from that found in 1948/49 by Tham (1953) in so far as there was a predominance of pennate diatoms throughout the year. Blooms were noted in May 1968, September 1968 and a minor one in November/December 1968. Whilst the blooms in May and November/December in 1968 are consistent with the pattern found by Tham (1953) in 1948 and 1949, the September 1968 bloom appears at first sight to be a new development but on further study it was found to be made up of 91.5% Biraphideae (of which 99.8% consists of *Nitzschia* spp.), 2.6% Araphideae (mainly *Thalassionema*), 4.1% Biddulphioideae (mainly *Bellerochea, Chaetoceros, Cerataulina* and *Biddulphia*) and 1.7% Discoideae (mainly *Coscinodiscus*). It has been established by Tham (1953) that during September south and south-west winds are very strong in Singapore Straits and these winds have caused great turbulence. It would appear that this has brought the pennate forms from the bottom up to the surface. Taking the distribution of the Centriceae alone the broad pattern of quantitative distribution of phytoplankton in Singapore Straits established by the findings of Tham (1953) for the years 1935, 1948 and 1949 appears to be still valid for the period April 1968 to March 1969 studied by Tham *et al.* (1972).

It is significant that the major phytoplankton bloom in Singapore Straits occurred in April/May during all the years studied, i. e. 1935, 1948, 1949 and

1968. This corresponds with the spring blooms recorded in various parts of the northern hemisphere (vide Raymont, 1963), and in these cases the blooms coincided with a rise in water temperature and an increase in solar radiation. But in Singapore Straits the annual temperature variation is of the order of only 3° C. and in any case the rise in water temperature takes place around February each year. Also the light intensity does not vary much during the year and during this period the nutrient content of the water is not high, so that this April/May bloom could not have been brought about by any rise in water temperature or any increase in solar radiation. Raymont (1963) in discussing the spring blooms stated that it appeared probable that some degree of stratification was necessary in the euphotic zone for effective phytoplankton production, at least in the early spring, and that the start of the spring increase was delayed if some degree of stability did not occur. This was emphasised by Rilev (1942, 1946) and was investigated by Sverdrup (1953). In Singapore Straits, April/May is the inter-monsoon period when the change-over from the north-east monsoon to the south-west monsoon occurs and during this period it was shown by Tham (1953) that windforce was at a minimum. Recent current meter readings taken during these two months showed that the direction of drift was uncertain and the resultant drift was comparatively low. It was also observed that during this April/May bloom the sea surface in Singapore Straits was extremely calm. It would thus appear that the April/May bloom in Singapore Straits has been brought about by the stability of the water column. The same would apply to the minor bloom during November which is the other inter-monsoon period when the south-west monsoon changes over to the north-east monsoon.

The January/February bloom and the occasional July/August bloom in Singapore Straits cannot, however, be explained in this way. During the early part of January at least, the water temperature is at a minimum, solar radiation is generally low and the nutrient content is high. It would thus appear that the January/February bloom could have been brought about by rising temperature, increase in solar radiation and high nutrient content of the water. The high nutrient content is due to the heavy runoff from the Malay Peninsula and Singapore as a result of the heavy rainfall during December/January each year and there is no doubt that there should be present in the water a host of other nutrients and trace elements which could spark off a bloom. The occasional July/August bloom could perhaps be due to the increased content of nutrients and trace elements in the water brought about by the turbulence caused by the strong south, south-east and south-west winds which are prevalent in Singapore Straits during this time of year.

Attention has been drawn earlier to the succession of species in the phytoplankton in Singapore Straits. This phenomenon has been observed and studied extensively. Raymont (1963) reviewing this subject came to the conclusion that although temperature and, to a lesser extent, light intensity and perhaps nutrient concentration may play a part in the changes, more subtle differences, particularly the biological history of the water, have an important role. In Singapore Straits it is most unlikely that temperature and even light intensity play an important role in the species succession of phytoplankton. It is more likely that the biological history of the water, the stability of the water column and turbulence play a role in species succession. In Singapore Straits, which receives water from the South China Sea mixed with coastal water from the Gulf of Thailand and eastern coast of the Malay Peninsula during the north-east monsoon and from the Java Sea and the maze of channels among the cluster of islands to the south-east of Sumatra during the south-west monsoon, it seems probable that seeding from these currents may also play a role in species succession.

There is one other phenomenon which should also be mentioned and that is the occurrence of fairly large quantities of a blue-green alga (Cyanophyceae), *Trichodesmium erythraeum,* in Singapore straits during the south-west monsoon (June to September). They are found mainly floating on the surface in patches and appear at first sight to be patches of floating sawdust. This was first mentioned by Tham (1953) who noted that it was very abundant in 1948 but was comparatively rare in 1949. Tham (unpublished) noted fairly large quantities again in September 1967.

ZOOPLANKTON

Generally speaking, zooplankton numbers are higher during the period from March to November every year. Invariably the plankton is dominated by copepods and their larval stages, the numbers varying from 40% to 70% of the total zooplankton count. The other dominant forms in descending order are the appendicularians, cirripede larvae, molluscan larvae, decapod larvae, siphonophores and chaetognaths. Other forms which are present throughout the year are fish eggs and fish larvae, echinoderm larvae, pteropods, *Lucifer,* amphipods, ostracods, polychaete larvae, cyphonautes larvae, other medusae and foraminiferans. Forms which occur sporadically are *Noctiluca,* ctenophores, cladocerans, euphausiids, heteropods, salps, isopods, brachiopod larvae and ascidian larvae. *Noctiluca,* when present, may dominate in numbers.

Noctiluca

In February 1948 a bloom of *Noctiluca* was observed by Tham (1953), but in 1949 no such phenomenon was observed. Wickstead (1961) found it very abundant during September and October 1955. Tham *et al.* (1972) found three periods of abundance in 1968 in respect of this organism, a major bloom during August/September and two minor ones during May and November.

Coelenterata

The siphonophores in Singapore Straits belong to species of *Diphyes* and *Lensia*, the former being more abundant (Lim, 1968). They are usually present in the plankton throughout the year. From the work of Tham (1953), Wickstead (1961) and Tham *et al.* (1972), there appears to be four periods during which these organisms may be abundant in Singapore, viz :– December/January, March/April, June and September/October/November.

Small medusae have never been observed in large numbers during the studies carried out so far, but large medusae may sometimes be present in Singapore Straits to such an extent that they become a nuisance to fishermen and people swimming along the beach.

Polychaeta

Polychaetes and their larvae are not usually common in the plankton but they may be observed in large numbers sporadically.

Chaetognatha

The chaetognaths in Singapore Straits are represented by two genera, *Sagitta* and *Krohnitta* (To, 1966). *Sagitta enflata* is the dominant form. Other species which may be present are *S. robusta, S. bedoti, S. johorensis* and *S. demipenna.* The genus *Krohnitta* is represented by the species *K. pacifica.* From the work of Tham (1953), Wickstead (1961) and Tham *et al.* (1972), there are three periods during the year, viz:- March/April, June/July and October/November/December, when chaetognaths may be found in Singapore Straits in large numbers in the plankton.

Cladocera

The cladocerans in Singapore Straits belong mainly to the genera *Evadne* and *Penilia,* species of the former genus being more common. Tham *et al.* (1972) have never observed them in large numbers in the plankton, but Wickstead (1965) states that *Penilia* can range from being completely absent to being present in numbers like 2,500/m^3, forming over 50% of the total plankton numbers.

Ostracoda

The ostracods are represented mainly by the genera *Pyrocypris* and *Euconchoecia* in the plankton of Singapore Straits. Tan (1966) found 250 to 450 ostracods per half hour horizontal haul in April, June and August in 1964 and in June and September in 1965, but the number never exceeded 40 in any month in 1966. Tham *et al.* (1972) found between 300 and 800 organisms in June and October 1968 and in January 1969.

Copepoda

The copepods in Singapore Straits are represented by the following sub-orders, families and genera :—

Sub-order	Family	Genus
Calanoida	Paracalanidae	*Paracalanus*
	do.	*Acrocalanus*
	Acartiidae	*Acartia*
	Eucalanidae	*Eucalanus*
	Pontellidae	*Calanopia*
	do.	*Labidocera*
	Calanidae	*Canthocalanus*
	Arietellidae	*Metacalanus*
	Temoridae	*Temora*
	Tortanidae	*Tortanus*
	Centropagidae	*Centropages*
	Pseudodiaptomidae	*Pseudodiaptomus*
	Candaciidae	*Candacia*
Harpacticoida	Ectinosomidae	*Microsetella*
	Macrosetellidae	*Macrosetella*
	Clytemnestridae	*Clytemnestra*
	Tachydiidae	*Euterpina*
Cyclopoida	Oithonidae	*Oithona*
	Oncaeidae	*Oncaea*
	Corycaeidae	*Corycaeus*

The families of each order have been listed in the order of dominance in the plankton catches during 1968. Tham (1953) in his study of the copepod population in Singapore Straits found that during the years 1948 and 1949, copepod numbers were highest during April/May, July (and also June in 1948) and October/November (and also December 1949). Tham *et al.* (1972) in a more detailed study from April 1968 to March 1969 found that, among the Calanoida, most genera were abundant during July and October, the months of greatest abundance for the total copepod count. These genera, viz:— *Paracalanus, Acrocalanus, Acartia, Eucalanus, Canthocalanus, Temora, Tortanus, Pseudodiaptomus* and *Candacia* were apparently brought into Singapore Straits by the currents of the south-west monsoon, although *Paracalanus* and *Acrocalanus* are believed to breed in Singapore Straits. Most of these genera were also found in fairly large numbers in March or May indicating that they were also brought into Singapore Straits by the north-east monsoon currents. The exceptions were *Labidocera* which were found in fair numbers in January, March and September, and *Metacalanus* which were found in fair numbers only in November.

The sub-order Harpacticoida appears to be common during two periods of the year, from September to November and again from January to April. Members of the sub-order Cyclopoida were present throughout the year but were more abundant from July to November. Among the three genera the genus *Corycaeus* was the most abundant.

From the point of view of total copepod numbers, Tham (1953) found for 1948-49, by pumping a measured quantity of sea water and filtering through a No. 20 (173 meshes per sq. in.) bolting silk net, a minimum of approximately 3,000 organisms per m^3 in January 1948 and 1949 and a maximum of approximately 40,000 organisms per m^3 in October 1948. Wickstead (1961) did not agree with these findings because his maximum record for 1955-56 was only 523 copepods per m^3 or 534 per m^3 including the nauplii, but his method of sampling was a vertical haul with the International coarse silk net and a 1 m stramin net similar to those used by Russell and Colman (1931) at the Great Barrier Reef. Tham *et al.* (1972) found, with a half hour horizontal haul with a muslin net, as many as 39,000 copepods in October 1968 and this agrees well with the figure (40,500/m^3) found in October 1948 by Tham (1953). In order to check further the figures obtained by Tham (1953) and by Tham *et al.* (1972), several pumped hauls of one m^3 were made at noon on 23 April 1970 with a mechanical pump and filtered through a Norpac Type Plankton net (mesh GG52 or 50.5 meshes per sq. in.) and the whole sample was counted by the staff of the Regional Marine Biological Centre at Singapore. The results were as follows :— (i) 22,358 copepods/m^3 at the surface, (ii) 9,467 at a depth of 5 fathoms and (iii) 13,538 at a depth of 10 fathoms. Tham (1953) found 23,000 copepods/m^3 in April 1948 and 28,900 copepods/m^3 in April 1949. The figures are therefore in fairly good agreement. This underlines the fact that the method of sampling as well as the net used is important. It was also found by Dr. Takashi Minoda that, by using simultaneously one pair of nets designed by Professor S. Motoda, viz:— (a) a Norpac type net which consisted of Pylen No. 60 (0.35 mm. x 0.35 mm. mesh) and (b) a double Norpac type net with a small net of Pylen No. 60 inside and a larger net of Pylen No. 200 (0.1 mm. x 0.1 mm. mesh) outside, a much larger number of copepods (at least double and as much as 56 times) was caught by the (b) double Norpac net. These samples were sorted and counted at the Regional Marine Biological Centre at Singapore. It is now the concensus of opinion among scientists engaged in the Co-operative Study of the Kuroshio (CSK) that, in the South China Sea and adjacent areas where the Paracalanidae are dominant in numbers, coarse nets are not adequate for sampling copepods on a quantitative basis.

Cirripedia

Cirripede larvae were observed by Tham (1953) in the plankton of Singapore Straits throughout the year but not in large numbers. Tham *et al.* (1972) found a maximum of about 11,000 organisms per half hour haul in Singapore

Straits in November 1968. Yang (1967) working in Johore Straits also found maximum numbers in November 1966 but the numbers were highest (100,000) inside Johore Straits and decreased to 60,000 at the entrance to Johore Straits and in the inshore waters of Singapore Straits it dropped to 4,500.

Lucifer

Tham (1953) reported that *Lucifer* was comparatively rare in the plankton of Singapore Straits for the years 1948 and 1949. From the work of Khoo (1967) and Chua (1967), *Lucifer* appears to be extremely rare in Johore Straits. Tham *et al.* (1972) found that *Lucifer* was more common in Singapore Straits during the north-east monsoon, the highest numbers being recorded in November 1968 and January 1969. Wickstead (1961) found that *Lucifer* was more common in Singapore Straits during November 1955, February 1956 and April 1956. These findings indicate that *Lucifer* in Singapore Straits are carried in with the South China Sea current.

Other Decapoda

Other decapods in the plankton consist mainly of brachyuran larvae as well as some penaeid and caridean larvae. Tham *et al.* (1972) found the largest number (3,500 in a half hour haul) of other decapods in the plankton in October 1969. Tham (1953) found that they were more common in 1948 and 1949 during March, June/July/August and October/November/December, the number being highest during June/July. Wickstead (1961) found peaks of abundance in June/July 1955, October/November 1955 and April 1956.

Mollusca

Tham *et al.* (1972) found a fair number of mollusca and molluscan larvae in the plankton of Singapore Straits in 1968/69, with peaks of abundance during March/April, July and October/November. Gastropods made up 75% of the total numbers, whilst the remaining 25% consisted of lamellibranch larvae. The bulk of the gastropods were larval stages, whilst pteropods and heteropods were comparatively rare. Wickstead (1961) found the peaks of abundance of molluscan larvae in 1955/56 during February, May/June, September/October and December.

Echinodermata

Tham et al. (1972) found echinoderm larvae to be very rare in the plankton except during February/March and May. Echinoderms, especially asteroids, are fairly abundant along the south coast of Singapore especially in the deeper portions of Singapore Straits so that March and May may be the spawning months.

Tunicata

Tham *et al.* (1972) noted fair numbers of appendicularians in the plankton of Singapore Straits being more common during March, May, August and November. They belong mainly to the genus *Oikopleura*. Gan (1968), who made a study of *Oikopleura* abundance in Singapore Straits during 1965 and 1966, found that they could appear in numbers during any month in the periods, March-April-May-June, August-September and November-December-January.

Salps are usually rare in the plankton, but they could suddenly appear in large numbers for a short period of time. The writer noted a very large swarm in June 1936.

Fish eggs and fish larvae

The work of Tham (1953) in 1948 and 1949 and that of Wickstead (1961) in 1955-56 show that fish eggs and fish larvae were never abundant in the plankton of Singapore Stra'ts. Tham *et al.* (1972) in their study in 1968-69 sorted out and counted all the fish eggs and fish larvae in the plankton collected. They found that the average number of fish eggs never exceeded 400 in any half hour haul and a similar count for fish larvae never exceeded 500. It is believed that only a few inshore fish spawn in Singapore Straits and that the main spawning areas are in the South China Sea. Tham and LeMare (1954) found a preponderance of juvenile fish in the inshore fish population of Singapore Straits during the first few months of the year (January to April). These juvenile fish are brought into Singapore Straits from the South China Sea by the monsoon currents of the north-east monsoon and they aggregate there because of the density of planktonic food.

Other groups

The other groups which occur in the plankton of Singapore Straits are, in descending order of abundance, Foraminifera, cyphonautes larvae, crustacean nauplii (excluding copepod nauplii), ascidian larvae, brachiopod larvae, Thaliacea, Amphipoda, Isopoda, Euphausiacea, stomatopod larvae, Mysidacea, Phyllosoma larvae, Ctenophora, Tomopteridae, actinotrocha larvae, Cumacea, Nemertinea and Platyhelminthes. Tham *et al.* (1972) found that in any one haul the number of organisms never exceeded 400 for Foraminifera, 250 for cyphonautes larvae and Ascidian larvae, 200 for crustacean nauplii (excluding copepod nauplii), 100 for brachiopod larvae and Isopoda and 50 for the others.

Interrelationships between Phytoplankton, Zooplankton and Fish

A close study of the variations in phytoplankton and zooplankton in Singapore Straits in 1948 and 1949 as given by Tham (1953) shows that, whilst the abundance of phytoplankton usually alternates with that of zooplankton, during Apr.l/May an abundance of phytoplankton coincides with an abundance of copepods and other zooplankters. The alternation of rich populations of phytoplankton and zooplankton can be explained by the grazing theory put forward by various workers including Harvey *et al.* (1935). The coincidence of rich populations of phytoplankton and zooplankton is however not so easy to explain. In the case of Singapore Straits the rich populations of phytoplankton during April 1948 and May 1949 were dominated by *Chaetoceros* spp. which made up 96% and 62% of the population respectively. Harvey (1937), studying selectivity in the diet of copepods, found that when *Calanus* was fed with a mixture of *Chaetoceros* and *Lauderia* the latter was readily consumed but *Chaetoceros* was hardly consumed. It is thus possible that the rich populations of phytoplankton in April 1948 and May 1949 were due to the fact that the *Chaetoceros* portion of the population was not consumed by the copepods. During these periods, conditions were optimal for the growth of the phytoplankton population because solar radiation was high and drift was at a minimum.

With regard to the relationship between the plankton and fish, the work of Tham (1950) has shown that the bulk of the fish caught in Singapore Straits are plankton feeders and even in the case of well known predators such as the lutianids, scomberomorids, trichiurids, the post-larval and small specimens also feed on zooplankton. Tham (1953) also noted that in 1948 and 1949 large catches of *Stolephorus* spp. as well as *Clupea (Harengula) fimbriata* and *Clupea* (*Harengula*) *perforata,* all plankton feeders, coincided with the peaks of abundance of phytoplankton and zooplankton. The large number of juvenile fish in the catches of Singapore Straits also indicates that Singapore Straits is the feeding ground of the juveniles of many species of fish and this appears to be due to the larger quantity of plankton in Singapore Straits as compared with the offshore areas of the South China Sea. Whilst the abundance of plankton in Singapore Straits results in an abundance of *Stolephorus* spp. and *Clupea* (*Harengula*) spp., the presence of these groups of species of fish, in turn, attracts large numbers of *Scomberomorus* spp. and *Chirocentrus dorab* which feed on them. This underlines the importance of plankton not only for the aggregation of plankton feeders but also indirectly for the aggregation of predacious fish which feed on plankton feeders.

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