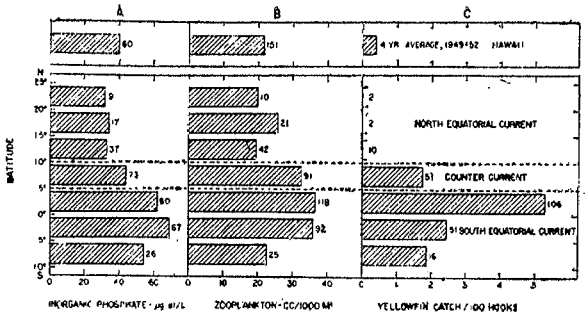


FIG. 3.—Variation with latitude of inorganic phosphate (A), zooplankton abundance (B), and yellowfin tuna catch (C), with the data combined into 5-degree intervals of latitude without regard to longitude and time of year. The approximate boundaries of the major equatorial currents are indicated. Part A is derived from cruises 2, 5, 8, 11, 14, 15 and 16 of the *Hugh M. Smith*. Part B is derived from cruises 2, 5, 7, 8, 9, 11, 14, 15, 16 and 18 of the *Hugh M. Smith* in the equatorial region and cruises 10, 12, 17 and 20 in Hawaiian waters. Part C is derived from cruises 7, 11 and 18 of the *Hugh M. Smith*; cruises 11, 12, 13, 14 and 15 of the *John R. Manning*; cruise 1 of the *Charles H. Gilbert* and cruise 1 of the *Cavalieri*. The vessels *Smith*, *Manning* and *Gilbert* are the property of the U.S. Fish and Wildlife Service. The vessel *Cavalieri* was chartered by the Government for this one fishing cruise. [The number of observations for each interval of latitude is indicated after each bar in the histogram.]

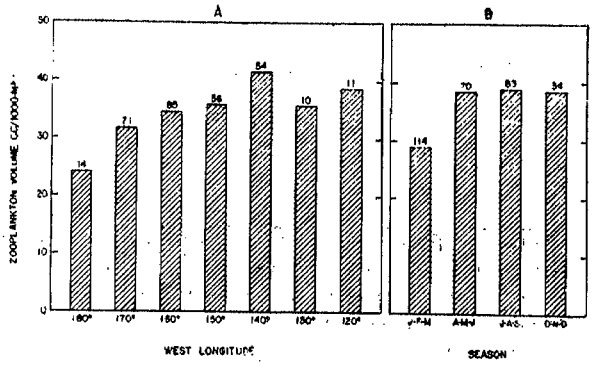


FIG. 4.—Variation in zooplankton abundance with longitude (A) and season (B), for all observations between 9° 59′ N. and 4° 59′ S. latitude. [The number of observations for each longitude and for each season is indicated above each bar in the histogram].

THE ROLE OF PLANKTONOLOGY IN FISHERIES DEVELOPMENT

by

Tham Ah Kow*

The first problem to be faced in fisheries development is to secure information on the nature of the stocks of fish as well as their quantitative distribution in space and time. One approach to this problem is the time-honoured method of trial and error. Through the ages, a great deal of information on the nature of the fish stocks in different parts of the world as well as their seasonal fluctuations in abundance has been accumulated. This knowledge has played an important part in indicating to marine ecologists the influences which the basic physical and chemical elements such as sunshine, wind, currents, temperature, salinity etc., exert on the biotic elements such as plankton and fish life. With this knowledge as a background, oceanographers, marine biologists and marine ecologists have been able to plan investigations which have revealed the complex mosaic showing the integration of these physical, chemical and biological elements of the marine ecosystem. The present state of our knowledge is aptly summed up by Allee *et al.* (1950) who state that, generally speaking, the changes of seasonal character in the animate portion of the marine community reflect the operation of one or more of the following phenomena :—

(1) Direct action by one or more of the basic physical influences upon organisms.

(2) Direct action of the secondary physical influences upon organisms.

(3) Direct action of the basic physical influences upon the inanimate medium of the community.

(4) Direct action of the secondary physical influences upon the inanimate medium of the community.

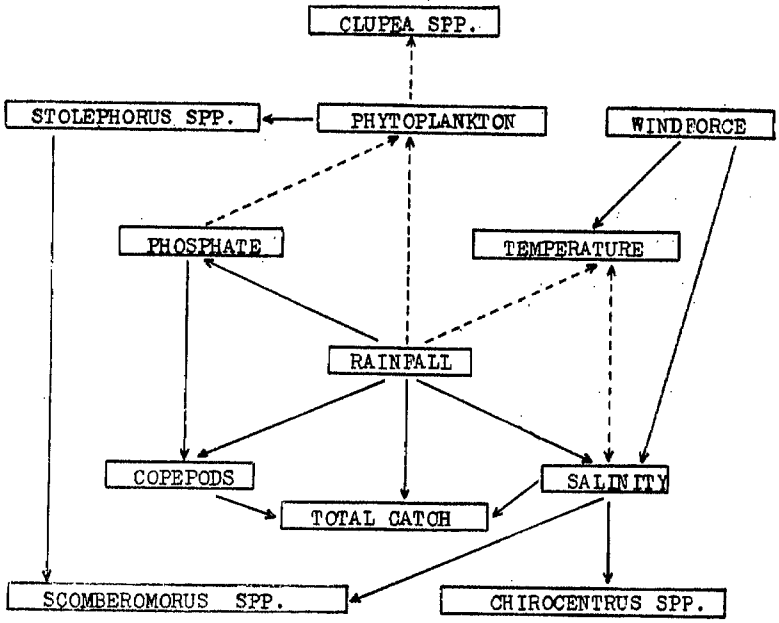
In an investigation on the physical, chemical and biological characteristics of Singapore Straits, Tham (1953) has found that the physical, chemical and biotic elements of the ecosystem are closely integrated. It was found that the physical elements such as rainfall, windforce, temperature, salinity and phosphate are inter-related. Rainfall is correlated with phosphate, salinity, number of copepods and the amount of total catch. Windforce is correlated with temperature and salinity.

There are then the inter-relationships between the different biotic elements of the marine ecosystem, viz.:—phytoplankton, zooplankton and fish. In the sea, as in the terrestrial environment, the prime relationship between organisms is that associated with nutrition. A study of the food of different species of fish all over the world has shown that many pelagic fish and the very young stages of almost all species of fish feed on plankton. In a study of the food of the fish of Singapore Straits, it has been found that about 80% of the species studied feed on plankton (Tham, 1950). Fishery workers in India have also found that plankton feeding is very widespread among the pelagic fish of the Indo-Pacific Region. Bapat and Bal (1950 and 1952) state that almost all the young of the fish species studied by them feed on plankton. According to Chacko (1949), many of the fish of the Gulf of Manaar feed on plankton.

Since plankton is such an important item in the diet of fish, the quantitative relationship between plankton and fish deserves our attention. It has been observed at widely separated locations all over the world that there is a positive correlation between the density of plankton and the density of the plankton-feeding fish population. It has been found that the occurrence of plankton-feeding whales is positively correlated with the distribution of the planktonic life upon which they are known to subsist. In Davis Strait it was shown by Hjort and Ruud (1929) that young euphausiid crustaceans (the young are considered to reflect numbers of adult specimens which are not so readily caught with the vertically hauled nets) had their maximum concentration over certain coastal banks where blue whales also occurred in maximum numbers. Mackintosh (1934) as well as Hardy and Gunther (1935) also found positive correlations between the distribution of blue and fin whales and the abundance of zooplankton, especially their favourite food *Euphausia superba*. Hardy, Lucas, Henderson and Fraser (1936) investigated the plankton by means of the plankton indicator and, in correlating the numbers of Calanid copepods in the plankton with the amount of herring caught in the same areas, they found that in most instances

* Fishery Officer (Research), Federation of Malaya and Singapore.

INTERRELATIONSHIPS



——————— STATISTICALLY SIGNIFICANT

- - - - - - - - - PROBABLY STATISTICALLY SIGNIFICANT

the greatest number of adult herring were caught in water rich in *Calanus* Along the west coast of India. Chidambaram and Devidas Menon (1945) found that the landings of fish were directly proportional to the quantity of plankton produced in the different months of the year. In Singapore Straits it has been found by Tham (1953) that there is a statistically significant positive correlation between the number of copepods and the amount of fish caught in the same areas. At the same time, the correlation coefficient between phytoplankton and *Stolephorus* spp. is statistically significant and, in turn, the catch of *Stolephorus* spp. is correlated with the catch of *Scomberomorus* spp. In simple terms, where there is an abundance of plankton, an abundance of plankton-feeding fish may be expected. In Malayan seas there are large stocks of *Stolephorus* spp., *Clupea* (*Harengula*) spp. and other Clupeids as well as Carangids, all of which are voracious plankton feeders. Where these species of fish are abundant, it may be expected that species of *Scomberomorus* and *Chirocentrus* will be abundant.

One of the foremost problems in fisheries development is to secure an intimate knowledge of the distribution of fish in space and time. The present state of knowledge with respect to the inter-relationships between plankton, plankton feeders and predators such as species of *Scomberomorus* and *Chirocentrus* indicates an approach to this problem based on scientific concepts. Since the correlation between the amount of plankton and the fish catch in Singapore Straits is significantly positive, it follows that a study of the distribution of plankton in space and time will serve as a means of indicating the spatial and temporal distribution of the probable centres of aggregation of plankton feeders and their predators. The role of plankton in fisheries development is therefore an extremely important one, as with an intimate knowledge of its distribution in space and time it should be possible to direct fisheries exploitation to the right place at the right time. This approach which is based on scientific concepts is a logical one and should prove more economical and fruitful than the method of trial and error.

REFERENCES

ALLEE, W. C., O. PARK, A. E., EMERSON, T. PARK, & K. P. SCHMIDT, (1950).—Principles of Animal Ecology. W. B. Saunders Co. Philadelphia and London.

BAPAT, S. V. & D. V. BAL, (1950).—The Food of Some Young Clupeids. Proc. Ind. Acad. Sci. Sect. B. Vol. 32, July to Dec. 1950.

BAPAT, S. V. & D. V. BAL, (1952).—The Food of Some Young Fishes from Bombay. Proc. Ind. Acad. Sci. Sect. B. Vol. 35, Jan. to June 1952.

CHACKO, P. I. (1949).—Food and Feeding Habits of the Fishes of the Gulf of Manaar. Proc. Ind. Acad. Sci. Sect. B. Vol. 29. Jan. to June 1949.

CHIDAMBARAM, K. & M. DEVIDAS MENON, (1945).—The Co-relation of the West Coast Fisheries with Plankton and Certain Oceanographical Factors. Proc. Ind. Acad. Sci. Sect. B. Vol. 22, July to Dec. 1945.

HARDY, A. C. & E. R. GUNTHER, (1935).—The Plankton of the South Georgia Whaling Grounds and Adjacent Waters, 1926-1927. *Discovery* Repts. Vol. II, pp. 1-456, 1935.

HARDY, A. C., C. E. LUCAS, G. T. D. HENDERSON, & J. H. FRASER, (1936).—The Ecological Relations between the Herring and the Plankton Investigated with the Plankton Indicator. Journ. Marine Biol. Assn. U.K. Vol. 21, pp. 147-291, 1936.

HJORT, J. & J. T. RUUD, (1929).—Whaling and Fishing in the North Atlantic. Conseil Perm. Int. pour l'Explor. de la Mer, Rapp et Proc. Verb. Vol. 56, No. 1, 123 pp., 1929.

MACKINTOSH, N. A. (1934).—Distribution of the Macroplankton in the Atlantic Sector of the Antarctic. *Discovery* Repts. Vol. 9, pp. 65-160, 1934.

THAM AH KOW (1950).—The Food and Feeding Relationships of the Fishes of Singapore Straits. Colonial Office. Fishery Publications Vol. 1, No. 1, 1950. Her Majesty's Stationery Office, London.

THAM AH KOW (1953).—A Preliminary Study of the Physical, Chemical and Biological Characteristics of Singapore Straits. Colonial Office. Fishery Publications Vol. 1, No. 4, 1953. Her Majesty's Stationery Office, London.