THE PLANKTON OF SOUTH VIET-NAM

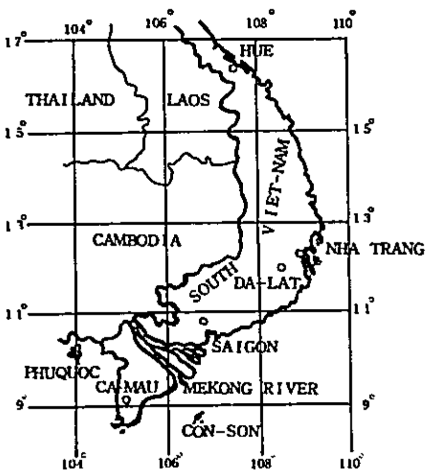
—Fresh Water and Marine Plankton—

by

Dr. AKIHIKO SHIROTA

Colombo Plan Expert on Planktology :
Faculty of Science, Saigon University and
the Oceanographic Institute of Nhatrang
Viet-Nam

1966



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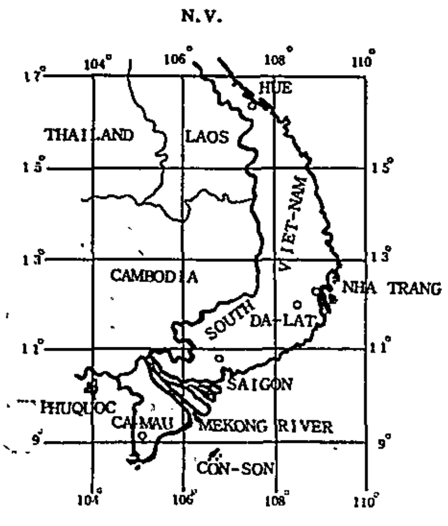

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PREFACE

At present when the world situation is making rapid progress and development, there is no good reason why the study of the oceans and lakes accounting for approximate 2/3 of the earth may be left behind the times. It should be said to be quite significant that the event of Internation Geophysical Year has recently been inaugurated and the unknown regions as well as the areas not fully surveyed heretofore are being exploited and revealed one by one.

The study of number of floating animals and floating plants living in water, that is, zoo-plankton and phyto-plankton has been prosecuted by many investigators, as a result of which it turned out that they also affect the human life directly or indirectly, and their importance is now being recognized increasingly.

At the request of Viet-Namese Government, the author proceeded to lead the planktology for the Viet-Namese students as the Expert of Japan under the Colombo Plan in Saigon University in 1963. The researches in plankton had just been instituted in this country and therefore the author was obliged to start with the most fundamental subject of what kinds of plankton are living there in what distribution pattern. A large number of literatures pertaining to plankton in the world are published, but those dealing with planktons in Southeast-Asia are not many in number. Further, the author keenly felt inconvenience in that no well-compiled reference materials concerning plankton were available in Viet-Nam.

The motive which actuated the author as a young and immature scholar to dare the survey of one country and undertake the publication of this book can be attributed, on one hand, to the author's great affection for Viet-Namese students and research workers silently continuing their studies under the present tragic situation in Viet-Nam as well as the author's great joy of co-operation in the same science. In the meantime, while working for Saigon University (1963-1965) and Nhatrang Oceanographic Institute (1965-1967), the author received a visit from a number of experts of UNESCO, FAO, USOM and COLOMBO including the research workers from abroad specializing in the same subject as well as the prominent persons of various universities. They gave the author many helpful advices as well as encouragement and desired the immediate publication and introduction of Viet-Namese plankton, which greatly moved the author.

Though this book is mostly based on the unaided surveys by the author himself and may not entirely be satisfactory, it would be the greatest pleasure for him if it should serve as a guide for the young Viet-Namese students and be utilized also by the research workers in the Southern Asian countries, by making up its deficiency, and contribute towards the basic studies as well as the oceanic and lacustrine development and researches including those related to fisheries.

The author hereby expresses his heartiest thanks to the Director of Viet-Nam Fisheries Bureau, Dr. Ngo-Ba-Than; the directors of the respective local fisheries bureaus; Dr. Le-Van-Thoi, the former Dean of Faculty of Science, Saigon University; Dr. Hoang-Quoc-Truong, Professor of Zoological Laboratory, Science Department of Saigon University; the Professor of Botanical Laboratory, Dr. Pham-Hoang-Ho; the ex-Director of Nhatrang Oceanographic Institute Dr. Nguyen-Chung-Tu, the former Director Dr. Hoang-Ngoc-Can, the present Director Dr. Nguyen-Hai, the Assistant Director Mr. Tran-Ngoc-Loi, the Chemical Laboratory assistant Mr. Nguyen-Thuong-Dao for their kind assistance, as well as to all the staff of the University and Research Institute for their co-operation.

The author also extends his thanks to Dr. Chikayoshi Matsudaira, Professor of oceanography at Tohoku University Agricultural Department, for his kind offer of electron microscopic photographs and Dr. Teiji Kariya, Professor of fisheries and biology at Tohoku University Agricultural Department, for his encouragement. Finally, the author expresses his deepest thanks to Director General Mr. Shinichi Shibusawa, the former Chief of External Operation Division, Mr. Kohei Yoshida, the former Chief of Experts Assignment Section, Mr. Yasuichi Uehara, and also Mr. Michio Takeda, and present Chief of Experts Assignment Section, Mr. Moriya Miyamoto, respectively of Overseas Technical Co-operation Agency taking charge of the furnishing of experimental equipments as well as technical aid to Asia, Africa, Middle and Near East, Central and South America, etc. and at the same time interested in the publication of this book, and to the staff of O.T.C.A. for their kind offices.

At Nhatrang Oceanographic Institute,
March 6, 1966

Akihiko Shirota

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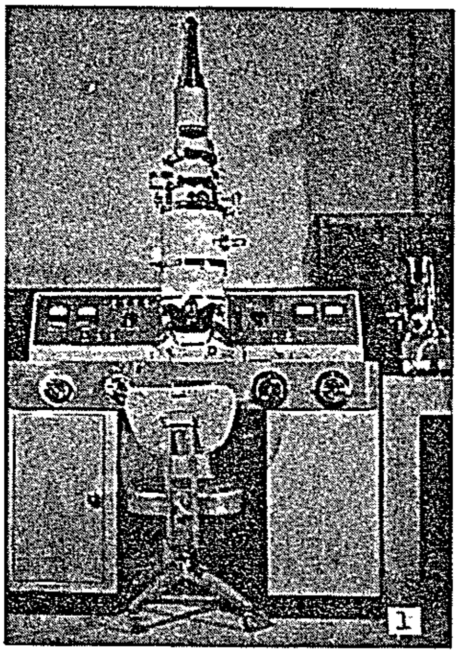
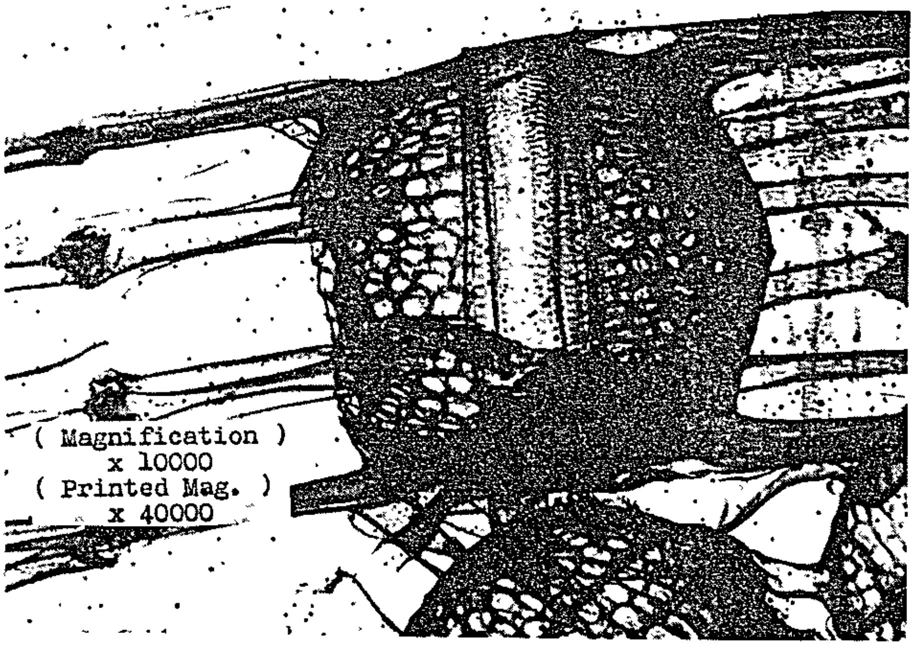
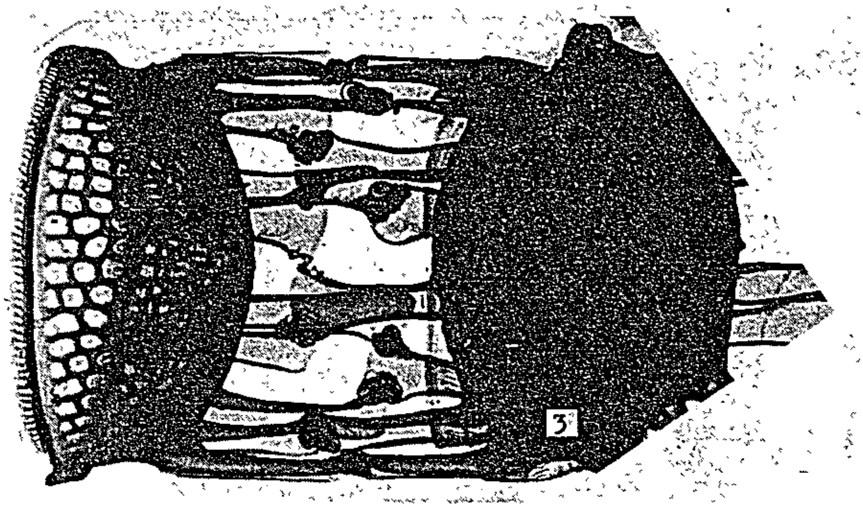
FRONTISPIECE

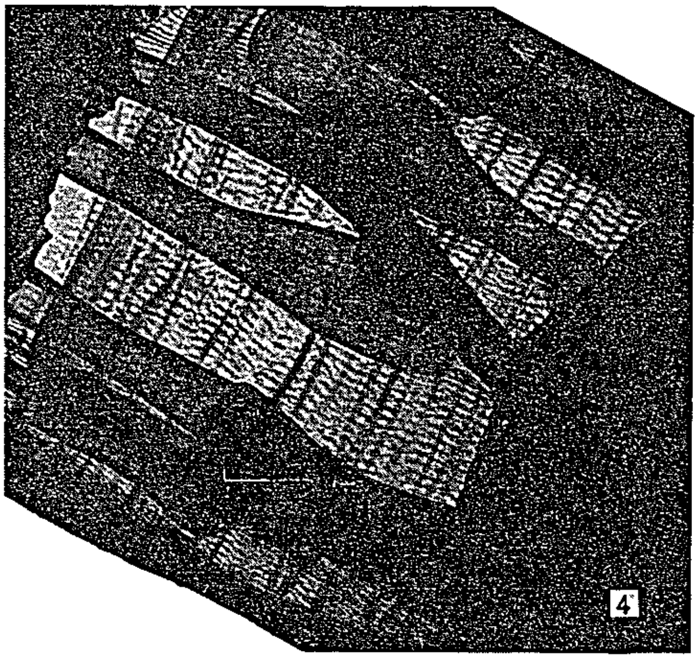


These pictures (2, 3, 4) show Skeletonema costatum (marine Diatom), they are taken by the Electron-microscope (made by Hitachi Co. in Japan ... 1) at the Laboratory of Oceanography, Department of Fisheries, Faculty of Agriculture, Tohoku University in Japan on June 2, 1960.





Picture 3. and 4. Skeletonema costatum (x 40000)



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Planktology, Oceanographic Institute of Nhatrang,
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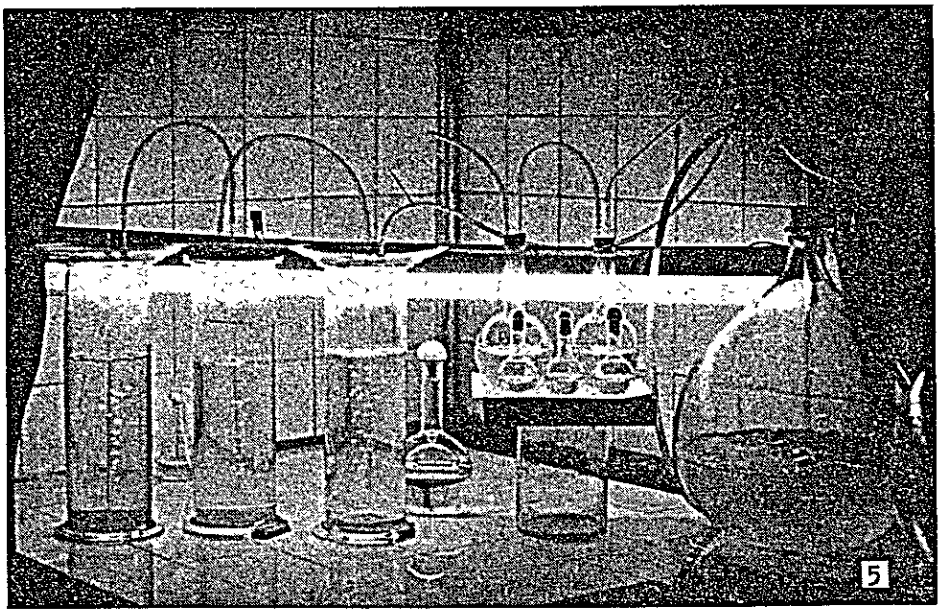

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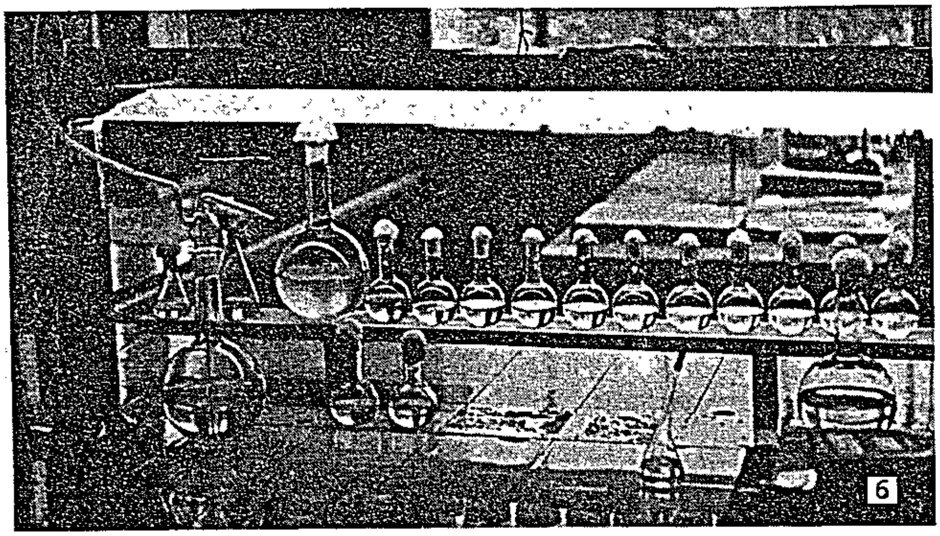

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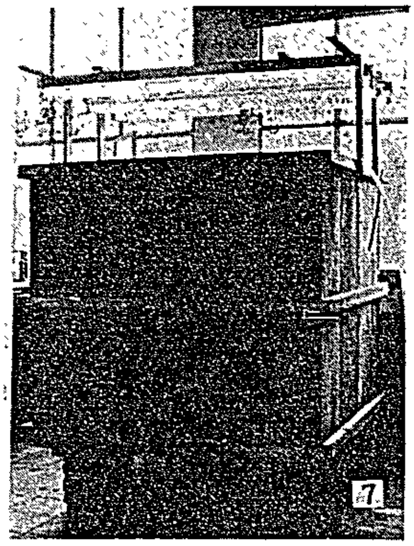

Mass culture (1 ton) of
Plankton at the Oceanographic
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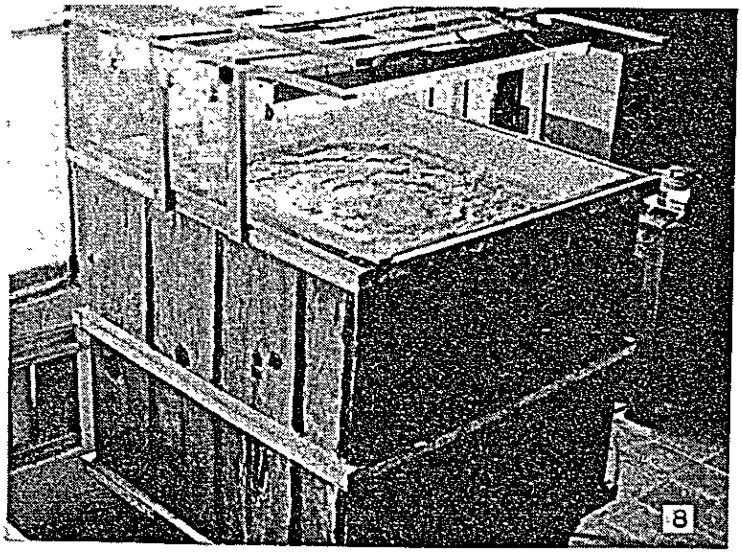
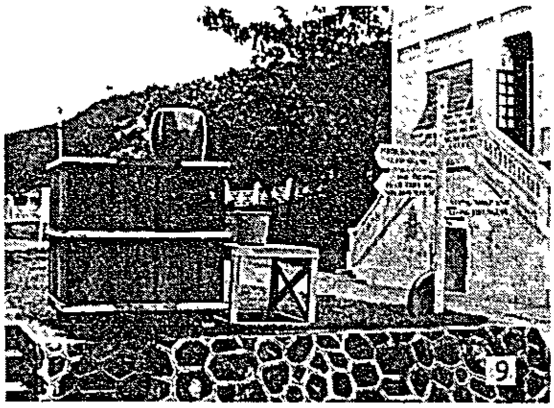
Picture 7. Outward appearance of the culture's box.

Picture 8. Mass culture of Diatom in the aerated condition.





Out-of-door
mass culture;
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Pictures 9. 11. 12.
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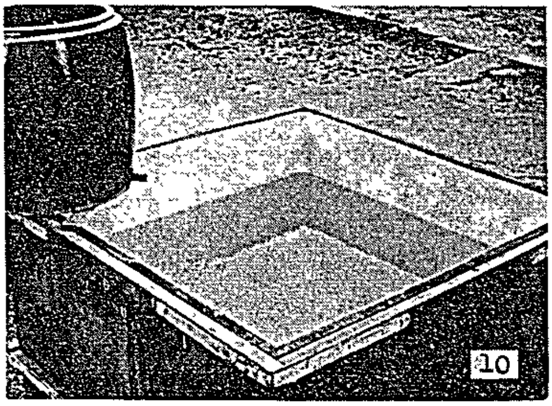

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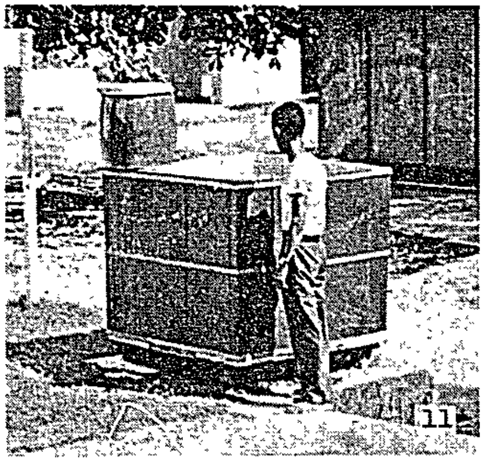
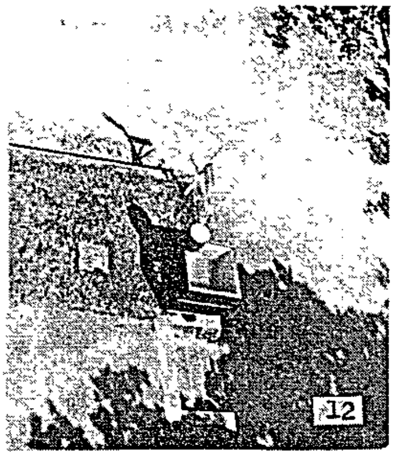
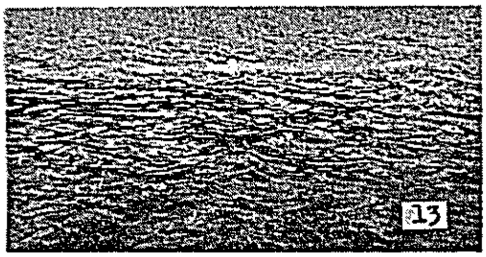
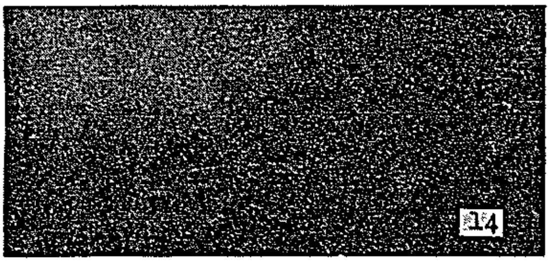




Current-rip occurs at the open sea of Nha-Trang (Pictures 13. 14. 15.).

The place is very important for fishery, because it is rich in plankton, as well as in small and younger fish as food for the big fish which have the economic value.





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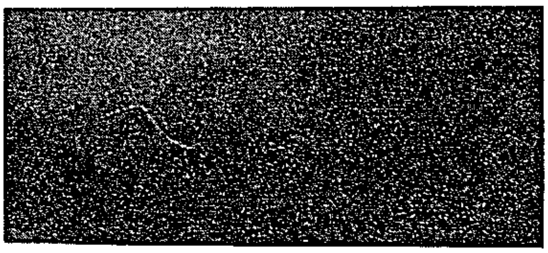


INTRODUCTION

South Viet-Nam is located on the east side of Indo-China Peninsula, adjoins North Viet-Nam in the north at N.L. 17°, borders on Cambodia as well as Laos in the west, facing South China Sea in the east, and has long shorelines in the south extending down to N.L. 8°30'. The year's temperature ranges from 26 to 30°C and under the influences of tropical monsoon, a year can be divided into dry and wet seasons subject to certain deviations according to the areas.

Though the major reports so far published on plankton in South Viet-Nam are enumerated in Chapter I, no reports are available on fresh water plankton except only a nominal part of Protozoa while in respect of marine plankton, the existing reports deal chiefly with the classification of plankton in specific areas and it may be said that up to the present no reports have been published pertaining to plankton over the entire area (coastal region) of Viet-Nam. As for the culture of plankton, no reports have been made before 1963.

The author has had opportunities to conduct the survey of plankton in principal inland water and coastal regions of Viet-Nam in and after 1963. However, in the case of inland survey, it was possible to visit only the limited areas and a thorough survey of seasonal variations of plankton in various areas could not be made. In the meantime, however, the author classified Viet-Namese fresh water and marine plankton according to the samples related to these regions and indexed approx. 1,700 kinds of plankton.

This book is chiefly based on the results of above-mentioned researches, but it also incorporates the following items. The contents of this book are as follows:

1. The principal studies made so far of plankton in Viet-Nam as well as the trends of planktology being currently pushed forward are introduced in Chapter I, to which some of the author's personal comments are added. By knowing the particulars of reports made by these pioneers, it would be possible to determine a policy concerning the types and methods of research and study to be made in future in that country.

2. About 1,700 types of fresh water plankton in lakes, marshes, ponds, culture ponds and streams in various areas of Viet-Nam as well as marine plankton in the coastal regions as indexed out by the author are described in Chapter III, while their distribution is shown in Chapter IV. The Chapter IV also

provides a paragraph related specifically to the plankton in hatcheries, in which plankton obtained from various fish ponds are compared and evaluated.

3. The itinerary of above survey and the brief memoranda pertaining to the survey sites are compiled in the form of tables in Chapter II.

4. As the study of plankton in Viet-Nam has so far been directed chiefly towards their classification, no reports were available concerning the relationship between plankton and their habitats. For the purpose of grasping the causes of increase or decrease of plankton depending on the environmental conditions, the author took an example of Nhatrang in Central Viet-Nam and made comparative analysis of the relations between plankton biomass and the environments in Nhatrang Bay and its open sea in dry and wet seasons. The result thereof is described in Chapter V.

5. For the purpose of information, part of the Report on Naga Expedition carried out in 1959-1961 to determine the characteristics of the current along Viet-Namese coasts and in the ocean, especially the South China Sea, and monsoon winds is extracted and described in Chapter VI.

6. In Chapter VII, the conclusion is drawn pertaining to South Viet-Namese fresh water and marine plankton on the basis of the results of above-mentioned survey conducted by the author and at the same time, the author's opinion is given as to the course to be taken in future application and development related to plankton in consideration of the geographical conditions in South Viet-Nam.

7. In Chapter VIII, the plankton in the southern region (low latitude zone) is observed from various angles and compared with the plankton in the northern region (high latitude zone) and their environments. The utilization of plankton is also briefly described and further, as to the culture of plankton, the world's major culture methods are outlined for both fresh water and marine plankton. I hope that these data will contribute to the future development of plankton physiology and culture.

8. The sketches of South Viet-Namese fresh water and marine plankton are shown in Chapter IX. These sketches were made by the author with an intention to make the beginners familiar with various types of plankton.

9. The pictures contained in Chapter X are those of stations and places taken by the author in course of survey of various areas. From what places had these plankton been collected can be clearly seen from the pictures, which indicate that in the case of survey of fresh water lakes, marshes and rivers, the characteristic color of water comes to the fore. Aerial photos are attached to the pictures related to the survey along the rivers in cities, etc., for better understanding of the conditions in the vicinity. These pictures are included in the hope that they may be of some benefit to those who are interested in the place of collection.

CHAPTER I: THE HISTORY OF PLANKTOLOGY IN VIET-NAM

The principal researches and studies of plankton which have been and are being conducted in Viet-Nam are introduced together with the author's comments as follows:

A. Fresh Water Plankton

The first study of fresh water plankton in Viet-Nam was initiated by M. Lefevre (1933). His report is concerned with phyto-plankton collected from the pond in Saigon Botanical Garden. Hoang-Q-Truong (1960) examined the free living Protozoa in Saigon-Cholon area and classified them into 110 kinds. Though his report deals with a biological classification, the survey seems to have been made bearing in mind the study conducted in Viet-Nam by C. Boisson (1957a, 1957b) as to Protozoa parasitic on man and animal. A. Shirota (1963a) investigated into fresh water plankton at the fish culture stations in Cholon, Saigon, Thu-Duc, Dalat, Nhatrang and Hue as well as in the lakes, marshes and streams, and classified them into 175 types of phyto-plankton and 55 types of zoo-plankton. This report may be the first one on the fresh water plankton in Viet-Nam in that it 1) deals with both phyto-plankton and zoo-plankton, 2) employs quantitative representation (gram or number per 1 m^3) and 3) takes into account the relation between plankton and fish culture. Subsequently, A. Shirota and Hoang-Q-Truong (1965a in press) made a survey of fresh water plankton in the principal areas of Viet-Nam and obtained many new informations. Tran-thi-Hanh has been studying the seasonal variations of plankton at Thu-Duc fish culture station in and after 1964 while Nhuyen-Thoung-Dao also started in 1966 the survey of the distribution and seasonal variations of Rotifera in the lakes and marshes in Dalat.

B. Marine Plankton

In respect of marine plankton, M. Rose (1926) made the first survey of plankton in Nhatrang Bay of Central Viet-Nam. Thereafter, C. Dawydoff (1936) examined quite in detail the plankton in Nhatrang Bay. This report furnishes the most valuable data in the past. The said report was prepared during the five years from 1929 to 1935 while he stayed at Nhatrang Oceanographic Institute, and describes 500 odd types including the classification of samples and benthos in the Gulf of Thailand. In addition, salinity and water temperature, though not complete, are also contained therein. R. Serène (1937) published a list of marine invertebrata living along the coast of Viet-Nam.

Serène (1948) investigated during the period of 1938 to 1942 into plankton (except Diatoms and Protozoa) in Nhatrang Bay. His report indicates the plankton appearing throughout a year in Nhatrang Bay in the number of individual per group and month, recording both day and night data. Specially interesting is that by providing the upper part of plankton net with electric lamps, plankton was collected 3 times, 30 minutes each, from 7 p.m. to 4:30 a.m. from the surface layer of 25 to 30 cm. As a result;. Crustacea (Ostracoda, Copepoda, Cumacae, Schizopoda, Isopoda, Amphipoda, Zoea, Megalopa, Decapoda, Stomatopoda), Chaetognatha, Polychaeta, Nematoda and pisces larva were caught scores of times or depending upon the species, several thousand times as many as a daytime 30 minute catch. For instance, in the case of Copepoda, the data of 1938-1939 set forth a daytime catch of approx. 1,400-10,000 (3,000 individuals on an average) from morning (6:30 a.m.) till evening (5:30 p.m.) as against 3,000-80,000 (53,000 individuals on an average) from evening (7 p.m.) till early morning (4:30 a.m.). Such tendency of markedly increased catch of plankton at night as compared with daytime could be observed similarly each year. On the contrary, Coelenterata including Medusa and Siphonophora as well as Tunicata (Salpa, Appendiculata) rather showed a decreasing tendency.

Needless to say, the fact (that the greater number of individuals are found at night) may be interpreted in terms of the influence due to phototaxis of organism to a certain degree, but clarifying it with regard to such environmental aspects as the distribution in the respective layers of dissolved oxygen, water temperature, salinity or chlorinity, difference between the cases of employment and non-employment of the lamp, relations with fishery, and to other aspects not taken up by him, will be a significant problem to be solved in future. Also, the question of the use of the lamp is quite interesting in connection with the fishery of pisces strong in phototaxis, such as squid, and is considered to be applicable quite extensively. In Japan, T. Suzuki (1963) published a detailed report on his studies made of the relations between squid migration and plankton, etc. by means of the meteorological radar and fish finder during daytime and at night.

M. Hamon (1956) made a survey of Chaetognatha in Nhatrang Bay while M. Yamashita (1958) investigated during the period of 1957 to 1958 into plankton in Nhatrang Bay and reported that the monthly maximum was 36.6 cc/m^3 in May, 1958 with the minimum of average 0.28 cc/m^3 in February, 1958, and that the increase at the time when the maximum of plankton was reached was due to phyto-plankton (chiefly Diatoms and green-algae) instead of zoo-plankton. The "green-algae" as termed by Yamashita is considered to be Trichodesmium Thiebautie and T. erythracum falling under Cyanophyta according to the author's survey.

M. Rose (1955) classified plankton on the basis of data of Nhatrang Bay plankton collected by M.G.Ranson during the period December 1953 to January 1954. The region surveyed was the small water area in the western part of Nhatrang Bay encompassed by the Islands Hon Lon, Hon Mieu, Hon Tam, Hon Mot and the Oceanographic Research Institute. This report does not contain any novel information. In the meantime, the said survey region is a calm sea located behind the large island called "Hon Lon" and not affected by strong northeast wind even in the rainy season. (His report is related to rainy season).

Hoang-Q-Truong (1962) directed his attention to phyto-planktons, especially Diatoms, in Nhatrang Bay and classified them into 154 species. This report is the first one made in Viet-Namese language by a Viet-Namese in investigating into Viet-Namese marine plankton (zoo-plankton not included).

A. Shirota (1963 b) conducted researches in the plankton biomass and environmental conditions in Nhatrang Bay and open sea (all the prior researches had dealt with the Bay only and no open sea survey had been made) and made clear the characteristics of Nhatrang plankton as follows; that is to say, plankton biomass in the dry season is 2.7 times higher in the Bay (0.88 g/m^3 on the average) than in the open sea (0.33 g/m^3 on the average, about 15 km from the beach) whereas in the rainy season, it is lower in the Bay (0.65 g/m^3 on the average) than in the open sea (1.49 g/m^3 on the average or 2.3 times that of Bay), a tendency entirely contrary to the case of dry season having been thus confirmed. He further drew the conclusion that the maximum plankton biomass in the open sea in the rainy season was higher than the maximum in Bay in the dry season and that the plankton fluctuations in dry and wet seasons were attributable to the influence of fresh water flowing from the two rivers into the Bay upon the sea water chlorinity.

He further points it out that discussing the Nhatrang plankton on the sole basis of the Bay data may lead to an erroneous conclusion and especially in case of taking into account fishery in Nhatrang (All the fishing boats are less than 1 ton and the area 10 to 20 km from the beach constitutes the principal fishing zone while the fishing operation is carried out quite seldom in the Bay in both dry and rainy seasons), the survey of open sea in comparison with the Bay data is indispensable.

In respect of an ocean survey and especially that of South China Sea, Naga reports (1961, 1963) incorporating the results of the recent Gulf of China and South China Sea Expedition (1959-1961) are available. This expedition was undertaken under the auspices of the University of California and Scripps Institution of Oceanography of U.S.A., in which several Thai and Viet-Namese staff also participated. This survey was made, as mentioned in the "INTRODUCTION", for the purpose of the development of unexploited or not fully surveyed areas from the viewpoint of the exploitation of protein resources with consideration for overpopulation in Southeast Asia as well as for the purpose of development of fishery. In point of plankton data, the survey was mainly directed towards zoo-plankton or the secondary producers living on phyto-plankton or the basic producers and therefore the said report does not deal with phyto-plankton. Among the zoo-plankton, Copepoda, Euphausia, Petropoda, Chretogratha and Siphonophora presenting useful water mass indices in many oceanic areas and being also important feed for commercial fish were taken up in the report.

According to the said report, the zoo-plankton biomass in the South Viet-Nam area is, if compared in terms of the standing crop, equivalent to 1/3-1/5 of plankton in the Gulf of Thailand coastal waters while the plankton biomass in the South China Sea is said to be corresponding to the plankton volume as measured in the open tropical Pacific by King and Demond (1953). The report says that the plankton in the Viet-Nam coastal region often accounted for more than 100 cc/1,000 m^3, whereas the mean value in the Total South China Sea Area ranged from 36 cc/1,000 m^3 in December 1959 to 68 cc/1,000 m^3 in September-October 1960.

Dividing the South China Sea facing South Viet-Nam into 4 parts on the basis of the said report, it could be said as follows:

1. Zoo-plankton in the coastal waters from Hue (N. Lat. 16°30') up to E. Long. 110° including Nhatrang and Phan-Rang amounts to 0.1 cc/m^3.

2. 0.15 cc/m^3 in the waters within the range from Phan-Rang to the southern tip (east side) of Ca-Mau Peninsula and up to N. Lat. 5-6°.

3. Varying depending on the season in the coastal water from the southern tip (west side) of Ca-Mau Peninsula to Phu-Quoc, that is, 1.0-1.1 cc/m^3 during the April-May period and 0.3-0.5 cc/m^3 during the August-January period.

4. 0.05 cc/m^3 or less in the external water farther to the east of 1. (East of E. Long. 110°).

According to the result of survey made by A. Shirota during the period of 1963 to 1965 in the Viet-Nam coastal waters (within

10-20 km from the beach), the plankton biomass including phyto- and zoo-plankton recorded less than 1.0 g/m^3 with the mean value of 0.3 g/m^3, while the maximum reached 2.0 g/m^3 in Central Viet-Nam in the rainy season. In the meantime, Shirota examined the plankton in the coastal waters to the west (about 15 km from the beach)of Ca-Mau Peninsula at Phu-Quoc and Rach-Gia from the middle to the latter part of September, 1964 and obtained the values of 0.6-0.8 g/m^3, though one cannot discuss the plankton in the waters west of Ca-Mau Peninsula regarding these two places as representing the entire area. The said period falls on the closing period of rainy season, but the above values are two to three times higher than the mean plankton biomass in the Viet-Nam coastal waters facing South China Sea. Accordingly, this tendency of higher plankton biomass in the waters west of Ca-Mau Peninsula as observed by Shirota coincides with the conclusion of Naga expedition. The difference in mass is considered to have been caused in that the places more than about 100 km from the beach were surveyed in the case of Naga expedition whereas Shirota surveyed the places only about 15 km from the beach. In the meantime, in respect of the survey at the same place, th higher plankton biomass in the rainy season than in the dry season is demonstrated by the result of Naga expedition covering the Ca-Mau Peninsula waters (higher biomass in the March-September period which falls on the rainy season).

C. Environmental Survey

As for the oceanic environmental survey, the reports by C. Dawydoff(1931-1933) and R. Serène (1935, 1949) are available and they drew the following conclusions concerning surface salinity and temperature in Nhatrang Bay of Central Viet-Nam. That is, they observed that in the Nhatrang Bay, the mean water temperature ranged between 28°C and 29°C in the April-October period (dry season) with the maximum of 31-31.4°C, while it ranged between 23°C and 24°C in January and February (rainy season) with the maximum of 21-22°C and salinity ranged between 33 and 35‰ (the maximum is 36.66‰ according to N. Hai), but it decreased down to 25-28‰ in the rainy season. Further, N. Hai, etc. (1960) and H. N. Can (Not yet published) made a survey of Nhatrang Bay as to the entirely same factors as above and deduced the entirely same conclusions.

Mentioned above are the survey results obtained in respect of Nhatrang Bay, but as to the survey of the open sea and the South China Sea, the reports by Shirota (1963 b and the one not yet published) and Naga expedition (1959-1961) are the only ones available. Table 1 shows the results of survey by A. Shirota

(1963) of Nhatrang Bay and its open sea, but no researches have so far been conducted into nitrate, phosphate and silicate, etc.

		Bay		Open sea (from beach 15-20 km)	
		Dry season	Rainy season	Dry season	Rainy season
Water Temperature (°C)	Surface	29.0	27.95	29.1	28.5
	15 m	26.4	28.45	28.35	28.5
Oxygen (cc/L)	Surface	4.33	4.35	4.38	4.33
	15 m	4.40	4.22	4.43	4.22
		13.2 m	5.6 m	13.15 m	13.13 m
Alkalinity CO_2 (mg/L)	Surface	-	50.05	-	36.5
	15 m	-	34.0	-	36.5
Chlorinity (°/oo)	Surface	20.09	14.81	20.35	19.13
	15 m	20.0	19.87	20.0	19.96
Salinity (°/oo)	Surface	36.29	26.76	36.76	34.56
	15 m	36.13	35.89	36.13	36.06

Table 1: The environment in the Dry and Rainy season in Nhatrang Bay and the open sea, Central Viet-Nam (by A. Shirota, 1963 b)

The result of oceanographic survey of the South China Sea is described in the aforementioned "Naga Expedition" reports.

D. The Culture of Plankton

It will not be too much to say that a study of culture has not been made at all in Viet-Nam. Pham-H-Ho of the Saigon University previously tried the culture of marine algae and ulva (though not being plankton). Also, he and a few colleagues initiated the culture of Spirogyra, Zygneme and Mougetial, etc. falling under fresh water Zygnemataceae. In respect of animal, Hoang-Q-Truong is now undertaking the culture of Protozoa.

As the study of culture is also the study of physiology and ecology and possible artificially to create an optimum environment for that species, so the study can develop to an applied research.

In the Planktology Laboratory of Nhatrang Oceanographic Institute, the following cultures are in progress:

1. Fresh Water Plankton

The author et al. carried out a pure culture of Scenedesmus dimorphs of Chlorophyta by means of Matsudaira medium. Scenedesmus is one of the most popular species and has been studied by a number of specialists. In this country, however, it may be the first time that such systematic culture has been undertaken.

Scenedesmus dimorphus employed is the one purely separated by A. Shirota in the Saigon University. According to Le-thi-Ngoc-Anh and A. Shirota (unpublished), the number of individuals reached 2 x 10^6/ml on an average and 4577760 individuals/ml as the maximum during the culture. (These values were obtained in an experiment to change the volume of nitrogen in Matsudaira medium). In the case of aeration, the mean value reached 5 x 10^6 individuals/ml which is 2.5 times as high as the value in the case of still water experiment.

As for zoo-plankton, the culture of Moina affinis of Cladocera was undertaken (by A. Shirota and Tran-D-An. 1966 a, in press). In this experiment, a satisfactory result was obtained employing Scenedesmus dimorphus as feed and therefore mass culture was tried. Using 1-ton box and four 40W fluorescent lamps and under continuous day-and night illumination, Moina affinis was placed in a 1 ton water tank in which Scenedesmus had been caused to multiply beforehand, and the multiplication process was observed. As a result, the number of Moina reached a maximum of 8560 individuals/L in about 10 days. This value (8.6 individuals/ml) is a high one as the experimental value in mass culture. In the case of experiments on the culture of Daphnia of Cladocera in a glass container of less than one litre, the value of 12 individuals/ml is he maximum obtained as far as the author knows.

The culture of Rotifera (Brachionus and a few other species) is being carried on by Nguyen-Thuong-Dao at Dalat under the guidance of the author.

In the meantime, no applied experiments have so far been conducted on pisces larva in Viet-Nam.

2. Marine Plankton

Similar to the case of fresh water plankton, the culture of marine plankton is still in a rudimentary stage. The author et al. are carrying out pure culture of Chaetoceros Lorenzianus and several species of Diatoms utilizing Miquel-Allen-Nelson culture medium. The culture of Diatoms has recently made a remarkable progress and also in respect of its culture medium, new ones have been invented and are being employed, that is, successful results have been achieved using EDTA (Ethylene-Diamine-Tetra-Acetic-Acid), TRIS (Tris-Hydroxy-methyl Aminomethane), Glycerophosphates, NTA (Nitro-Trio-Acetate) and Vitamin B_{12}, etc., but the culture by means of such media has not yet been conducted in Viet-Nam.

On the other hand, the culture of naturally caught zoo-plankton is not yet undertaken, but in respect of Artemia salina (A. Shirota introduced dry eggs first in Viet-Nam in 1963), eggs could be obtained in about 5 to 6 days by feeding Artemia with cultured Chaetoceros and Coscinodiscus and through an aeration for about 10 days in still water (water temperature: 28°C), and could be bred repeatedly through ten-odd generations. At the same time, many permanent eggs could be recovered successfully. (A. Shirota and Nguyen-T.-Dao; Not published yet). Further, the author and others are studying the life history and breeding of Mysis (Mesopodopsis slabberi) by means of such cultured Artemia.

E. The Relation Between Plankton & Fishing-Ground

It is often observed that when supersonic waves are emitted into the water, reflections from the positions other than the sea bottom or the school of fish are recorded and appear as if they represent the sea bottom or the school of fish. With the progress of study in various countries on the cause of such phenomenon, it has been found that such layer can be observed at every place in any sea of the world and inasmuch as it is the layer which scatters sound waves in the deep sea, it has been designated as "Deep sea Scattering Layer" or in short "DSL".

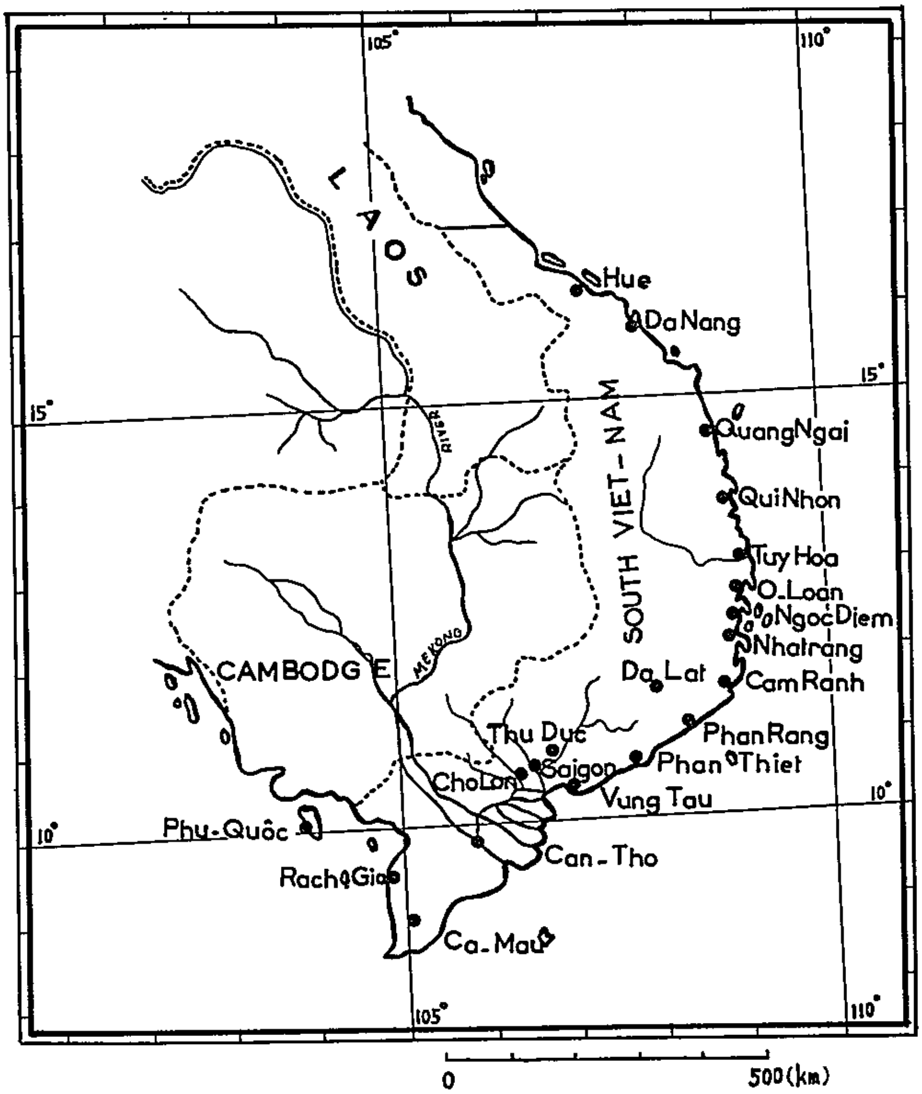
The cause of formation of DSL is being studied by many research workers and so far it has been confirmed that it consists of planktons and especially 1) it comprises zoo-plankton serving as feed for principal pisces and Mollusca (especially Decapoda = squid), 2) they can be observed abundantly in current rip and 3) the school of fish moves in accordance with the daily cycle of zoo-plankton movement (to rise at about sunset and fall at about sunrise), and so the move of fish school can be detected on the basis of such changes in DSL. Accordingly, it is confirmed that a place where DSL exists constitutes comparatively good fishing-ground in many cases.

Such studies by means of fish finders are carried out mostly in the high latitude zones (due also to an abundant existence of planktons) and this kind of study seems to be conducted quite seldom in the southern areas. Such researches have already been carried out exhaustively in the East China Sea, but the survey of the South China Sea seems to have not yet been undertaken.

At the advice of Dr. Kinosuke Kimura, Professor of TOHOKU University, and with the cooperation and support of Dr. Hai, Director of Nhatrang Oceanographic Research Institute in Viet-Nam, the author started to tackle with this problem and is now continuing the researches.

CHAPTER II. RESEARCHING PLACES AND DATES

SITUATION OF SOUTH VIET-NAM AND THE AREA OF RESEARCH



Place	Sampling Station	Date	Note	
Hue	Fish culture station	July 23, 1963	28°C	pH= 5,8
	Perfumes river	Mar. 10, 1964	24,7°C	pH= 5,2
Da-Nang	Buong river	Mar. 11, 1964	25,9°C	Brackish
Quang-Ngai	Drir river	Mar. 13, 1964	24,1°C	Brackish
O-Loan Dam	Bay	Apr. 10, 1964	30,9°C	Brackish
Phu-Huu (Ngoc-Diem)	Pond	May 12, 1965	30°C	pH= 6,4
Nhatrang	Fish culture station	May 13, 1963	29,0°C	Brackish
	"	Jun. 18, 1964	29,5°C	pH= 8,0
	"	Dec. 5, 1964	29,1°C	pH= 8,0
	River (Cua Be Nhatrang)	Jun. 20, 1964	28,8°C	pH= 8,0
	Ponds	Nov. 6, 1964	26 - 30°C	
Da-Lat	Cam-Ly river	Apr. 16, 1963	24,0°C	pH= 5,5
	Fish culture ponds	Apr. 16, 1963	26,0°C	pH= 6,0
		Aug. 30, 1964	28,7°C	pH= 6,2
	Pond of Prenn	Apr. 18, 1963	23,0°C	pH= 5,5
	Than-Tho lake	Apr. 17, 1963	25,0°C	pH= 5,5
	Me-Linh lake	Apr. 17, 1963	24,0°C	pH= 5,5
	Van-Kiep lake	A 19, 1963	24,2°C	pH= 5,6
	Xuan-Huong lake	Apr. 22, 1963	24,3°C	pH= 5,8
Song-Pha	Dam of Da-Nhim	Apr. 20 - 21, 1963	25,6°C	pH= 5,8
		Aug. 31, 1964	28,2°C	pH= 6,7
Phan-Thiet	River	May 21, 1964	29,0°C	Brackish
		Jan. 28, 1965	26,0°C	Brackish
Bien-Hoa	Dong-Nai river	Feb. 21, 1964	26,0°C	pH= 5,0
		Sep. 27, 1964	28,4°C	pH= 5,2
Thu-Duc	Fish culture pond	Apr. 9, 1963	28,0°C	pH= 5,0
		Dec. 7, 1963	28,2°C	pH= 5,0
		Jan. 8, 1964	27,4°C	pH= 5,2
		Aug. 11, 1964	29,8°C	pH= 6,0
		Mar. 2, 1965	29,0°C	pH= 5,5
Saigon	Saigon river	Mar. 22, 1963	25,8°C	pH=5,8-6,2
		Aug. 3, 1963	28,0°C	pH= 6,2
Cholon	Fish culture pond	Mar. 26, 1963	31,0°C	pH= 7,6
	Kieu-Long Muoi	Mar. 26, 1963	29,5°C	pH= 7,4
	River, ponds	Feb. 7, 1964	28,6°C	pH= 5,8
			28,3°C	pH= 4,0
Can-Tho	Mekong river	Nov. 16, 1963	28,0°C	transparency 20cm
	Pond of Airport	Sep. 10, 1964	31,4°C	pH= 5,8
Ca-Mau	Fish culture pond 1	Sep. 12, 1964	27,9°C	pH= 6,8
	" 2	Sep. 12, 1964	27,8°C	pH= 7,2
	River	Sep. 12, 1964	28,4°C	pH= 4,5
	Lake	Sep. 13, 1964	27,7°C	pH= 6,4
Rach-Gia	Fish culture pond	Sep. 16, 1964	29,5°C	pH= 6,0
	River and pond of field	Sep. 16, 1964	River is brackish	
	Lake WT. 29,5°C		Pond 29,2°C	pH= 5,8
Phu-Quoc	River	Sep. 18, 1964	28,4°C	Brackish

Place	Sampling Station	Date	Note
Thuan-An	15-20 Km from beach	Mar. 9, 1964	W.T. 22.5°C
Da-Nang	"	Mar. 11, 1964	25.2°C
Quang-Ngai	"	Mar. 13, 1964	24.4°C
Qui-Nhon	"	Apr. 12, 1964	26.8°C
	(Bay)		28.1°C
Tuy-Hoa	"	Apr. 9, 1964	28.1°C
O-Loan	Bay	Apr. 9, 1964	31.0°C
Phu-Huu	Brackish river	Apr. 17, 19, 27, 1965	29-32°C ; Cl(°/oo) 7.7-15.5
		May 20, 1965	
		Jun. 10, 1965	
		Aug. 18, 1965	
Ngoc-Diem	Bay	Apr. 17, 27, 1965	28.4°C ; Cl(°/oo) 19.8
		May 20, 1965	28.5-30°C
Nha-Trang	Bay and Open Sea	Apr. 25, 1965	
		May 20, 21, 1963	
		Jun. 11, 1963	
		Oct. 1, 2, 1963	
		May 12, 1964	
		Jun. 17, 1964	
		Aug. 28, 1964	
		Dec. 16, 1963	
		Dec. 12, 1963	
		Apr. 15, 1965	
		Jun. 15, 1965	
		Sep. 6, 1965	
Cam-Ranh	Bay	Jun. 14, 1963	29.0°C
		May 12, 1964	29.3°C
Phan-Ranh		May 20, 1964	29.2°C
Phan-Thiet	15-20 Km from beach	Mar. 30, 31, 1963	
		May 21, 1964	29.2°C
Vung-Tau		Sep. 12, 1963	30.6°C
		Apr. 10, 1964	29.2°C
Rach-Gia	"	Sep. 16, 1964	30.4°C
Phu-Quoc	"	Sep. 18, 1964	28.2°C

CHAPTER III. CLASSIFICATION OF THE FRESH WATER AND THE MARINE PLANKTON IN SOUTH VIET-NAM

A.

FRESH WATER PLANKTON

Note:	D. ------------	Diameter
	Col. D. -------	Diameter of a Colony
	F. ------------	Female
	M. ------------	Male
	♀ ------------	Female
	♂ ------------	Male
	H. ------------	Height
	L. ------------	Length
	W. ------------	Width
	Leg 5 ---------	5 th. Leg

PHYTO-PLANKTON

Phylum CYANOPHYTA

Order CHROOCOCCALES

Family CHROOCOCCACEAE

Chroococcus giganteus West D.50μ 1

" limneticus Lemmermann D.8-10μ 2

Coelosphaerium Kutzingianum Nageli D.48-90μ 3

Aphanocapsa pulchra (Kutz.) Rab. Col.D.60μ 4

Merismopedia elegans A.Braun Col.D.50-60μ 5

Polycystis incerta Lemm. D.60-70μ 6

Synechocystis aquatilis Sauvageau D.4μ 7

Order OSCILIATORIALES

Suborder OSCILLATORINEAE

Family OSCILLATORIACEAE

Arthrospira Jenneri (Kutz.) Stiz. W.5-7μ 8

Lyngbya contorta Lemm. 9

" Birgei G.M.Smith W.20-24μ 10

Oscillatoria formosa Bory W.7-8μ 11

" limosa Ag. W.14-17μ 12

" princeps Vaucher D.16-90μ 13

Phormidium autumnale (AG.) Gomont W.7-10μ 14

Phorphyrosiphon Notarisii (Menegh.) Kutz. W.25-30μ 15

Spirulina major Kutz. W.3-4μ 16

" princepus (W&G.S.West) G.S.West D.10-14μ 17

Symploca muscorum (Ag.) Gomont D.5-8μ 18

Trichodesmium lacustre Klebahn W.7μ 19

Suborder NOSTOCHINEAE

Family NOSTOCACEAE

Anabaena circinalis (Kutz.) Rab. 20

" Levanderi Lemm. W.5μ 21

Anabaenopsis Elenkinii Miller W.4-5μ 22

Aulosira implexa Bornet & Flahault W.8-10μ 23

Aphanizomenon flos-aquae (L.) Ralfs W.5μ 24

Nostoc Linckia. (Roth.) Born. W.3-4μ 25

" Sphaericum Vaucher 26

Nodularia spumigena Mert W.16-18μ 27

" " var. minor Fritsch W.6-8μ 28

Family SCYTONEMATACEAE

Plectonema Tomasiniana (Kutz.) Born W.17-20μ.......29

Phylum CHRYSOPHYTA
Class BACILLARIACEAE (DIATOMS)
Order I CENTRALES
Suborder I DISCINEAE
Family 1. MELOCIRACEAE

Melosira Agussizii 30
" distans Kutzing D.4-20μ H.4-9μ 31
" granulata Ralfs D.5-21μ H.5-18μ 32
" " var. angustissima Mull D.3-5μ L.30-50μ. 33
" " " fo. spiralis D.15-25μ H.4-8μ 34
" " var. muzzanensis 35
" " " valida 36
" islandica O. Mull D.7-27μ H.4-21μ 37
" italica Kutzing D.5-28μ H.8-21μ 38
" malayensis 39
" varians Agardh D.8-35μ H.9-13μ 40

Family 2. COSCINODISCACEAE

Cyclotella comta Kutzing D.15-50μ 41
" Kutzingiana Thawaites D.10-45μ 42
" Meneghiniana Kutzing D.10-30μ 43
Stephanodiscus Hantzschii Grunow D.8-20μ 44

Suborder II SOLENIINEAE
Family 3. RHIZOSOLENIACEAE

Rhizosolenia eriensis H.L. Smith D.6-15μ L.40-150μ 45
" longiseta Zacharias D.4-10μ L.70-250μ .. 46

Suborder III BIDDULPHIINEAE
Family 4. CHAETOCERACEAE

Chaetoceros Muelleri Lemmermann W.5-30μ 47

Family 5. BIDDULPHIACEAE

Attheya Zachariasi J. Brunow W.12-40μ 48

Order II PENNALES
Suborder I ARAPHIDINEAE
Family 5. FRAGILARIACEAE

Asterionella formosa Hassall L.40-130μ W.1-2μ 49
" gracillima (Hant.) Heiberg L.40-130μ 50
Fragilaria capucina Desm L.25-100μ 51
" construens Grunow L.7-25μ W.5-12μ 52
" crotonensis Kitton L.40-70μ 53
Synedra acus Kutzing L.100-300μ W.5-6μ 54
" " var. angustissima L.500μ W.1-2μ 55
" " " radians Hust W.2-4μ L.40-200μ ... 56

Cymbella	parva Cleve L.25-70μ W.8-12μ	94
"	turgida Cleve L.30-100μ W.9-25μ	95
"	ventricosa Kutz. L.10-40μ W.5-12μ	96
Frustulia	rhomboides (Ehr.) Toni L.70-140μ	97
Gomphonema	acuminatum Ehrenberg L.30-70μ	98
Gyrosigma	attenuatum (Kutz.) Rabh. L.150-240μ W.23-26μ ...	99
Mastogloia	danseii (Thwaites) W. Smith L.40-65μ .	100
Neidium	affine (Ehr.) Pfitzer L. very variable	101
"	" var. amphirhynchus (Ehr.) Cleve ...	102
Pinnularia	gibba Ehr. L.80-90μ	103
"	splendida Hust. L.45μ	104
"	nobilis Ehr. L.230-260μ	105
Stauroneis	anceps Ehr.	106

Family 10. EPITHEMIACEAE

Epithemia	argus Kutz. L.30-130μ W.6-15μ	107
"	" var. alpestris Grun.	108
"	turgida Kutz. L.60-100μ W.15-18μ	109
"	zebra Kutz. L.30-150μ W.7-14μ	110
"	" var. porcellus Grun.	111
"	" " saxonica Grun. L. 15-70μ W.8-10μ	112
Rhopalodia	gibba (Ehr.) O.Muller L.150μ	113
"	ventricosa (Kutz.) O.Muller L.80μ ...	114

Family 11. NITZSCHIACEAE

Hantzschia	amphioxys (Grun.) L.35-60μ	115
Nitzschia	acicularis W.Smith L.50-150μ	116
"	actinastroides	117
"	filiformis Hust L.20-100μ W.4-6μ	118
"	fonticola	119
"	brebissonii W.Smith L.200-250μ	120
"	nyassensis	121
"	philippinarum	122
"	ricta Hantsch	123
"	subrostrata	124
"	vermicularis (Kutz.) Grun. L.90-250μ W.5-7μ ...	125

Family 12. SURIRELLACEAE

Cymatopleura	solea (Breb) W.Smith L.30-300μ W.10-40μ	126
Campylodiscus	hibernicus Ehr. L.80-130μ	127
Surirella	biseriata Brebisson L.80-350μ W.30-80μ	128
"	elegans Ehr. L.130μ W.40-90μ	129
"	ovalis Breb. L.40-80μ	130

Phylum PROTOZOA
Class MASTIGOPHORA
Subclass PHYTOMASTIGOPHORA (PHYTOFLAGELLATA)
Order CHRYSOMONADALES
Family MALLOMONADACEAE
Mallomonas caudata var. macrolepis Conrad L.50-75µ. 268
" producta Iwanoff L.34-36µ 269

Family OCHROMONADACEAE
Dinobryon divergens Imhof L.30-35µ 270
" sertularia Ehr. L.30-37µ 271
" stipitatum Stein L.55-64µ 272
Epipyxis utriculus Stein L.27-30µ 273
Uroglenopsis americana (Calkins) Lemm. D.15-18µ . 274

Order CHRYSOCAPSALES
Family CHRYSOCAPSACEAE
Chrysocapsa planktonica (W. & G.S. West)
Pascher Col.D.30µ 275

Order RHIZOCHLORIDALES
Family STIPITOCOCCACEAE
Stipitococcus urceolatus W. & G.S. West
L.10-17µ 276

Order RHIZOCHRYSIDALES
Family RHIZOCHRYSIDACEAE
Chrysamoeba radians Klebs W.23-25µ 277

Class CHLOROPHYCEAE
Order CHLOROCHYTRIDIALES
Family CHLOROCHYTRIDIACEAE
Pedinomonas minor Korshikov L.2-7µ 278

Order POLYBLEPHARIDALES
Family POLYBLEPHARIDACEAE
Dunaliella salina Teodor L.20µ 279
Heteromastix angulata Korshikov L.7-10µ 280
Pyramidomonas tetrarhynchos Schmards L.30µ 281
Stephanoptera gracilis M.Smith L.15-17µ 282

Order VOLVOCALES
Family CHLAMYDOMONADACEAE
Chlamydomonas completa 283
" chrysomonadis 284
" cingulata Pascher L.23-25µ 285
" inhabilis 286
" kvildensis 287

Glenodinium berolinense (Lemm.) Lindem
L.28-34μ 311
" kulczynskii (Woloszynska) Schiller
L.20-30μ 312
" penardiforme (Lindemann) Schi. L.20μ .. 313
" quadridens (Stein) Schi. L.37-40μ ... 314
" uliginosum Schilling L.25μ 315
Hemidinium nasutum Stein L.25-30μ 316
Sphaerodinium cinctum Ehr. L.40-46μ 317

Family GONYAULACACEAE
Gonyaulax apiculata (Penard) Entz. L.45-52μ ... 318
" palustre Lemm. L.35-37μ 319

Family PERIDINIACEAE
Peridinium aciculiferum 320
" africanum 321
" gatunense Nygaard L.46-48μ 322
" palatinum Lauterborn L.48-52μ 323
" spiniferum 324
" striolatum 325
" umbonatum Stein L.28-30μ 326

Order CRYPTOPHYCEAE
Suborder MONOMASTIGACEAE
Family MONOMASTIGACEAE
Monomastix opisthostigma Scherffel L.21μ 327

Suborder CRYPTOMONADALES
Family CRYPTOCHRYSIDACEAE
Cryptochrysis commutata Pascher L.20-25μ 328

Family CRYPTOMONADACEAE
Cryptomonas erosa Ehr. L.40μ 329
Chilomonas Paramaecium Ehr. L.40-45μ 330

Order EUGLENALES
Family ASTASIACEAE
Astasia Dangeardii Lemm. L.30-35μ 331

Family EUGLENACEAE
Euglena acus Ehr. L.52-175μ D.8-18μ 332
" " var. rigida Hubner L.109-126μ
D.7-9μ 333
" acutissima Lemmerman L.120-150μ
D.9-11μ 334
" " var. longa n. var. L.220-350μ
D.10-135μ 335

Euglena	anabaena var. minor	336
"	caudata Hubner L.90-120µ D.27-50µ ..	337
"	deses Ehr. L.86-170µ D.11-21µ	338
"	" var. tenuis Lemm. L.95-140µ D.8-11µ	339
"	ehrenbergii Klebs L.190-400µ D.13-30µ	340
"	geniculata	341
"	gracilis Klebs L.35-55µ D.8-22µ	342
"	granulata Klebs L.60-95µ D.18-27µ ..	343
"	hyalina	344
"	intermedia Klebs L.85-130µ D.8-12µ .	345
"	klebsii Mainx L.45-85µ D.5-8µ	346
"	minima	347
"	oblonga Schmitz. L.52-70µ D.25-40µ .	348
"	oxyuris Schmarda L.140-450µ D.19-38µ	349
"	pisciformis Klebs L.21-34µ D.5-8µ ..	350
"	polymorpha Dangeard L.57-92µ D.15-25µ	351
"	proxima Dang. L.55-75µ D.19-30µ	352
"	pseudospiroides Swirenko L.95-150µ D.15-22µ	353
"	pseudoviridis	354
"	rostrifera n. sp. L.90-140µ D.18-48µ	355
"	rubra Hardy L.76-167µ D.25-36µ	356
"	sociabilis Dangeard L.65-112µ D.16-30µ	357
"	spirogyra Ehr. L.80-126µ D.10-35µ ..	358
"	" var. abrupte-acuminata Lemm. L.130-145µ D.15-17µ ..	359
"	spiroides Lemm. L.75-164µ D.12-16µ .	360
"	splendens Dang. L.74-110µ D.21-27µ .	361
"	spirogyra var. marchica	362
"	terricola Dang. L.68-93µ D.8-17	363
"	tripteris Dujardin L.90-120µ	364
"	velata Klebs L.80-115µ D.25-35µ	365
Cryptoglena	pigra Ehr. L.15-18µ D.10µ	366
Lepocinclis	fusiformis Carter L.50µ	367
"	ovum (Ehr.) Lemm. L.30µ	368
Phacus	acuminata Stokes L.30-40µ D.20-30µ..	369
"	" var. iowensis no. var. L.28-33µ D.17-20µ	370
"	alata Klebs L.28-40µ W.21-28µ	371
"	longicauda (Ehr.) Duj. L.120-170µ W.45-70µ	372
"	pleuronectes (O.F.M.) Duj. L.40-100µ W.29-70µ	373

ZOO-PLANKTON

Phylum PROTOZOA
Subphylum PLASMODROMA
Class MASTIGOPHORA
Subclass ZOOMASTIGOPHORA (ZOOFLAGELLATA)
Order PROTOMONADINA

Codonodendron ocellatum L.15-25μ 386
Monas vivipara Ehr. L.20μ 387
" coronifera Skuja. L.20-24μ 388
Oicomonas termo (Ehr.) S.Kent L.5-20μ ... 389
Physomonas vestita Stokes 390
Polyoeca dumosa 391
Salpingorhiza pascheriana Klug. L.15μ 392

Class SARCODINA
Subclass RHIZOPODA
Order AMOEBINA (AMOEBAEA)

Amoeba guttula Dujardin L.35μ 393
" polypoidia 394
Astramoeba radiosa Ehr. L.100μ 395
Chaos diffluens Muller L.300-600μ 396
Pelomyxa palustris Greeff L.1500-3000μ 397
" villosa Leidy L.500μ 398
Rugipes bilzi Schaeffer L.300μ 399

Order TESTACEA

Arcella polypora Penard D.80-150μ 400
" discoides Ehr. D.90-146μ 401
" megastoma Penard D.190-365μ 402
" vulgaris Ehr. D.100-152μ 403
Assulina muscorum Greeff L.28-50μ 404
" seminulum Ehr. L.60-90μ 405
Centropyxis aculeata (Ehr.) Stein D.120-150μ. 406
" constricta (Ehr.) Penard L.120-150μ 407
" ecornis (Ehr.) Leidy D.200-275μ.. 408
Chlamydophrys minor Belar L.16-20μ 409
Difflugia urceolata Carter D.200-350μ 410
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" corona Wallich L.180-230μ 412
" lebes Penard L.400μ 413
" oblonga Ehr. L.100-300μ 414
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" laevis Ehr. L.2?-55μ 416
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" roesali Ehr. L.540µ 506

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" patella (O.F.Muller) L.20µ 512

Family EPALCIDAE

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Oxytricha fallax Stein L.150µ 524
Paraholosticha herbicola Kahl L.170µ 525
Pleurotricha grandis Stein L.260µ 526
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Phylum ARTHROPODA
Subphylum MANDIBULATA
Class CRUSTACEA
Subclass ENTOMOSTRACA
Order PHYLLOPODA
Suborder CLADOCERA
Tribe CTENOPODA
Family SIDIDAE

Sida crystallina (O.F.Muller) F.3-4mm M.1.5-2.0mm 547
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" " var. brevicornis L.0.4-0.5mm 554
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" karau King F.0.45mm 560
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" rectangula Sars F.0.35-0.43mm 562
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" diaphana (King) F.0.5mm M.0.4mm 565
" globulosa Daday F.0.3-0.4mm 566
Camptocercus rectirostris Schodler F.1.0mm ... 567
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" gibbus Lilljeborg F.0.5mm 569
" sphaericus (O.F.Mull.) F.0.3-0.5mm M.0.2mm 570
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Phylum TROCHEIMINTHES
Class ROTIFERA (ROTATORIA)
Order BDELLOIDEA
Family PHILODINIDAE

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Embata commensalis Bryce L.600µ 628
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Order MONOGONONTA
Suborder PLOIMA
Family ASPLANCHNIDAE

Asplanchna priodonta Gosse L.900-1500µ 631
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Brachionus bakeri (Laut;) L.160-250µ 633
" bidentata L.250-45µ 634
" calyciflorus L.300µ 635
" falcatus Zacharias L.150-300µ 636
" havanaensis 637
" plicatilis Pallas L.350µ 638
" pala Ehrenberg L.250-400µ 639
" quadridentatus Hermann 640
Colurella adriatica Bory L.80-100µ 641
Dipleuchlanis propatula Beauchamp 642
Diplois daviesiae Gosse L.300-370µ 643
Epiphanes brachionus Ehr. L.350-500µ 644
" clavulata Ehr. L.5--µ 645
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Keratella cochlearis Bory ; Vincent L.100µ.. 650
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" quadrata (O.F.Mull.) L.135µ 652
" stipitata 653
" valga 654
" serrulata Gillerd 655
Lepadella patella St.Vincent L.100-200µ 656
" ovalis L.100-200µ 657
Notholca acuminata Gosse L.180µ 658
Platyias polyacanthus Harring L.250µ 659
" patulus L.200-220µ 660
" quadricornis L.180-200µ 661

Phyto-Plankton (Fresh water)

Phylum	Class	Subclass	Order	Suborder	Family	Number of Species
Cyanophyta			Chroococcales		Chroococcaceae	7
			Oscillatoriales	Oscillatorineae	Oscillatoriaceae	12
				Nostochineae	Nostocaceae	9
					Scytonemataceae	1
Chrysophyta	Bacillariaceae		Centrales	Discineae	Melociraceae	11
					Coscinodiscaceae	4
				Soleniineae	Rhizosoleniaceae	2
				Biddulphiineae	Chaetoceraceae	1
					Biddulphiaceae	1
			Pennales	Araphidineae	Frafilariaceae	15
					Tabellariaceae	8
				Monoraphidineae	Achnanthaceae	5
				Biraphidineae	Naviculaceae	30
					Epithamiaceae	8
					Nitzschiaceae	11
					Surirellaceae	9
	Heterocontae (Xanthophyceae)		Heterococcales		Pleurochloridaceae	2
			Heterotrichales		Tribonemataceae	2
Chlorophyta	Chlorophyceae		Tetrasporales		Palmellaceae	3
			Chlorococcales		Chlorococcaceae	4
					Micractiniaceae	3
					Characiaceae	1
					Coelastraceae	1
					Dictyosphaeriaceae	1
					Hydrodictyaceae	3
					Oocystaceae	18
					Scebedesmaceae	12
			Zygnematales		Zygnemataceae	9
					Mesotaeniaceae	1
					Desmidiaceae	61
			Ulotrichales	Ulotrichineae	Microsporaceae	1
					Protococcaceae	1
					Trentepohliaceae	1
					Ulotrichaceae	1
				Sphaeropleineae	Sphaeropleaceae	1
			Ulvales		Schizomeridaceae	1
			Cladophorales		Cladophoraceae	2
			Oedogoniales		Oedogoniaceae	3
			Schizogoniales		Schizogoniaceae	1

Total species of the fresh water phyto-plankton 267

Zoo-Plankton (Fresh water)

Phylum	Class	Subclass	Order	Suborder	Family	Number of Species
Protozoa	Mastigophora	Phytomastigophora	Chrysomonadales		Mallomonadaceae	2
		(Phytoflagellata)				
			Chrysocapsales		Ochromonadaceae	5
			Rhizochloridales		Stipitococcaceae	1
			Rhizochrysidales		Rhizochrysidaceae	1
	Chlorophyceae		Chlorochytridiales		Chlorochytridiaceae	1
			Polyblepharidales		Polyblepharidaceae	4
			Volvocales		Chlamydomonadaceae	9
					Haematococcaceae	1
					Phacotaceae	1
					Spondylomoraceae	1
					Volvocaceae	8
			Dinophyceae	Gymnodiniales	Gymnodiniaceae	5
				Dinococcales	Phytodiniaceae	1
				Peridiniales	Ceratiaceae	1
					Glenodiniaceae	8
					Gonyaulacaceae	2
					Peridiniaceae	7
			Cryptophyceae	Monomastigales	Monomastigaceae	1
				Cryptomonadales	*Cryptochrysidaceae*	1
					Cryptomonadaceae	2
			Euglenales		Astasiaceae	1
					Euglenaceae	50
					Peranemaceae	4
		Zoomastigophora	Protomonadina			7
		(Zooflagellata)				
	Sarcodina	Rhizopoda	Amoebina			7
			Testaceae			28
		Actinopoda	Actinophrydia			4
	Ciliata	Euciliata	Holotricha	Gymnostomata	Holophryidae	16
					Actinobolinidae	1
					Amphileptidae	3
					Chlamydodontidae	1
					Colepidae	2
					Didiniidae	1
					Dysteriidae	1
					Loxodidae	1
					Nassulidae	4
					Spathidiidae	3
					Tracheliidae	4
				Trichostomina	Colpodidae	4
					Conchopthiridae	1
					Paramecidae	5
					Plagiopylidae	1
					Trichopelmidae	1
				Hymenostomina	Frontoniidae	8
					Pleuronematidae	4
			Spirotrichida	Heterotrichina	Bursariidae	3
					Metopidae	2
					Reichnowellidae	1
					Spirostomidae	5
					Stentoridae	3
				Hypotrichina	Aspidiscidae	1
					Euplotidae	2
					Epalcidae	2
					Oxytrichidae	20
			Peritricha	Mobilia	Urceolariidae	3
				Sessilia	Stylozoonidae	1
					Epistylidae	2
					Ophrydiidae	1
					Vaginicolidae	2
					Vorticellidae	1
	Suctoria		Tentaculiferida		Podophryidae	2
Arthropoda	Crustacea	Entomostraca	Phyllopoda	Cladocera	Sididae	4
					Bosminidae	7
					Chydoridae	21
					Daphnidae	15
					Macrothricidae	2
					Polyphemidae	1
			Copepoda	*Calanoida*	*Centropagidae*	2
					Diaptomidae	10
					Temoridae	1
				Podoplea	Cyclopidae	15
					Canthocamptidae	1
					Ergasilidae	1
Trochelminthes	Rotifera		Bdelloidea		Philodinidae	4
			Monogononta	Ploima	Asplanchnidae	2
					Brachionidae	29
					Lecanidae	5
					Proalidae	1
					Dicranophoridae	3
					Gastropidae	2
					Microcodonidae	1
					Notommatidae	4
					Synchaetidae	6
					Tetrasiphonidae	1
					Trichocercidae	5
			Flosculariaceae		Conochilidae	1
					Hexarthridae	1
					Testudinellidae	6
			Collothecaceae		Collothecidae	1

Total species of the fresh water zoo-plankton 428

B.

MARINE PLANKTON

Note: D. -------------- Diameter

Col. D. --------- Diameter of a Colony

F. -------------- Female

M. -------------- Male

♀ -------------- Female

♂ -------------- Male

H. -------------- Height

L. -------------- Length

W. -------------- Width

PHYTO-PLANKTON

Phylum CYANOPHYTA
  Class CYANOPHYCEAE
    Order HORMOGONEAE
      Family OSCILIATORIACEAE

Trichodesmium	erytheraeum Ehr.	L.-100µ	1
"	Thiebauti Gom. W.5-16	L.(Col.)-6000µ..	2

Phylum CHRYSOPHYTA
  Class BACILIARIACEAE (DIATOMS)
    Order CENTRALES
     Suborder DISCINEAE
      Family MELOSIRACEAE

Melosira	Juergensii Agardh D.10-38µ	3
"	nummuloides Agar. D.10-40µ	4
Hyalodiscus	stelliger Bailey D.30-85µ	5

      Family COSCINODISCACEAE

Actinophychus	undulatus Ralfs D.20-150µ	6
Actinocyclus	Ehrenbergi Ralfs D.50-300µ	7
Asterolampra	Grevillei Wallich D.70-125µ	8
"	marylandica Ehr. D.50-150µ	9
Asteromphalus	Cleveanus Grunow D.40-70µ	10
"	flabellatus Greville D.40-60µ ...	11
"	hepaticus Ralfs D.42-175µ	12
Coscinodiscus	asteromphalus Ehr. D.80-400µ	13
"	curvatulus Grunow D.40-100µ	14
"	excentricus Ehr. D.20-100µ	15
"	gigas Ehr. D.150-300µ	16
"	" var. praetexta Hustedt D.300-600µ	17
"	Janischii A.Schmidt D.115-250µ ..	18
"	lineatus Ehr. D.30-150µ	19
"	marginatus Ehr. D.200-375µ	20
"	nitidus Gregory D.25-100µ	21
"	nobilis Grunow D.325-490µ	22
"	nodulifer Schmidt D.20-100µ	23
"	oculus-iridis Ehr. D.100-300µ ...	24
"	perforatus Ehr. D.90-200µ	25
"	radiatus Ehr. D.30-180µ	26
"	Rothii Grunow D.40-175µ	27
"	stellaris Roper D.60-175µ	28
"	subtilis=fasciculata Ehr. D.48-90µ	29
Cyclotella	striata (Kutz.) Grunow D.10-50µ..	30

Cyclotella striata var. ambigua Grunow
D.20-30μ 31
Ethmodiscus Gazellae Janisch D.2000μ
H.3000μ 32
Gossleriella tropica Schutt D.120-250μ 33
Hemidiscus cuneiformis Wallich D.40-110μ ... 34
Planktoniella sol Schutt D.10-60μ 35

Family CORETHRONACEAE
Corethron hystrix=(*criophilum*) *Castracane*
D.20-33μ L.30-50μ 36
" pelagicum Brun D.90-150μ L.100μ . 37

Family LEPTOCYLINDRACEAE
Dactyliosolen antarcticus Castracane D.15-75μ.. 38
" mediterraneus Peragallo D.10-35μ.. 39
Leptocylindrus danicus Cleve D.6-12μ
L.80-130μ...... 40
Guinardia Blavyana Peragallo D.40680 41
" flaccida (Castr.) Perag.
D.25-90μ L.80-150μ42

Family SKELETONEMACEAE
Skeletonema costatum (Grev.) D.18-35μ
L.-10000μ 43
Stephanopyxis nipponica Gran & Yendo D.27-40μ.. 44
" palmeriana (Gran) Grunow
D.35-150μ 45
" turris (Greville) D.10-75μ....... 46

Family THALASSIOSIRACEAE
Coscinosira Oestrupi Ostenfeld D.10-20μ 47
Lauderia borealis Gran D.30-50μ 48
Schrodella delicatula Peragallo D.18-30μ ... 49
" schroderi (Bergon) D.13-40μ 50
Thalassiosira condensata Cleve *D.17-30μ* 51
" rotula Meunier 52

Suborder SOLENIINEAE
Family RHIZOSOLENIACEAE
Rhizosolenia acuminata Gran. D,35-225μ
L.1000μ ,...... 53
" alata Brightwell D.7-15μ L.700μ . 54
" " fo. curvirostris Gran 55
" " " gracillima Grunow D.5-7μ
L.700μ 56
" " " indica Ostenfeld D.20-50μ 57
" " " inermis (Castr.) 58

Cerataulina compacta Ostenfeld 126
Dithylium Brightwellii Grunow D.25-100µ
L.80µ 127
" sol Grunow D.40-225µ .,............. 128
Hemiaulus Hauckii Grunow L.8-75µ 129
" indicus Karsten 130
" membranacus Cleve W.67-97µ 131
" sinensis Greville L.12-90µ 132
Isthmia nervosa Kutz. L.170-240µ W.240µ... 133
Lithodesmium undulatum Ehr. L.40-90µ 134
Triceratium arcticum var. D.80-150µ 135
" favus Ehr. L.40-350µ 136
" alternaus Van Heurck L.27-34µ
W.32-39µ 137
" reticulum Ehr. L.25-80µ 138
" revale A.Schmidt L.140-180µ 139

Family EUCAMPIACEAE
Climacodium biconcavum Cleve L.60µ
W.35-65µ 140
" Frauenfeldianum Grunow
L.10-30µ W.75-225µ 141
Eucampia cornuta Grunow L.100-160µ
W.30-40µ 142
" zoodiacus Ehr. L.10-60µ 143
Streptotheca indica Karsten W.200µ 144
" thamesis Shrubsole L.60-120µ 145

Order PENNALES
Suborder ARAPHIDINEAE
Family FRAGILARIACEAE
Asterionella japonica Cleve L.50-100µ 146
" notata Grunow L.50-105µ 147
Fragilaria interrmedia Grunow L.15-60µ
W.2.5-5µ 148
" oceanica fo. typica Cleve
L.8-60µ W.3-8µ 149
Pseudoeunotia doliolus Grun. L.40-60µ
W.6-8µ 150
Synedra fulgens W.Smith L.170-450µ 151
" " var. mediterranea Grun. L.170-
440µ 152
" Gaillonii Ehr. L.110-270µ ...., 153
Thalassionema nitzschioides Gru. L.10-110µ
W.2-3µ 154
Thalassiothrix delicatula Cupp. L.1500-1700µ.. 155
" Frauenfeldii Gru. L.8-200µ
W.2-4µ 156

Thalassiothrix mediterranea var. pacifica
Cupp. L.580-750μ 157

Family TABELLARIACEAE

Climacosphenia moniligera Ehr. L.300-600μ
W.25-35μ............... 158

Grammatophora angulosa Ehr. L.14-35μ 159
" marina Kutzing L.18-100μ
W.8-15μ 160
" serpentina Ehr. L.25-150μ
W.12-18μ 161

Licmophora abbreviata Agardh L.20-110μ
W.4-8μ 162
" flabellata (Garm) Agardh
L.100μ 163

Plagiogramma vanheurckii Grunow L.20-35μ 164

Rhabdonema adriaticum Kutz. L.25-150μ
W.7-10μ 165

Striatella unipunctata Agar. L.35-le
W.8-20μ 166

Suborder MONORAPHIDINEAE

Family ACNANTHACEAE

Achnanthes brevipes Agar. L.50-70μ
W.20-25μ 167
" longipes Agar. L.70-120μ 168

Campyloneis Grevillei Gru. L.44μ W.13μ 169

Cocconeis scutellum Ehr. L.20-60μ
W.12-40μ 170

Suborder BIRAPHIDINEAE

Family NAVICULACEAE

Amphiprora alata Kutz. L.60-160μ
W.30-60μ 171
" gigantea Grun. var. sulcata (OMe) 172

Amphora hyalina Kutz. L.90-130μ
W.25-34μ 173
" lineata Greg. L.57μ W.13μ 174
" lineolata Ehr. L.30-60μ
W.13-28μ 175
" quadrata Breb. var. L.67μ W.42μ.. 176

Diploneis crabro Ehr. L.60-100μ 177

Gyrosigma acuminatum Rabh. L.100-200μ
W.15-20μ 178
" balticum Rabh. L.150μ 179
" spenceri Cleve L.150μ 180
" strigile (W.Smith) L.250-360μ
W.27-35μ 181

Mastogloia *minuta* Grev. L.18-20μ
W.8-10μ 182
Navicula cancellata Donk L.52μ 183
" elegans W.Smith L.60-115μ
W.20-30μ 184
" lyra Ehr. L.60-150μ 185
Pleurosigma affine Grun. L.120-150μ
W.17-33μ 186
" angulatum W.Smith L.150-360μ
W.36-50μ 187
" compactum Grev. L.281μ W.62μ 188
" elongatum W.Smith L.130-380μ
W.20-30μ 189
" fasciola W.Smith L.90-107μ 190
" intermedium W.Smith L.230μ W.12μ. 191
" naviculaceum Breb. L.79μ W.16μ .. 192
" nicobaricum Grun. L.130μ 193
" Normanii Ralfs L.127μ W.24μ 194
" pelagicum Perag. L.194μ W.24μ.... 195
" rectum Donkin L.142μ W.12μ 196
" rigidum var. incurvata Brun.
L.200μ W.30μ 197
" salinarum Grun. L.90-130μ
W.13-17μ 198
Trachyneis aspera (Ehr.) Cleve L.100-200μ .. 199
Tropidoneis lepidoptera Cleve L.65-100μ 200

Family NITZSCHIACEAE
Nitzschia closterium W.Smith L.32-260μ
W.2-6μ 201
" hungarica Grun. L.80-120μ 202
" lanceolata W.Smith L.100-200μ
W.17μ 203
" longissima Grun. L.250-300μ 204
" " var. reversa W.Smith
L.115-220μ 205
" paradoxa Gmelin L.60-150μ
W.4-8μ 206
" pacifica Cupp L.80-140μ 207
" plana W.Smith L.70μ 208
" pungens var. atlantica Cleve
L.137μ 209
" seriata Cleve L.90-100μ W.6μ ... 210
" sigma W.Smith L.50-100μ W.4-15μ. 211
" " var. intercedens Grun. L.300μ. 212
" spectabilis Ralfs L.150-450μ
W.10-15μ 213
" vitrea Norman L.90-120μ 214

Family SURIRELLACEAE

ZOO-PLANKTON

Family CYTTAROCYLIDAE

Cyttarocylis cassis (Heack) L.180-200μ 402
" plagiostoma Dad. L.140μ 403

Family DICTYOCYSTIDAE

Dictyocysta lepida Ehr. L.65-75μ 404
" mulleri Brandt. L.54-62μ 405

Family EPIPLOCYLIDAE

Epiplocylis blanda (Daday) L.120-135μ 406
" undella (Ost. & Sch.) L.110μ 407
" " var. constricta Kofoid & Campbell L.130-150μ 408

Family PETALOTRICHIDAE

Petalotricha ampulla (Fol) L.100μ 409

Family PTYCHOCYLIDAE

Favella adriatrica (Imh.) L.120-145μ 410
" azorica (Cleve) L.90-117μ 411
" campanula (Sch.) Jorg. L.155μ 412
" ehrenbergi (C. & L.) L.300-400μ ... 413
" fistulicauda Jorg. L.155μ 414
" markuzowskii (Dad;) L.250-450μ 415
Poroecus apiculatus (Cleve) L.115μ 416

Family TINTINNIDIDAE

Tintinnidium neapolitanum Dad. L.117μ 417

Family RHABDONELLIDAE

Protorhabdonella simplex (Cleve) L.50-60μ ... 418
Rhadbonella amor (Cleve) L.88-105μ 419
" elegans Jorg. L.110-125μ 420
" spiralis (Fol.) L.270-365μ 421
" striata (Biedermann) Brandt L.200-250μ 422
Rhabdonellopsis apophysata (Cleve) L.300-350μ 423
" minima Kofoid & Campbell L.175-230μ 424

Family TINTINNIDAE

Amphorellopsis tetragona (Jorg.) L.125μ...... 425
Dadayiella ganymedes (Entz SR.) L.85-105μ .. 426
" pachytoecus (Jorg.) L.100-105μ .. 427
Eutintinnus elegans Jorg. L.150-190μ......... 428
" fraknoi Daday L.350-500μ......... 429
" latus Jorg. L.350-400μ........... 430
" lusus-undae Entz Sr. L.210-230μ . 431
" stramentus Kofoid & Campbell L.200-300μ 432

Ormosella trachelium (Jorg.) L.100μ 433
Salpingella attenuata Jorg. L.255-435μ 434
" acuminata Cl. & L. L.200-380μ ... 435
Steenstrupiella steenstrupii (Claparede & Lachmann) L.90-95μ 436
Tintinnus inquilinus Muller L.90-95μ 437
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" acuta Jorg. L.60-70μ 441
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Class TETRAXONIDA
Order ASTROMONAXONELLIDA
Family CLIONADAE
Alectona millari Carter & Topsent 450

Class CALCAREA
Order HOMOCOELA (ASCONOSA)
Family LEUCOSOLENIDAE
Leucosolenia blanca Miklucho Maclay L.150-180μ 451
" complicata (Montagu) L.150-170μ. 452
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Subphylum CONIDARIA
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Order HYDROMEDUSAE
Suborder ANTHOMEDUSAE

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" ramosa (Van Beneden)
H.2.5-4mm 456
Bythotiara murrayi Gunth. H.20mm 457
Cladonema radiatum (Dujardin) H.4mm 458
Corymorpha nutans Sars H.5mm D.3mm 459
Dipurena ophiogaster Haeckel H.5mm
D.4mm 460
Ectopleura dumortieri (Van Beneden)
H.3mm D2.5mm 461
Euphysa aurata Forbes H.6mm D.4.5mm ... 462
Leuckartiara nobilis Hartlaub H.20-27mm 463
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Podocoryne areolata Alder D.2-3.8mm 465
" carnea Sars fo. exigua
Haeckel H.3.5mm 466
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Suborder LEPTOMEDUSAE

Aequorea pensilis (Heackel) D.25mm 470
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Eucheilota cirrata (Haeckel) D.16mm 473
Eutima bitentaculata (Q. & G.) H.8-10mm
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Helgicirra schulzei Hartlaub D.25-30mm 475
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Suborder DISCONECTAE
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" nozakii Kishinouye D.500mm 533
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Order CYDIPPIDEA
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Hormiphora palmata Chun. L.18.5-43mm 540
" plumosa Agassiz H.5-20mm 541
Lampetia pancerina Chun. H.20-50mm 542
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" rhodopis Chun. H.6-7mm 544

Order LOBATEA
Bolinopsis mikado Moser L.25mm 545
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Bolina hydatina Chun. H.25-40mm 547
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Phylum MOLLUSCA
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Subclass PROSOBRANCHIA
Order MESOGASTROPODA
Tribe HETEROPODA
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" gaudichaudi Soul. L.5-10mm 632
" helicinoides 633
" inclinata Soul. 634
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" peroni Lesueur L.10-11mm across .. 636
" Quoyana 637
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Firoloida desmaresti Lesueur 641
Pterotrachea mutica 642

Tribe PTENOGLOSSA
Family JANTHINIDAE

Janthina globosa Swainson H.30mm W.10mm 643
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Tribe NUDIBRANCHIATA
Family AEOLIDIDAE

Glaucus lineatus Reinhaldt L.15-20mm 645

Family PHYLLIRRHOIDAE

Phyllirrhoe bucephalum Per. & Les.
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Subclass OPISTHOBRANCHIA
Order PTEROPODA
Suborder THECOSOMATA
Family LIMACINIDAE

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" globulosa Rang L.7mm 650
" inflexa (Lesueur) L.4.5-5mm 651
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M.1.4-1.5mm 732

Aetideopsis multiserrata (Wolfenden)
F.2.7-2.8mm 733

Chiridiella macrodactyla G.O.Sars F.2.7mm .. 734

Chirundina streetsii Giesb. F.4.1-5.3mm
M.3.8-4.4mm 735

Chiridius gracilis Farran F.2.4-2.8mm ... 736

Euaetideus giesbrecht (Cleve) F.1.5-2.2mm.. 737

Euchirella rostrata (Claus) F.3.0-3.1mm
M.2.5-3.0mm 738

" brevis (- amoena) G.O.Sars
F.3.5-4.0mm 739

" curticauda Giesb. F.3.5-4.4mm
M.4.3mm 740

" maxima Wolfenden F.6.8-7.4mm
M.5.6-7.0mm 741

" messinensis Claus F.4.7-6.2mm
M.4.0-5.5mm 742

" pulchra (Lubbock) F.3.0-4.4mm
M.3.7mm 743

Gaetanus kruppii Giesb. F.3.6-5.7mm
M.3.7-5.6mm 744

" miles Giesb. F.3.5-3.9mm 745

" minor Farran F.1.8-2.4mm 746

" pileatus Farran F.5.6-6.2mm 747

Pseudochirella cryptospina (G.O.Sars)
F.4.7-4.9mm M.5.3mm 748

" notacantha (G.O.Sars)
F.4.7-4.9mm M.5.3mm 749

" obtusa (G.O.Sars) F.5.3-5.8mm
M.4.8mm 750

" pustulifera (G.O.Sars)
F.7.3-7.4mm 751

" scopularis G.O.Sars F.3.0-4.0
mm ... 752

Undeuchaeta major Giesb. F.4.5-5.5mm
M.6.0-6,6mm 753

" plumosa (Lubbock) F.3.0-4.2mm
M.3.2mm 754

Family SPINOCALANIDAE

Monacilla tenera G.O.Sars F.1.8-2.3mm 755

" typica G.O.Sars F.2.0-2.4mm
M.1.6-2.3mm 756

Spinocalanus caudatus G.O.Sars F.1.5mm 757

Labidocera Kroyeri Brady F.2.4-2.5mm
M.2.0mm 827
" pavo Giesbr. F.2.1mm 828
" wollastoni Lubbock F.2.2-2.3mm ... 829
Pontellina plumata (Dana) F.1.7-1.8mm
M.1.5-1.6mm 830
Pontella chiercheae Giesbr. F.3.3mm M.3.0mm 831
" Lo Biancoi Canu. F.4.0-4.2mm
M.3.3-3.8mm 832
Pontellopsis regalis Dana F.4.0-4.4mm
M.3.4-3.5mm 833

Suborder PODOPLEA (CYCLOPOIDA)

Family MORMONILLIDAE
Mormonilla phasma Giesbr. F.1.6-1.7mm 834

Family OITHONIDAE
Oithona nana Giesbr. F.0.5-0.7mm
M.0.5-0.6mm 835
" plumifera Baird F.1.0-1.5mm
M.0.8-1.0mm 836
" robusta Biesbr. F.1.6-1.7mm
M.1.2mm 837
" setigera Dana F.1.2-1.9mm 838

Family ECTINOSOMIDAE
Microsetella norvegica Boeck F.0.4-0.5mm
M.0.3-0.4mm 839
" rosea Dana F.0.6-0.9mm 840

Family MACROSETELLIDAE
Macrosetella gracilis (Dana) F.1.4-1.5mm
M.1.1-1.3mm 841
Miracia efferata Dana F.1.5-2.0mm 842

Family TACHYDIIDAE
Eyterpe acutifrons Dana F.0.5-0.8mm
M.0.5-0.6mm 843

Family CLYTEMNESTRIDAE
Clytemnestra scutellata Dana F.1.0-1.2mm
M.1.0-1.3mm 844
" rostrata Brady F.0.6-1.0mm
M.0.8-0.9mm 845
Laophonte brevirostris Claus F.0.7mm 846

Order DECAPODA

Suborder MACRURA (REPTANTIA)

Lucifer acestra 928
" raynaudii Bate L.7.0-12.0mm 929
" sp. (Zoea larva) 930
" " (Mysis larva) 931
Palinurus's larva (Pyllosoma larva) 932
Shrimps larva (Zoea larva) 933
" " (Mysis larva) 934

Suborder ANOMURA

Paguridea's larva (Glaucothoe larva) 935

Suborder BRACHYURA

Eriphia spinifrons (Zoea larva) 936
Inachus sp. (Zoea larva) 937
Maia sp. (Zoea larva) 938
Macropodia sp. (Zoea larva) 939
Porcellana longicornis (Metazoea larva) 940
Portunus sp. (Zoea larva) 941

Order STOMATOPODA

Squilla's larva L.10.0mm (Alima larva) 942
" " L.9.0-10.0mm (Alima larva).... 943
Stomatopoda's larva (Erichthus larva) 944

Phylum PROCHORDATA

Subphylum UROCHORDA (TUNICATA)

Class APPENDICULARIA (COPELATA)

Family KOWALEVSKIDAE

Kowalevskaia tenuis Fol. Trunk L.0.5-1.0mm.. 945

Family APPENDICULARIDAE

Appendicularia sicula Fol. T.L.0.5mm 946
Fritillaria pellucida Busch. T.L.1.0-2.0mm.. 947
" borealis acuta Lohm. T.L.1.3mm. 948
" " truncata Lohm.
T.L.0.9mm 949
" formica Fol. T.L.1.5mm 950
" fraudax Lohm. 951
" haplostoma Fol. T.L.1.0mm 952
" megachile Fol. T.L.0.9-1.0mm ... 953
" tenella Lohmann T.L.1.2mm 954
" venusta Lohm. T.L.1.1mm 955
Oikopleura albicans Leuck. T.L.5.0mm 956

Oikopleura	cophocerca Gegenbaur T.L.1.4mm	957
"	dioica Fol. T.L.1.3mm	958
"	fusiformis Fol. T.L.1.5mm	959
"	labradoriensis Lohm. T.L.2.4mm	960
"	longicauda Vogt. T.L.1.2mm	961
"	parva Lohmann T.L.0.8mm	962
"	rufescens Fol. T.L. 1.5mm	963
Stegosoma	magnum Lohmann T.L.1.5-3.5mm	964
Ciona	intestinalis (Appendicularia larva)	965

Class THALIACEA

Subclass MYOSOMATA

Order SALPIDA

Family SALPIDAE

Cyclosalpa	affinis Chamisso	966
"	bakeri Ritter L.3.0-5.0	967
"	pinnata Forskal	968
"	virgula Vogt.	969
Iasis	zonaria Pallas Pallas L.3.0-6.0mm.	970
Ihlea	punctata Forskal	971
Pegea	confoederata (Forskal)	972
"	" var. bicaudata Quoy & Gaimard ..	973
Salpa	fusiformis Cuvier L.3.0-6.5mm	974
"	maxima Forskal L.5.0-15.0mm	975
Thalia	democratica (Forskal) L.15-25.0mm..	976
Thetys	vagina (Tilesius) L.19.0	977

Order DOLIOLARIA

Family DOLIOLIDAE

Doliolum	denticulatum Q. & G. L.9.0mm	978
"	*gegenbauri Uljanin L.9.0mm*	979
"	" var. tritonis Herdman L.17.0mm.	980
"	mulleri var. krohni Borgert L.7.0mm	981
"	nationalis Borgert L.3.0mm	982

Subclass PYROSOMATA

Order PYROSOMATIDA

Family PYROSOMATIDAE

Pyrosoma	atlanticum Peron	983

Larva of PROCHORDATA

Balanoglossus	misakiensis (Tornaria larva)....	984

Phyto-Plankton (Marine)

Phylum	Class	Subclass	Order	Suborder	Family	Number of Species
Cyanophyta			Hormogoneae		Oscillatoriaceae	2
Cyanophyta	Bacillariaceae (Diatoms)	Discineae			Melosiraceae	3
					Coscinodiscaceae	30
					Corethronaceae	2
					Leptocylindraceae	5
					Skeletonemaceae	4
					Thalassiosiraceae	6
				Soleniineae	Rhizosoleniaceae	21
				Biddulphiineae	Bacteriastraceae	8
					Chaetoceraceae	33
					Biddulphiaceae	25
					Eucampiaceae	6
			Pennales	Araphidineae	Fragilariaceae	12
					Tabellariaceae	9
				Monoraphidineae	Acnanthaceae	4
				Biraphidineae	Naviculaceae	30
					Nitzschiaceae	14
					Surirellaceae	8

Total species of the marine phyto-plankton 222

Zoo-Plankton (Marine)

Phylum	Class	Subclass	Order	Suborder	Family	Number of Species
Protozoa	Mastigophora		Chrysomonadina		Dictyochaceae	4
			Dinoflagellata		Phytodiniidae	4
					Prorocentridae	1
					Peridiniidae	97
	Sarcodina		Foraminifera		Globigerinidae	5
					Cymbaloporidae	1
			Radiolaria		Acanthochiasmidae	1
					Acanthoplegmidae	3
					Acanthometridae	5
					Amphilithidae	2
					Aulacanthidae	1
					Aulosphaeridae	1
					Cyrtoidae	6
					Coelodendridae	1
					Discoidae	1
					Dorataspidae	2
					Astrolithidae	1
					Gigartaconidae	2
					Medusettidae	2
					Phyllostauridae	2
					Plectoidae	1
					Sagosphaeridae	1
					Sphaeroidae	6
					Spyroidae	1
					Sphaerozoidae	2
					Stauraconidae	1
	Ciliophora	Ciliata	Peritrichea		Vorticellidae	2
			Holotricha	Tintinnoinea	Codonellidae	13
					Codonellopsidae	7
					Coxliellidae	3
					Cyttarocylidae	2
					Dictyocystidae	2
					Epiplocylidae	3
					Petalotrichidae	1
					Ptychocylidae	7
					Tintinnididae	1
					Tintinnidae	15
					Rhabdonellidae	7
					Undellidae	5
					Xystonellidae	5
Porifera	Tetraxonida		Astromonaxonellida		Clionadae	1
	Calcarea		Homocoela		Leucosolenidae	4
Coelenterata	Hydrozoa		Hydromedusae	Anthomedusae		15
(Subphylum) Conidaria				Leptomedusae		12
			Trachylina	Trachomedusae		11
				Limnomedusae		3
			Siphonophora	Calycophorae		25
				Physophorae		5
				Cystonectae		3
				Disconectae		3
	Scyphomedusae		Cubomedusae			1
			Semaeostomae			7
			Rhizostomae			2
(Subphylum) Ctenophora			Cydippidea			6
			Cestidea			2
			Beroidea			3
			Lobatea			2
Plathelminthes	Turbellaria		Polyclada			1
Nemertini						1
Trochelminthes	Rotifera		Monogononta	Ploima	Synchaetidae	4
					Dicranophoridae	1
			Flosculariaceae		Sinantherinidae	1
Annelida	Polychaeta			Nereidiformiae	Phyllodocidae	6
					Alciopidae	7
					Tomopteridae	7
					Typhloscolecidae	2
				(Larval stage of POLYCHAETA)		
Chaetognatha	Sagitoidea				Sagittidae	31
Mollusca	Gastropoda	Prosobranchia	Mesogastropoda		Atlantidae	8
				(Tribe) Heteropoda	Carinaria	2
					Pterotracheidae	2
				(Tribe) Ptenoglossa	Janthinidae	2
				(Tribe) Nudibranchiata	Aeolididae	1
					Phyllirrhoidae	1
		Opisthobranchia	Pteropoda	Thecosomata	Limacinidae	2
					Cavolinidae	18
					Peraclidae	3
					Cymbuliidae	2
				Gymnosomata	Pneumodermatidae	1
					Thliptodontidae	1
				(Larval stage of Mollusca)		
Molluscoidea						3
Echinodermata						14
Arthropoda	Crustacea		Phyllopoda	Cladocera	Polyphemidae	6
			Ostracoda		Halocypridae	7
			Copepoda	Calanoida	Eucalanidae	6
					Calanidae	8
					Paracalanidae	7
					Pseudocalanidae	4
					Aetideidae	23
					Spinocalanidae	4
					Megacalanidae	3
					Heterorhabdidae	3
					Acartiidae	5
					Metridiidae	4
					Euchaetidae	3
					Phaennidae	2
					Scolecithricidae	2
					Centropagidae	4
					Temoridae	4
					Candaciidae	8
					Lucicutiidae	5
					Augaptilidae	19
					Pontellidae	11
				Podoplea	Mormonillidae	1
					Oithonidae	4
					Ectinosomidae	2
					Macrosetellidae	2
					Tachidiidae	1
					Clytemnestridae	3
					Oncaeidae	6
					Corycaeidae	11
					Sapphirinidae	18
				(Parasitic COPEPODA)		1
		Malacostraca	Cirripedia			8
			Amphipoda		Anchylomeridae	3
					Hyperiidae	8
					Lycaeidae	3
					Oxycephalidae	6
					Phronimidae	3
					Platyscelidae	3
					Scelidae	1
					Vibiliidae	1
					Euphausidae	6
			Euphausiacea			4
			Mysidacea			7
			Decapoda	Macrura		1
				Anomura		6
				Brachyura		3
			Stomatopoda			
Prochordata	Appendicularia				Kowalevskidae	1
					Appendiculariidae	20
	Thaliacea	Myosomata	Salpida		Salpidae	12
			Doliolaria		Doliolidae	5
		Pyrosomata	Pyrosomatida		Pyrosomatidae	1
				(Larval stage of PROCHORDATA)		1

Total species of the marine zoo-plankton 763

CHAPTER IV. DISTRIBUTION OF PLANKTON IN SOUTH VIET-NAM

A. FRESH WATER PLANKTON

The fresh water plankton in Viet-Nam can be divided into the following four kinds according to the places they live in.

1. Eulimno-plankton .... this kind lives in the lakes, which is also used for the fresh water fish culture, at Da-Lat, Rach-Gia, and Ca-Mau.

2. Potamo-plankton .... this lives in such large rivers as the Saigon and the Mekong, and be used for fish and fishery indirectly.

3. Helo-plankton .... this lives in small ponds and pools.

4. The plankton which grows in a cultivating farm artificially controlled at Thu-Duc, Da-Lat, Cholon, and Hue.

Even when the same kind of plankton lives in several places, its use differs according to the place where it lives. Except the kind of 3. these plankton have the value as plankton.

Fresh water plankton differs from marine plankton. In the case of fresh water plankton, quite different types of plankton are sometimes found even in places which are very near to each other. This is apparent from the distribution of plankton in each lake at Da-Lat. This is characteristic of fresh water plankton, which are largely influenced by the circumstances of the place they live in, especially by the quality of the water.

Here are some important fresh water plankton from the ones we have recognized in South Viet-Nam.

1. PHYTO-PLANKTON

The important types which are found in South Viet-Nam are the following three phylums: (1) Chrysophyta (2) Chlorophyta (3) Cyanophyta.

(1) Chrysophyta

The diatoms such as Fragilariaceae, Coscinodiascaceae, Melosiraceae, Rhizosoleniaceae, Tabelariaceae, Achnanthaceae, Surirellaceae, Naviculaceae, and Nitzschiaceae are found quite commonly in all areas. Among them, Fragilaria, Melosira glanulata, Navicula lanceolata, Nitzshia paradoxa (Bacillaria paradoxa), N.nyassensis were sometimes found in great quantity.

(2) Chlorophyta

Selenastrum gracile, S.Bibraianum, Staurastrum tohopekaligense, S.wolterechii, Crucigenia fenestrata, Franceia tuberculata, Arthrodesmus apiculatus, A.cuvatus are the sorts which are commonly found.

Ankistrodesmus falcatus, Staurastrum smithii, Spirogyra prolifica, Pandorina minodi, Mougestia, Dictosphaerium pulchellum, Scenedesmus armatus, and S.dimorphus, S.Bijiga, are found in great quantity at certain places in a certain season.

(3) Cyanophyta

Spirulina princeps is found everywhere, and Anabaena circinalis, Anabaenopsis Elenkinii and Oscillatoria limosa are the kinds which are found so abundantly at every fish farm as to make the water look dark green.

2. ZOO-PLANKTON

Among the zoo-plankton which are important are (1) Protozoa, especially Euglenoidea, Dinoflagellata (2) Rotifera (3) Crustacea etc.

(1) Protozoa

Protozoa as fresh water plankton is not so abundant, but some kinds, such as Euglenoidea, Dinoflagellata, Infusoria etc. are important from the quantitative point of view.

Euglena deses, Cryptoglena pigra, Peridinium striolatum etc. which belong to Phyto-mastigophora are found in huge quantity at places. Besides, of the 161 kinds which were found in Viet-Nam, at least one kind is always to be found. Dinobryon, Glenodinium, Chlamydomonas, Peridinium, Euglena, Phacus etc. are scarce in quantity but rich in variety.

Trichodina pediculus, Holophrya simplex, Spasmostoma viride, Pleuronema coronatum etc. which belong to Zoo-mastigophora are sometimes found in large quantity.

(2) Rotifera

Rotifera (Rotatoria) is widely distributed everywhere in

Viet-Nam, and is important as natural living food for small fresh water fish. Rotifera usually grows in small ponds and is sometimes found growing in large mass. For instance, Brachionus bakeri and B.urceolaris were discovered in the pond in the Airport of Can-Tho, and they proved to be excellent.

Rotifera multiplies rapidly in its season. It appears in abundance at a time, and vanishes suddenly. It changes its form according to the environments. Brachionus urceolaris (Can-Tho), Keratella aculeata (Ca-Mau) etc. are found in large quantity. Keratella valga, Filinia longiseta, Monostyla quadridentata, Lepadella patella etc. are also found very commonly.

(3) Crustacea

Most of the fresh water crustacea is Phyllopoda, especially Cladocera. Copepoda is comparatively scarce. This is quite the opposite to the case of marine crustacea, where Copepoda is by far the greater in quantity.

(a) Copepoda

In Viet-Nam, Cyclopidae and Diaptomidae make the most part of Copepoda, and are found commonly everywhere.

Cyclops strenuus, C.bicolor, Pseudodiaptomus marinus etc. are widely distributed. Cyclops vicinus (Da-Nhim), C.vernalis (Da-Nhim), Mesocyclops lenkarti (Xuan-Huong lake, Dalat), Diaptomus reighardi (Da-Nhim), Eodiaptomus japonicus (Da-Nhim), Sinodiaptomus Sarsi (Xuan-Huong lake, Da-Lat) etc. are the sorts which are found abundantly. Osphranticum labronectum, Diaptomus kenai are found in various places, though not in large quantity.

The identification of Copepoda is determined by the forms of the first antenna and the fifth legs, but even within the same kind some differences are seen in its forms according to the environments.

(b) Cladocera

The importance of Cladocera in fresh water is greater than that of Copepoda. In ordinary circumstances, most of its kinds increase by parthenogenesis among females. Because of its ovoviviparity it multiplies rapidly, which makes it important in point of productivity. What is more, its ability to swim is inferior to that of Copepoda, which makes it easier for Pisces at level stage to feed on it.

In South Viet-Nam also, as many as 50 kinds were found of Cladocera, while of Copepoda only 30 were recognized. It is found in large quantity in such alpine lakes as those at Dalat (1300 m above sea level), but more varieties and larger quantity of it can be found in lakes and ponds on lowlands.

Also commonly found are: Daphnia rosea, Moina macrocopa, Pseudosida bidentata, Oxyurella longicauda, Alona, Bosmina etc. Chydorus sphaericus, Moina brachiata, M.macrocopa, Sida crystallina etc. are sometimes found in great mass.

The classification of Cladocera is difficult like that of Copepoda and as even the same kind differs in its form according to the living environments, much care must be taken not to make mistakes (which is especially conspicuous with Daphnia and Bosmina)

B. MARINE PLANKTON

The marine plankton is more complicated than the fresh water plankton from the taxonomical and morphological points of view. For in the sea, there are numerous kinds of creatures, which are not to be found in fresh water, at their different stages: larval stage, metamorphosical stage, heterogenesical stage. These live in the sea in large quantity together with their adults.

Of the marine plankton, 1. Diatoms and 2. Copepoda are the important kinds and are found in plenty. Along the coasts of Viet-Nam, the following kinds are also easily found and are considered valuable as food for pisces and crustaceans:

3. Dinoflagellata	4. Chaetognatha	5. Appendicularidae
6. Siphonophora	7. Radiolaria	8. Cilliophora

These will be explained in the following.

1. PHYTO-PLANKTON

(1) Cyanophyta

Of this type, Trichodesmium Thiebautie and T.erytheraeum are found in abundance along the coasts of Central Viet-Nam, including Nhatrang, regardless of the seasons. In Nhatrang there are times when these two kinds alone amount to as much as 0.5 g/m^3 to 0.7 g/m^3.

(2) Diatoms

This is considered to be the most important of the whole marine phytoplankton. About 200 kinds of this were discovered along the coasts of Viet-Nam.

Chaetoceraceae and Bacteriastraceae are the most usual kinds. The following are found quite commonly at any time along all the coasts of Viet-Nam:

Rhizosoleniaceae, Coscinodiscaceae, Thalassiothrix, Thalassionema, Eucampia, Asterionella, Nitzshiaceae, Biddulphiaceae.

2. ZOO-PLANKTON

(1) Dinoflagellata

This includes the most important kinds of Protozoa. Especially Ceratium can be seen most plentifully along the area from Phan-Thiet to Nhatrang. 41 kinds of it was found in the whole area. Also to be found all over the area are: Peridinium, Gymnodinium, Glenodinium, Gonyaulax, Dinophysis (abundant in Nhatrang and Cam-Ranh), and Ornithocercus.

(2) Radiolaria

Though not abundant, this plankton has a large variety. 41 species of it have already been discovered, and its distribution covers the whole area. Of these species the most commonly found are: Amphibelone hydrotomica, Acanthocolla cruciata, Amphiacon denticulatus, Amphilonche elongata and Cyrtoidae (Theoconus zancleus, Dictyophimus tripus, Acanthocorys umbellifera).

(3) Ciliophora

Of this class, too, numerous species (72) have been found. Its distribution covers the whole area, but its quantity is small. The most commonly seen are: Tintinnopsis butschlii, Codonellopsis morchella, C.mortensenii, C.ostenfeldi, Stenosemella nivalis, Favella markuzowskii, Epiplocylis blanda, Xystonellidae, Eutintinnus fraknoi, E.latus, E.lusus-undae, E.elegans etc.

(4) Coelenterata

Among the already discovered species, Hydromedusae, Trachylina, Siphonophora, Scyphomedusae etc. are the important ones. Of these, Siphonophora is most abundantly found, and is distributed almost all over the area. Leptomedusae (Octorchis gegenbauri, Eirene viridula etc.) and Liriope tetraphylla etc. sometimes choke the cock of a plankton-net.

(5) Chaetognatha

This phylum is the largest of net-plankton that can be seen with naked eyes, sometimes reaching 50 mm. It is found over the whole area, though its quantity is more or less different at each place. The greater part of it is Sagitta, and 31 species of it have been identified along the coasts of Viet-Nam.

Chaetognatha is valuable not only as the food for fish, but also as an index to the study of the sea currents, being related to the sea temperature and the salt.

(6) Prochordata

This phylum is also distributed all over Viet-Nam and is especially abundant in the middle and the south of South Viet-Nam. It includes Oikopleura, Fritillaria, Doliolidae, Salpidae, and is important as the food for fish.

(7) Copepoda

This is the most important animal plankton of all the marine plankton. 176 species of this have been found along the coasts of Viet-Nam.

(a) Calanidae

This includ s 9 species, among which are Calanus, Canthocalanus, Neocalanus etc. All of these are commonly to be found.

(b) Eucalanidae

This is a somewhat large kind. It includes Rhincalanus and Eucalanus, and can be seen very commonly everywhere.

(c) Paracalanidae

This includes Calocalanus and Paracalanus. It is small and can be found in all areas, though not in large quantity.

(d) Pseudocalanidae

This has a characteristic that its female lacks the fifth legs, which makes it easy to distinguish it from another family by looking at its side. It is found throughout the country not in large quantity.

(e) Aetideidae

This is rather a large species. Though small in quantity, it is rich in kinds, and commonly to be seen.

(f) Acartiidae

A small coastal zoo-plankton to be found quite commonly.

(g) Metridae

Though originally a deep-sea plankton, this is commonly found along the coastal areas as well.

(h) Euchaetidae

Large size and a pointed head are the characteristics of this kind. Rarely to be found.

(i) Phaemnidae

Of its species, Cornucalanus is commonly found.

(j) Centropagidae

Though not found in large quantity this can be commonly found throughout the country.

(k) Temoridae

Also commonly seen throughout the country.

(l) Candaciidae

The characteristic of this is that the front part of its head is more of less square-shaped. To be found very commonly along the coasts.

(m) Lucicutiidae

Of this family, Lucicutia longiserrata, L.lucida, L.atlantica are commonly found.

(n) Augaptilidae

19 species of this have been discovered. They can commonly be seen along the coastal areas.

(o) Pontellidae

11 species of this have been discovered so far, among which is Pontella Lo Biancoi, a beautiful, blue-colored one. They are commonly found along the coasts of Viet-Nam, though not in quantities.

(p) Oithonidae

An important species of a small size commonly found in the coastal areas and in the open sea.

(q) Ectinosomidae

A species of a small size, of which Microsetella norvegica and M.rosea can be most commonly found, sometimes in quantities, along the coasts of Viet-Nam.

(r) Macrosetellidae

Like Ectinosomidae this can be found very commonly, though not in abundance.

(s) Oncaeidae

Oncaea and Lubbockia of this family are commonly found in the open sea and along the coasts as well.

(t) Corycaeidae

This can be seen most commonly along all the coasts of Viet-Nam. 11 species have been found so far.

(u) Sapphirinidae

The body of this plankton is flat. With the male it is flat and in the shape of a leaf, and it emits fluorescence. It is quite common along the coasts of South Viet-Nam. 18 species including Sapphirina and Copilia have already been discovered.

(8) Decapoda

Lucifer raynaudii and L.acestra of this group can be always found in abundance, especially in Nhatrang and in the Central Viet-Nam.

(9) Mollusca

Of this phylum, the most often found are those which belong to Cavolinidae, such as Creseis aciculata, C.virgula conica, C.virgula virgula, Styliola subula, Euclis etc. Atlantidae and Limacinidae are also found throughout the whole area.

Table 2

Distribution of Fresh Water Plankton
in South Viet-Nam

Note: (Regions)	(Researching Places)
A region	Rach-Gia, Phu-Quoc, Ca-Mau, Can-Tho.
B region	Cholon, Saigon, Thu-Duc, Bien-Hoa, Phan-Thiet.
C region	Da-Lat, Da-Nhim (Song-Pha).
D region	Nha-Trang, Phu-Huu.
E region	Hue, Da-Nang, Quang-Ngai.

CCC	Abundant	(45%)
CC	Frequent	(30%)
C	Common	(15%)
R	Rare	(8%)
RR	Very rare	(2%)

Family or Genus	A	B	C	D	E
CYANOPHYTA					
Chroococcaceae	C	C	C	C	
Oscillatoriaceae	C C C	C C C	C	C	C
Nostocaceae	C C C	C C C	C C	C	C
Plectonema	C	C C	R	C C	
CHRYSOPHYTA					
Melosiraceae	R	R	C C	C C	C C
Coscinodiscaceae	C	R	R		
Rhizosoleniaceae		R R			
Chaetoceros		R R	R R		
Attheya	R R		R R		R
Fragilariaceae	C	R	C	R	R
Tabellariaceae	C	C	C	C	R
Achnanthaceae		R	C	C C C	R
Naviculaceae	C	C	C	C	C
Epithemiaceae				R R	
Nitzschiaceae	C	C	C	C	C
Surirellaceae	R	R	R	R	C
Pleurochloridaceae			R	R	
Tribonemataceae					
CHLOROPHYTA					
Palmellaceae	C	C	R	C	C
Chlorococcaceae		C	R	R	
Micractiniaceae	C	C	C	C	C
Schroederia			C		
Coelastrum			R		
Dictyosphaerium	R	R	R		
Hydrodictyaceae	C	C	C	C	C
Oocystaceae			C C	R	
Scenedesmaceae	C	C	C	R	R
Zygnemataceae	C	R	C C	C	C
Gonatozygon	C				
Desmidiaceae	C C	C	C C C	C	C
Microspora			R		
Protococcus		C	C	C	
Trentepohlia			R		
Ulothrix		R R			
Sphaeroplea			R R		
Schizomeris		R			
Cladophoraceae		C	C	C	
Oedogoniaceae	C	R	R R		
Schizogonium	C	C	C	R	

Family or Genus	A	B	C	D	E
PROTOZOA					
(Phyto-Mastigophora)					
Mallomonadaceae		C	R		
Ochromonadaceae			C C		C
Chrysocapsa		R	R R	R R	
Chrysamoeba		C	R	C	
Stipitococcus		C	C		
Polyblepharidaceae	C	C	C	C	
Chlamydomonadaceae	C	C C	C C	C	C
Haematococcus			R		
Pedinopera		C			
Pascheriella	C	C	C	C	C
Volvocaceae	C	C	C	C	C
.Gymnodiniaceae			C		
Hypnodinium		C	R	R	
Ceratium			R R		
Prorocentraceae	C	C	C	C	C
Gonyaulacaceae			C	C	
Peridiniaceae		C	C	C	
Monomastix	C	C		C	
Cryptochrysis		C			
Cryptomonadaceae		C		C	
Astasia	C	C	C	C	
Euglenaceae	C C	C	C C	C	C C
Peranemaceae	R				
(Zoo-Mastigophora)					
Zooflagellata	C	C	C	C	C
Rhizopoda	C	C C	R	C	C
Actinopoda	C	C	C	C	C
Ciliophora	C C	C C	C	C	C
TROCHELMINTHES					
Rotifera	C C C	C C	C	C	C
ARTHROPODA					
Cyclopidae	C	C	C	C	C
Calanoida	C	C	C C	C	R
Diaptomidae	C	C	C	R	R
Daphnidae	C	C	C C	C	C
Sididae	C	C	C	C	C
Bosminidae	C	C	C	C	C
Chydoridae	C C	C	C C	C	
Macrothricidae	C	C	C	C	C

Table 3

Distribution of Marine Plankton
in South Viet-Nam

Note: (Regions)

A region ...... Rach-Gia, Phu-Quoc, Westcoast of Ca-Mau

B region ...... East coast of Ca-Mau, Vung-Tau, Phan-Thiet.

C region ...... Cam-Ranh, Nha-Trang, Phu-Huu, Tuy-Hoa, Qui-Nhon.

D region ...... Thuan-An (Hue), Da-Nang, Quang-Ngai.

CCC	Abundant	(45%)
CC	Frequent	(30%)
C	Common	(15%)
R	Rare	(8%)
RR	Very rare	(2%)

Family	A	B	C	D
CYANOPHYTA				
Oscillatoriaceae	R	C C	C C C	C
CHRYSOPHYTA				
Melosiraceae	C	R	R	R
Coscinodiscaceae	C	C	C	C
Corethronaceae	R	R	R	R
Leptocylindraceae	R	R	C	R
Skeletonemaceae	C	C	C	C
Thalassiosiraceae	C	C	C	C
Rhizosoleniaceae	C	C	C C	C
Bacteriastraceae	C	C C	C C	C
Chaetoceraceae	C	C	C C	C
Biddulphiaceae	C	C C	C C	C
Eucampiaceae	C C	C	C C	C
Fragilariaceae	C C	C	C C	C
Tabellariaceae	C	C	C	C
Acnanthaceae	R	C	C	
Naviculaceae	C	C	C	C
Nitzschiaceae	C	C	C	C
Surirellaceae	C	C	C	C
PROTOZOA				
Dictyochaceae	R R	R R	R	R R
Peridiniidae	C C	C	C C	C
Globigerinidae	C	C	C C	C
Cymbaloporidae			R	
Acanthochiasmidae	C	C	C	C
Acanthoplegmidae	R	R	R	R
Acanthometridae	R	C	C	R
Amphilithidae	R R	R R	C	R R
Aulacanthidae			R R	
Aulosphaeridae	R R		R R	
Cyrtoidae	C	C	C	C
Coelodendridae	R R		R R	
Discoidae		R R	R R	
Gigartaconidae	R	R	C	R
Medusettidae	R R	R R	R R	R R
Phyllostauridae			R	
Plectoidae			R R	
Spyroidae	R	R R	R	
Sphaeroidae			R R	
Sphaerozoidae		R R	R R	
Stauraconidae	R	R R	R	R

Family	A	B	C	D
Astrolithidae	R R	R R	R R	
Vorticellidae	C	C	C	C
Codonellidae	C	C	C	C
Codonelliopsidae	C	C	C	C
Coxliellidae	R	R	R	R
Cyttarocylidae	R	R	C	
Dictyocystidae		R	R	
Epiplocylidae	C	C	C	C
Petalotrichidae	R	R	R	R
Ptychocylidae	C	C	C	C
Tintinnididae	R	C	R	R
Rhabdonellidae	R	R	C	R
Tintinnidae	C	C	C	C
Undellidae	R		R	
xystonellidae	C	C	C	C
PORIFERA				
Clionadae			R R	
Leucosolenidae	R	R	C	R
COELENTERATA				
Hydromedusae	C	C	C	C
Trachylina	C	C	C	C
Siphonophora	C C	C C	C C	C
Scyphomedusae	C	R	C	R
Ctenophora	C	C	C	C
PLATHEIMINTHES				
Planocera (Larvae)		R	R	
NEMERTINI				
Cerebratulus (Larvae)			R R	
TROCHELMINTHES				
Synchaetidae	R R	R R	R R	R R
Dicranophoridae	R	C	C	
Sinantherinidae	R R		R R	
ANNELIDA				
Phyllodocidae			R R	
Typhloscolecidae		R R	R R	
Alciopidae	R R		R R	
Tomopteridae	R	R	R	R

Family	A	B	C	D
Polychaeta Larvae	C	C	C	C
CHAETOGNATHA				
Sagittidae	C	C	C	C
MOLLUSCA				
Heteropoda	C	C	C	C
Ptenoglossa	R R	R R	R R	R R
Nudibranchiata	R R	R R	R R	R R
Limacinidae	C	C	C	C
Cavolinidae	C	C	C	C
Peraclidae	R	R	R	R
Cymbuliidae	R	R	R	R
Pneumodermatidae			R R	
Thliptodontidae			R R	
Mollusca Larvae	R	R R	R R	R
MOLLUSCOIDEA				
Larvae	R R	R R	R R	R R
ECHINODERMATA				
Bipinnaria Larvae	R	R	R	R
Ophiopluteus Larvae	R	C	C	R R
Auricularia Larvae	R R	R R	R R	R R
Echinopluteus Larvae	R	C	C	R
ARTHROPODA				
Polyhemidae	C	C	C	C
Halocypridae	R	R	R	R
Eucalanidae	C	C	C	C
Calanidae	C	C	C	C
Paracalanidae	C	C	C	C
Pseudocalanidae	C	C	C	C
Aetideidae	C	C	C	C
Spinocalanidae	C	C	C	C
Megacalanidae	R	R	R	R
Heterorhabdidae	R R	R R	R	R
Acartiidae	C	C	C	C
Metridiidae		R R	R R	
Euchaetidae	C	C	C	R
Phaemnidae	C	C	C	C
Scolecithriciidae	C C	C	C C	C
Centropagidae	R	R	R	R

Family	A	B	C	D
Temoridae	R	R	R	R
Candaciidae	R	R	R	R
Lucicutiidae	C	C	C	C
Augaptilidae	C	C	C	C
Pontellidae	R	R	C	R
Mormonillidae	C	R	C	C
Oithonidae	C	C	C	C
Ectinosomidae	C	C	C	C
Macrosetellidae	R	R	C	R
Tachydiidae	R R		R R	
Clytemnestridae			R R	
Oncaeidae	C	R	C	R
Corycaeidae	C	C	C	C
Sapphirinidae	C	C	C	C
Cirripedia (Larvae)	R R	R R	R R	
Amphipoda	R	R	R	R
Euphausiacea	R	R R	R R	R
Mysidacea	C	R	R	R
Decapoda (Larvae)	C	C	C	C
Stomatopoda (Larvae)			R R	
PROCHORDATA				
Kowalevskidae	R	R	R	R
Appendicularidae	C	C	C	C
Salpidae	C	C	C	C
Doliolidae	C	C	C	R
Pyrosomatidae	R	R	R	R
Prochordata Larvae			R R	

	CAN-LY	Pond of PRENN	THAN-THO Lake	ME-LINH Lake	VAN-KIEP Lake	XUAN-HUONG Lake	DA-NHIM Dam
CYANOPHYTA							
Oscillatoria princeps	205						
Spirulina princeps					50		
CHRYSOPHYTA (Diatoms)							
Achnanthes coarctata		548					
Amphora ovalis		167		184			
Bacillaria paradoxa		4759					
var. tumidula		63					
Cymbella naviculiformis			528				
parva			1536				
Diatoma vulgare		204					
Fragilaria capucina			741	25			
construens		83					
pinnata		33		11			
subsalina			468		73		
utermohli		1000					
virescens		177					
sp.			271				
Melosira Agussizii	75						
glanulata				109			
Navicula placentula			334				
var. lanceolata			72				
radiosa		432	207				
rhynchocephala		334					
rostrata			718				
Nitzschia fonticola			346				
nyassensis		67	1082				
seriata			540				
Rhizosolenia longiseta			65				
Rhopalodia gibba		84					
Surirella splendida		84					
Synedra fasciculata			50				
Utermohli			48				
Tribonema angustissimum				9			
CHLOROPHYTA							
Acanthosphaera Zachariasi					35		
Ankistrodesmus falcatus			486				
Chodatella subsalsa				8			
Cosmarium indentatum			33				
nymannianum			73				
phaseolus			122				
Echinosphaerella limnetica			16				
Mougeotia viridis				28	177		
Mougeotiopsis calospora	474		1102				
Oedogonium crispum			5				
Pachycladon umbrinus			1394				
Pandorina minodi							26887
Pediastrum biradiatum				13			
Pleurodiscus purpureus	327						
Rhizoclonium hieroglyphium				103			
Schizogonium murale			802				
Sphaerocystis schroeteri					317		
Sphaeroplea annulina							272
Spirogyra azygospora	613						
ionia		4215					
prolifica			7515		115		
pseudocylindrica		1358					
Staurastrum indentatum			2680				
smithii			9352				
Treubaria crassispina					13		
Zygnema insigne					307		
PROTOZOA (Phyto-Mastigophora)							
Chlamydomonas chrysomonadis			802				
completa			534				
Dinobryon divergens							324
Euglena acus				17			
Hemidinium nasutum					154		
Peridinium striolatum					192		
(Zoo-Mastigophora)							
Bryometopus sphagni			130				
Physomonas vestita			47				
Vorticella campanula				4	7		
TROCHELMINTHES							
Filinia longiseta				12			
Notholca acuminata				8			
Platyia quadricornis							1418
Polyarthra vulgaris				10			
ARTHROPODA (Copepoda)							
Cyclops strenuus	33						
vernalis							12308
vicinus							9369
Diaptomus kenai			2512				
reighardi	17						45558
Eodiaptomus japonicus							26687
Megacalanus princeps					13		
Mesocyclops Leuckarti					5	3206	
Sinodiaptomus Sarsi				1015	8	4168	
(Cladocera)							
Alona monocantha	885						
Ceriodaphnia megops							1470
rigaudi	15						
Chydorus sphaericus							3858
Daphnia rosea						1122	
Moina brachiata						7485	
macrocopa				20		8608	
Oxyurella longicaudis						60	
Sida crystallina			312				29392
Simocephalus vetulus	18						

Table 4 The plankton in each lake of Dalat

(C) THE PLANKTON OF FISH CULTURE STATIONS

The Table 6 shows the result of my survey of the plankton in several fish culture stations in Viet-Nam. This is a mere survey of plankton and does not deal with its relationship with the productivity of fish, but in comparison with the ponds and lakes in general in Viet-Nam may at least be ablo to draw from this the following conclusions.

1. The rate of production of plankton (numbers/m^3) is 5 to 15 times higher than that of the lakes and ponds in general. The author thinks this is because of the fact that the remnants of the food for fish (rice or rice bran) and the excrements of fish are decomposed into such catabolic matters as ammonia and nitrate, which in turn are fed by the plankton.

2. The PH is as low as 5.5 except at Cholon (PH 7.6) and Nhatrang (Brackish). This is the average PH of the lakes and ponds in general.

3. The following table (Table 5) shows the representative plankton groups developing in each of the fish culture stations.

Fish Culture Stations	Cyanophyta	Chrysophyta	Chlorophyta	Protozoa (phyto-mastigophora)	Copepoda	Notes		
						Culture fish	PH	W.T.(^{o}C)
Cholon (Kieu Cong Muoi)				○		Canbogian Carp.	7.6	31.0
Thu-Duc	○					Carp. Tilapia	5.0	28.0
Dalat (larval stage)			○		○	Carp.	6.0	26.0
Dalat (younger stage)			○	○		Carp.	5.5	25.8
Hue		○				Carp.	-	-
Nhatrang (Brackish)		○				Tilapia Chanos chams	8.0	28.0

Table 5. The representative plankton groups which have developed in ponds of each fish culture station.

It is clear from Table 5 and 6 that the formation of the plankton in one culture station is different from that in another. Generally speaking, each kind of the marine animals lives on its own food suitable for itself. The natural living food varies in its kind according to the species of the animals and the palces they live in, and the quantity of the food has influence on the production of the marine creatures. It is natural, therefore, that where there is much food there is a rapid growth and a great production of useful animals.

On the other hand, fish culture stations should be put under a good management, that is, we must try to provide the fish with such food and environments as are necessary and proper for their growth.

For example, in the case of Tilapia mossambica and Chanos chanos (generally called "milk fish") which are commonly cultivated in Viet-Nam, the phyto-plankton is given for food at their larval and younger stages.

(According to W.H. Schwester, 1952, 50% to 70% of the contents of Tilapia intestine is phyto-plankton, and 11% to 17% is zoo-plankton.) It is, therefore, necessary to take positive measures to increase phyto-plankton for these herbivorous fish.

In multiplying ordinary fish such as carp, it is necessary not only to provide them with suitable living environments (that is, to make dissolved oxygen, PH, and water conditions suitable for them) but also to pay full attention to such matters as the manufacturing and compounding of food based upon nutritive chemistry, the making of a food which is quick of digestion and absorption, the frequency of feeding in one day, growth rate, and an economical quantity of food to be given to fish.

		CHOLON (n/m³)	THU-DUC (n/m³)	DALAT (Hatched stage) (n/m³)	DALAT (Younger stage) (n/m³)	HUE (n/m³)	NHATRANG (Brackish) (n/m³)
CYANOPHYTA	Anabaenopsis Elenkinii		29734				
	Anabaena circinalis			6827			
	Chroococcus giganteus						2472
	Coelosphaerium Kuetzingiamum						359
	Oscillatoria limosa		11393				
	Spirulina princeps		13604				
	Symploca muscorum		807				
CHRYSOPHYTA	Achnanthes sp.						10528
	Amphora ovalis						792
	Botrydiopsis arrhiza			1870			
	Chaetoceros muelleri						457
	Cyclotella Kutzing			200			
	Diatoma linearis						810
	Diatomella balfouriana						259
	Epithemia sp.						382
	Fragilaria capitata			89			
	construens						1074
	lanceolata				367		
	subsalina						237
	Frustulia rhomboides						3560
	Gyrosigma kutzingii						698
	Hantzschia amphioxys			187			
	Melosira granulata				662850		
	var. valida			2899		22752	
	isolandica			97		678	
	malayensis					78	
	varians			13			
	Meridion circulare					24	
	Navicula lanceolata						6122
	placentula				334		2538
	Nitzschia acicularis						5078
	actinastroides					108	
	closterium		123				
	kutzingiana						481
	nyassensis			748			
	philippinarum			94			
	subrostrata			73			
	Phaeogloea mucosa				36		
	Pinnularia sp.			94			
	Rhbdonema adriaticum						4696
	Rhopalodia gibba				58		
	Surirella robusta						15137
	Synedra affinis						2589
	acus				526		
	cunningtoni				238		
	fasciculata			284	364		
	lanceolata				351		
CHLOROPHYTA	Ankistrodesmus falcatus			8143	51300		
	Arthrodesmus apiculatus				35800		
	arcuatus				6276		
	curvatus				29530		
	Closterium moniliforme				2214		
	setaceum						3068
	Closteriopsis longissima			434			
	Coelastrum cambricum				367		
	Cosmarium exasperatum			531			
	phaseolus			334			
	praemorsum				501		
	Crucigenia fenestrata			6359	11072		
	quadrata			374			
	Desmidium bengalicum					18	
	Dictosphaerium pulchellum				95958		
	Echinosphaerell limnetica		20				
	Franceia tuberculata			11414			
	Geminella interrupta		13				
	Hyalotheca sp.			18			
	Micrasterias mahabuleshwarensis					12	
	Microspora amoena						776
	Mougeotia sp.				122531		
	Pachycladon umbrinum			67			
	Palmella miniata				7381		
	Pediastrum biradiatum			237	351	120	
	Pleurodiscus purpureus					438	
	Protococcus viridis						172
	Scenedesmus armatus			468	19192		
	dimorphus			3367	17715		
	Schroederia setigera				3322		117
	Selenastrum Bibraianum				11810		
	gracile			9352			
	Spirogyra ahmedabadensis			654			
	prolifica			296			
	protecta				110		
	Staurastrum acanthastrum				175		
	anatinoides			2993		120	
	corniculatum			50	2214		
	kalimantanum				2214		
	tohopekaligense				8858		
	variabile				2952		
	woltereckii				12179		
	megacanthum			281			
	gracile			629			
	orbiculare			85			
	pseudopachyrhynchum			94			
	punctulatum			140			
	Tetraedron lobatum			208			2707
	Volvox aureus		250				2580
	Westella botryoides						
	Xanthidium burkillii				1476	180	
	sexmamillatum						
PROTOZOA (Phyto-Mastigophora	Ceratium hirundinella				5		481
	var. silesiacum						3039
	Chlamydomonas inhabilis						247
	kvildensis				2405		
	praecox					3840	
	Rodhei				680		
	Chrysocapsa planctonica						
	Cryptoglena pigra	9690		247		132	
	Dinobryon divergens			1964			
	sertularia						
	Euglena clara		84				
	deses	2170					
	geniculata				369		
	halina		80				
	pseudoviridis		227				117
	velata		82				
	Glenodinium steinii				2670		596
	uliginosum				20		
	Hypnodinum sphaerium	500					244
	Peridinium aciculiferum				651		
	africanum						351
	spiniferum			184	19561		
	striolatum				300		
	Phacus longicauda						
	Protochrysis phaeophycearum	17700					
(Zoo-Mastigophora)	Acanthocystis chaetophora				334		
	Actinophrys sol	72					
	Ctedoctema acanthocrypta		583				
	Cyclidium glaucoma	651					
	Didinium sp.		100				
	Euplotes patella	585					
	Gastronauta membranacea	150					169
	Glaucoma scintillans	250				12306	
	Holophrya simplex						
	Pleuronema coronatum		838			11184	
	Spasmostoma viride						491
	Steinia candeus			189846			
	Trichodina sp.						1880
TROCHELMINTHES	Brachionus urceolaris					96	
	Colurella obtusa					30	
	Dipleuchlanis propatula					60	
	Keratella cochlearis			84	304		
	valga			78			
	Lepadella patella	52				24	
	Monostyla quadridentata						157
CRUSTACEA	Acartia Clausi						130
	Calanus sp.						164
	Cyclops bicolor						
	strenuus	84		111			
	vernalis				174		
	Diaptomus reighardi				65		
	Eodiaptomus japonicus						
	Mesocyclops lenckarti		65	33271			
	Osphranticum labronectum						387
	Pseudodiaptomus marinus			149	375		
	Sida crystallina						

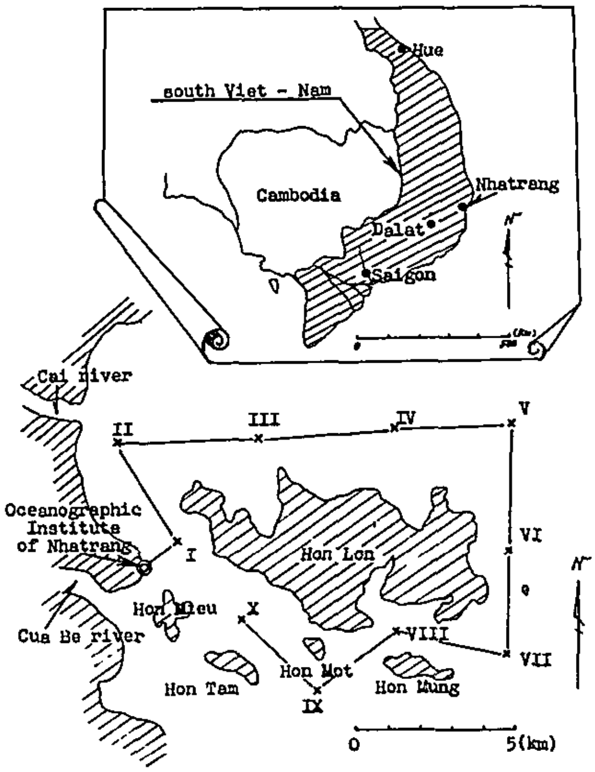
Table 6 The plankton species was taken from the ponds of each Fish culture station in Viet-Nam.
(unit .... the number of Individuals per Cubic meter (n/m^3))

CHAPTER V ENVIRONMENT AND PLANKTON BIOMASS IN THE DRY AND THE RAINY SEASON IN NHATRANG BAY AND THE OPEN SEA, CENTRAL VIET-NAM

A. RESEARCHING STATIONS AND RESEARCHING METHODS

1. RESEARCHING STATIONS

Ten researching stations were established (Fig. 1) in Nhatrang Bay and the open sea (about 14 km. from the beach) around Hon Lon (Lon Island).



2. RESEARCHING INSTRUMENTS

(1) Mercury thermometer (35°C)

(2) Kitahara water collecting equipment.

(3) Hydrometer.

(4) Medicines are used to the fixation of dissolved oxygen. ($MnCl_2$ and KI + KOH solutions)

(5) Oxygen bottles (about 100 cc Volume).

(6) Secchi plate for the measurement of transparency.

(7) Plankton nets.

(a) Phyto-plankton net (Mullergaze No. 5)

for the horizonta ---- Diameter 30 cm.
for the vertical ------ " 25 cm.

(b) Zoo-plankton net (Mullergaze No. 25)

for the horizontal ---- Diameter 30 cm.

(8) Solution for the fixation of plankton

Formarin -------------- 4 - 6 % neutral

(9) Ropes. 100 m., 20 m., 10 m., ---- Diameter 6 mm.

(10) Pouches and bottles for the collected samples.

(a) Pouch: Nylon or Vinyl ---- Size 20 x 30 cm

(mainly, it was used to the water samples)

(b) Bottles: Plastic bottle; D. (5.5; 3.5; 2.7 cm)
H. (11, 8, 7 cm)

3. ITEMS OF THE RESEARCH

(1) Observation at the same station on one day.

(a) Station ---- St. I

(b) Date and Time

Dry season ---- May 20 - 21, 1963
Rainy season --- Oct. 1 - 2, 1963

from sunrise to after sunset --- 5:30 a.m. to 8:30 p.m.

(c) Measurement: Temperature, Dissolved oxygen, Density, Alkalinity, Chlorinity and Salinity, Transparency, and Horizontal and Vertical distribution of plankton to each depths.

(2) Observations in Nhatrang Bay and in the open sea.

(a) Station ----- Sts. I - X

(b) Date -------- Dry season May 21, 1963
Rainy season Oct. 2, 1963

(c) Measurement: Temperature, Dissolved oxygen, Density, Alkalinity, Chlorinity and Salinity, Transparency, Quantity of plankton (phyto- and zoo-plankdon) at each station.

4. PREPARATION OF CHEMICALS AND THE METHOD OF ANALYSIS OF THE SAMPLES

(1) Determination of specific gravity -- the water was taken to the laboratory, as it is difficult to get a correct determination of the ship because of the rolling and pitching. Density of the sea water is determined by the Akanuma's specific gravity meter. As it varies with the temperature, the density determined in any temperature is converted into that of 15°C (σ_{15}) and is compared. This conversion is made according to Makalof's list (Appendix Table I).

Here is the formula used in the conversion of the gravity by the Table .

$$\sigma_{15} = (g - g') m + 1.0260$$

g is the standing density; g' is the density of the standard sea water at t °C obtained from this Table; m is a multiplier obtained from the Table; and 1.0260 is constant.

(2) Determination of dissolved oxygen -- Winker's method.

(3) Method of getting Cl (°/oo), S (°/oo) from the Density -- the relations among the Density, Cl and S can be known from Knudsen's table (Appendix, Table II). The values of Chlorinity and Salinity in this report are obtained from

this Table. Although the determination of Chlorine by means of the $AgNO_3$ solution is no doubt accurate, it is not used here. The relation between Chlorinity and Salinity is given by Knudsen in the following formula.

$$S = 0.030 + 1.8050\ Cl$$

S is Salinity; Cl is Chlorinity.

(4) Determination of Alkalinity -- The fixed quantity of carbonic acid and carbonate in the sea water, called "the determination of Alkalinity" was formerly indicated with the milligram of CO_2 or CC but is now indicated with the mg/atom/L or milli-eqiv/L of HCL which is necessary for the neutralization of carbonate. The following is the method of determination. The carbonate of Ca is determined by the following method, as it does not show the color reaction.

Add HCl to the water containg $CaCO_3$, and HCl neutralized by $CaCO_3$ diminishes in quantity.

$$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$$

Measure this decrease of HCl by means of Iodine method. This is called the determination of E. Ruppin, and is chiefly used for the determination of the sea water.

First, add a certain amount of HCl to a certain amount of the water, and after removing CO_2 by boiling it, potassium iodide and potassium acid iodide are to be added. Then I, equivalent to the amount of HCl remaining in the water, will be separated throught the following reaction, and it is to be titrated.

$$KIO_3 + 5KI + 6HCl = 6KCl + 3H_2O = 3I$$

(a) Reagent

(i) N/20 HCl

(ii) N/20 KIO_3 ..... Dissolve 1.784 g. of KIO_3 into distilled water, making it 1 liter.

(iii) Dissolve 10 gr. of pure KI into distilled water, making it 100 CC, and store it in the dark.

(iv) N/10 $Na_2S_2O_3$

(v) 1 % starch solution

(b) Operation

Take 100 CC of the sea water into a hard flask, and 1.5 CC of N/20 HCl to this, and after removing CO_2 with a few minutes boiling, cool it until it becomes of the same temperature as that in the room. Then, add 7.5 CC of N/20 KIO_3 and 5 CC of 10% KI, sealing it up and keeping it in the dark place for more than ten minutes, and I will be separated. Use starch solution for the indicater, and titrate it with N/10 $Na_2S_2O_3$.

(c) Calculation

If X CC of N/10 $Na_2S_2O_3$ was necessary,

CO_2 par 1 L. = X x 2.2 mg x 10

(5) Determination of plankton

(a) Balance of plankton

Samples fixed by formalin (about 4 - 5% neutral farmalin) are collected and balanced through the following process (Fig. 2).

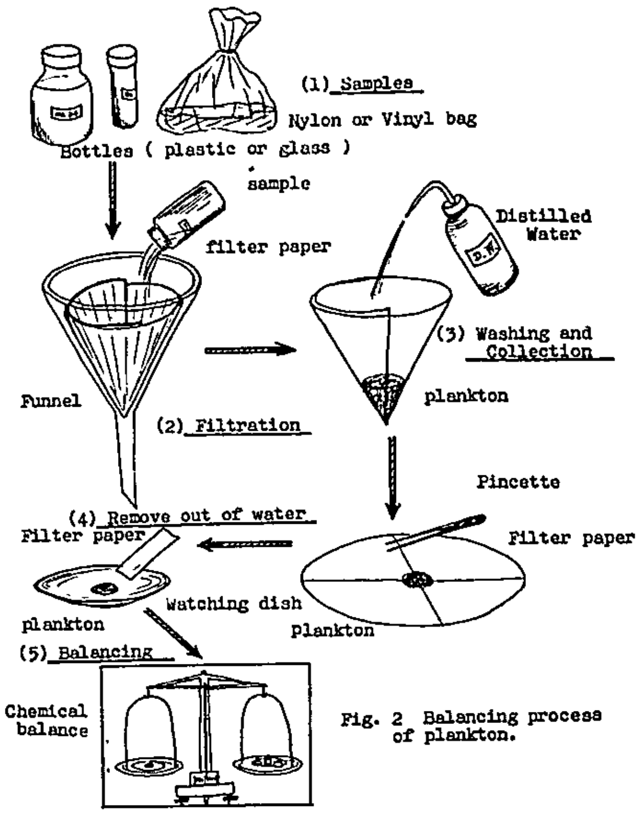


Fig. 2 Balancing process of plankton.

In filtering the samples fixed by formalin, the plankton left on filter paper should be from time to time washed down with distilled water so as to make it gathered at the bottom. It must be done immediately after filtering the water, for after it gets dry, plankton will be stuck to filter paper and won't come off. Twenty or thirty minutes later, open filter paper and, picking up the gathered plankton very carefully and quietly, remove it onto the watch dish. Then by press a piece of filter paper to the gathered plankton, remove water out of it, and weigh it with the micro-balance. (Weigh it together with the plate, and later deduct the weight of the plate.)

(b) The method of determination of the individual number.

As for plankton, even among the same species, the size varies with the growth and the degree of reproduction, (sometimes it is influenced by the environment of water), so it is almost impossible to convert its number into quantity. It must be remembered that, if it done, there will be an error to a great extent,

(c) Measurement of the volume of plankton

Put the collected plankton into the mes-cylinder, and the amount of plankton precipitated after certain hours will be the whole volume. What we have to have in mind this method is that the error in the volume will be procuced by the specific gravity of the sea water, by the difference in sedimentation verocity among the different species of zoo- and phyto-plankton, and also by the varieties of aperture during the precipitation caused by the different sizes of the species. Measurement must be done, therefore, taking these things into consideration.

Another method is to precipitate plankton by centrifugal separation and measure its volume. It is convenient, in this method, to convert the centrifugal, the volume, and the wet-weight beforehand.

(d) Determination of organic nitrogen in plankton.

This is the most accurate method to measure the quantity of plankton, and is generally used in Japan.

(i) Filter the samples fixed by formalin, and then remove formalin.

(ii) Wash plankton several times with distilled water.

(iii) Reverse the filter paper, and pour plankton gently into the Kjeldahl's decomposition bottle with distilled water.

(iv) Add concentrated sulfuric acid three to ten times as much as the amount of the sample (sometimes use catalyser) and boil it from ten to twenty hours.

(v) Taking a certain amount of this liquid, make it gasified ammonia by Kjeldahl's distilling method, and put it into the precise normal solution of HCl. Titrate it with N/100 $Na_2S_2O_3$, using starch solution as the indicator. The above is a rough summary of the operation, and the details will be obtained in the chemical books.

The author himself has determined the quantity by the balancing method (a).

B. RESULTS

Comparison between the dry season (May 20, 21, 1963) and the rainy season (October 1, 2, 1963) was the chief object of this survey.

1. THE OBSERVATIONS AT THE STANDING POINT. (AT ST. I)

(1) Atmospheric temperature and water temperature.

The results are shown in the Table 7, Table 8, and Fig. 3. In the dry season atmospheric temperature in the daytime is usually over 30°C, which occurs less often in the rainy season.

		Time	a.m. 5:30	8:00	11:00	p.m. 14:00	18:00	20:30	Mean Tem.
Dry season May 21, 1963	A.T. (°C)		26.4	28.5	30.8	31.4	29.8	28.9	29.3
	W.T. (°C)	Depth (m) 0	28.4	28.9	29.6	29.5	28.9	29.0	29.1
		5	28.6	28.9	29.0	29.0	29.1	29.1	29.0
		10	26.4	26.7	26.8	26.7	26.3	26.9	26.6
		15	24.9	25.0	24.8	25.1	24.9	25.3	25.0

Time			a.m. 5:30	8:00	11:00	14:00	p.m. 18:00	20:30	Mean Tem.
	A.T. (°C)		24.8	28.9	29.6	29.5	28.9	29.0	29.1
	W.T. (°C)	Depth (m) 0	28.4	28.4	29.0	29.2	28.3	28.5	28.6
		5	29.0	29.1	29.1	29.2	29.1	29.1	29.1
		10	28.8	28.9	29.0	29.0	28.8	28.9	28.9
		15	28.8	28.4	28.0	28.0	28.1	28.6	28.3

Table 7. Atmospheric temperature (A.T.) and Water temperature (W.T.).

	A.T. (°C)	W.T. (°C) 0 m.	5 m.	10 m.	15 m.	Deviation (°C)
Dry season	29.3	29.1	29.0	26.6	25.0	± 4.1
Rainy season	27.4	28.6	29.1	28.9	28.3	± 0.8

Table 8. Average A.T and average W. T.

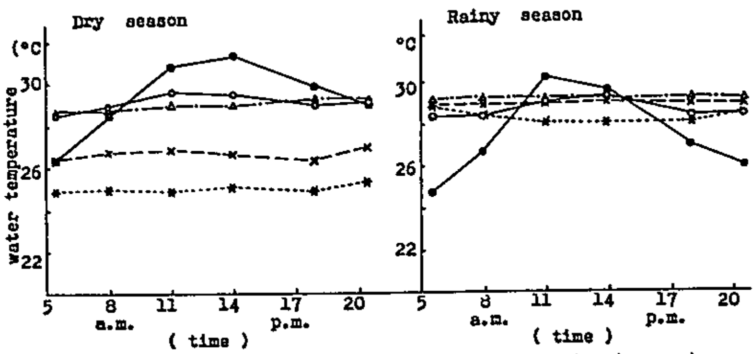


Fig.3 The relation between the depth and the water temperature at St. I.

The average temperature of the dry and the rainy seasons was respectively 29.3°C and 27.4°C, and the difference between them was about 2°C.

In both the dry and the rainy seasons, the water temperature is found to have a tendency of falling according as the water gets deeper. But, compared with the rainy season, this tendency is more remarkable in the dry season. The difference of temperature by about 4°C was recognized between the surface and the 15 m. layer. As the water mass between the surface and the 5 m. layer shows nearly the same degree with the average atmospheric temperatures, it is considered that the water temperatures suddenly falls under 5 meters. In the rainy season, however, the water temperature from the surface to the 15 m. layer was higher than the average atmospheric temperature, and the average difference of water temperature was very small -- 0.8°C.

The water temperature in the early morning is higher than the atmospheric temperature. This shows the keeping-warm quality of the sea water.

The fact that the difference in the water temperature between the surface and the 15 m. layer varies with the seasonal change, i.e. 4.1°C in the dry season, and 0.8°C in the rainy season, has a great influence upon the vertical distribution of plankton, which will be mentioned in the later chapter.

It means that the circulation between the surface and the underlying water is not easily done in the dry season, and that, accordingly, the distribution of plankton varies in quality and quantity with the different depths of the water. In the rainy season, on the contrary, the circulation is easily done, and so it is supposed that the plankton is almost equally distributed throughout. The temperature of the surface water was found to fall in some degree at sunrise and after sunset. This shows that the surface water is likely to influenced by the atmospheric temperature.

As for the change from the dry to the rainy season in the average difference of water temperature, it will be explained that the temperature which has been falling during the rainy season of the preceding year, rises on and near the surface in summer (i.e. the dry season) because of the strong sunshine, while in the rainy season the sunshine is weak, and the surface water and the underlying water become easily mixed because of the wind and the rain.

(2) Dissolved oxygen.

The amount of dissolved oxygen obtained at the different hours at each depth at the same standing point, and also the average amount of oxygen at each depth, are shown in the Table 9.

Depth	0 m.		5 m.		10 m.		15 m.	
Time	D.S.	R.S.	D.S.	R.S.	D.S.	R.S.	D.S.	R.S.
5:30	4.39	4.49	4.37	4.34	4.53	4.28	-	-
8:00	-	4.42	-	4.28	-	4.35	-	4.28
11:00	4.49	4.35	4.60	4.49	4.72	4.21	4.69	4.28
14:00	4.37	-	4.23	4.42	4.57	4.35	4.48	4.21
18:00	4.47	4.35	-	4.40	4.70	4.35	4.57	4.42
20:30	4.36	4.56	4.61	4.28	4.61	-	4.61	4.35
Mean Oxygen (cc/L)	4.42	4.44	4.47	4.37	4.63	4.31	4.59	4.31

Table 9. Dissolved oxygen at each depth at the same station (St. I)

It was known from this Table that the amount of dissolved oxygen at the same depth on the same day changed in some degree as the time goes on.

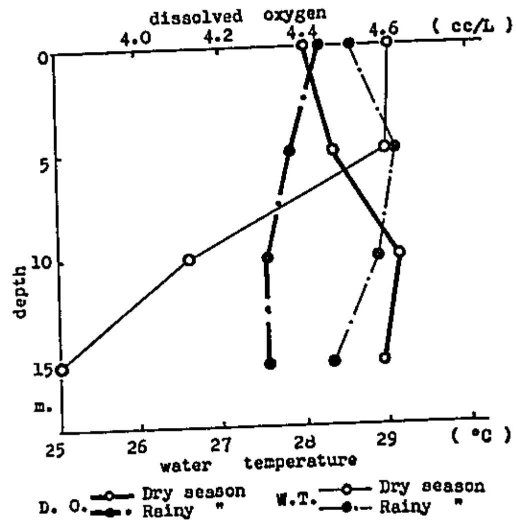


Fig. 4 The relation among the Dissolved Oxygen, Water Temperature and Water Depth at the same station (St. I).

In the Figure 4. are shown the average amount of dissolved oxygen at a certain depth on a certain day, and also its comparison with that of different depths and with the average water temperature.

This figure shows that the average amount of dissolved oxygen at each depth is greater in the dry season than in the rainy season. That is, in the rainy season, the amount of oxygen decreases as the water becomes deeper, and reaches the constant value (4.3 cc/L) at the depth of 10 - 15 meters, while, in the dry season, it conversly shows the tendency of increasing, and gets the constant value 4.5 cc/L also at the depth of 10 - 15 meters.

In both season, however, the amount of oxygen of the surface water is about the same, and the fact is common to both that at the 10 - 15 m. layer, there is not a sudden change in the amount but the value is almost constant.

In order to explain the difference of the two seasons, water temperature may be considered as one of the factors. In the dry season a sudden fall of water temperature under 5 meters was observed. This may mean that at the lower depth than 5 meters, the amount of dissolved oxygen increases, for it is known that the lower is the temperature, the greater is the amount of the oxygen in the water. This was proved by observation.

In the rainy season, having no sudden changes of water temperature and the water being mixed, not much difference was observed between each layer, but the amount of dissolved oxygen was seen to decrease gradually, from the surface to the 10 m. layer. This may be because the water of this season is muddy (whose transparency is small, probably owing to the influence of the rivers), and may have some relation to the consumption of oxygen by microbes and organisms, which are the cause of the mudiness of the water.

(3) Transparency

The transparency at the Station I. inside Nhatrang Bay was 13.5 - 14.0 Meter in the dry season, while in the rainy season it was 5.5 - 8.0 m., which was much lower than the other. The particles of mud carried by the rivers are considered to be the cause of this phenomenon. In Nhatrang Bay, the influence of mud carried by the rivers was observed one or two days after the rainfall, and the gradual change of the sea water from deep blue to muddy yellow was seen with the naked eye. Recovery of transparency generally takes 5 - 7 days, but in the rainy season, owing to the constant rain at the upper streams, recovery is either very slow or does not take place at all.

(4) Alkalinity

The average alkalinity in the dry and the rainy seasons at the Station I. was 35 and 50 mg/L respectively (as to the surface water). The values of alkalinity of the surface and of the 15 m. layer water are almost the same in the dry season, but in the rainy season, alkalinity of the surface water and that under the 5 m. layer differ in value. This is because on the surface is the sea water with the lighter (specific gravity) density (influenced by the rivers), and these two masses can be distinguished. The Table 10. shows alkalinity of the surface and at the 15 m. layer, and the Figure 5, the change of alkalinity within a day during the rainy season.

(unit .... mg/L)

		Surface Water	15 m. layer Water
Alkalinity	Dry season	35	35
	Rainy season	45.8 - 55	35

Table 10. Alkalinity of the surface and at the 15 m. layer

From this Figure may be known the difference in the quality between the water mass of the surface and that under the 5 m. layer.

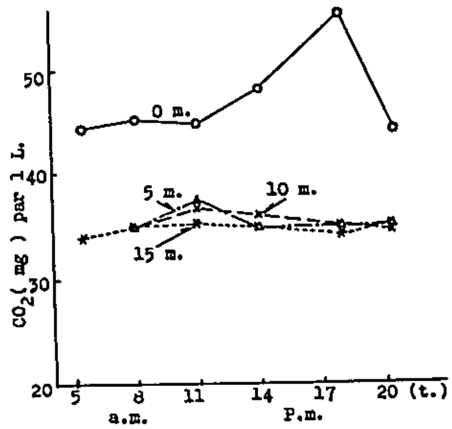


Fig. 5 The change of alkalinity within a day during the rainy season.

(5) Density

The Table 11. shows the density of the surface water and the 15 m. layer water, in both the dry and the rainy seasons. The density of the sea water ($_{15}$) usually lies between 1.0000 and 1.0310. It is known from this Table that the densities of the surface and of the 15 m. layer are nearly the same in the dry season, but that in the other season the difference is very great.

	Surface Water (σ_{15})	15m. layer Water (σ_{15})
Dry season	1.0250 - 1.0274	1.0265 - 1.0275
Rainy season	1.0180 - 1.0190	1.0265 - 1.0270

Table 11. Density at the same station.

As in the case of alkalinity, this is undoubtedly by the influence of the rivers in the rainy season - i.e., inflow of the fresh water, and it is proved that in the rainy season there lie two water masses of the different qualities, on and under the surface.

(6) The yield of plankton

When an investigation was made as to the amount of plankton living in Nhatrang Bay, in the water with the above qualities, the results obtained were as shown in the Figure 6. It shows the vertical and the horizontal plankton biomass at each hour in both seasons by g/m^3, which was obtained through the night and day observations at a standing point (St. I).

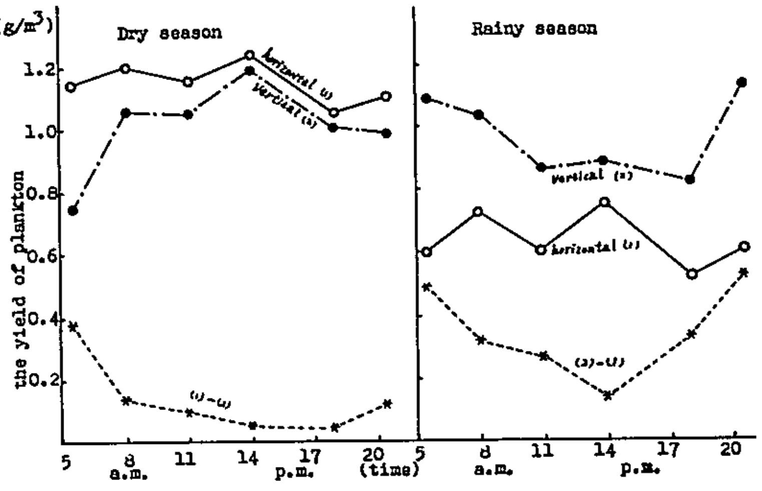


Fig. 6 The plankton biomass at the same station (St. I) on one day.

Comparing these two seasons, it is seen that the vertical and the horizontal plankton biomass is greater in the dry season, and that the difference between the two (i.e. the vertical biomass and the horizontal biomass) is also smaller then. For in the dry season the average horizontal plankton biomass was 1.15 g/m^3 and the vertical biomass 1.01 g/m^3, the difference being only 0.14 g/m^3, while in the rainy season the average horizontal biomass, 0.97 g/m^3, the vertical biomass 0.63 g/m^3, and so the difference was 0.34 g/m^3. In this case, contrary to the dry season, the vertical biomass was greater than the horizontal one. Thinking about this difference, it is considered that in the rainy season the fresh water of the small (light) density covers the surface, (because there alkalinity is found to be greater and the density smaller), which makes the water unsuitable for the existence of plankton, and consequently brings about the poor yield.

Through the observation of the change in the plankton biomass collected at certain time, a big difference was recognized in both seasons between the vertical and the horizontal yield before sunrise and after sunset (Fig. 6). The vertical distribution rate of plankton in the surface water and the under layer water is designated in the Table 12. in percentage.

	layer (m)	(Time) 5:30	8:00	11:00	14:00	18:00	20:30	mean %
D.S.	0 - 1	60	53	52	51	51	53	55
R.S.	0 - 1	35	41	41	46	38	35	39
D.S.	1 - 10	40	47	48	49	49	47	45
R.S.	1 - 10	65	59	59	54	62	65	61

Table 12. The vertical distribution rate of plankton at the same station on one day. (D.S.--Dry season; R.S.--Rainy season)

The average rate of the horizontal distribution in the surface water (0 - 1 m.) was 55 % in the dry season, and 39 % in the rainy season. The reason why it is lower in the latter is that the environment is not fit for plankton because of the inflow of the fresh water. In both seasons, however, the amount of plankton inhabiting the surface water between 0 - 1 m. was found through this table to be much greater than that inhabiting the lower part.

2. THE OBSERVATIONS IN NHATRANG BAY AND IN THE OPEN SEA

Here is the results of the survey in the dry season (May 20) and in the rainy season (Oct. 1), at the ten stations. Hon Lon (Lon Island) is the principal one, in Nhatrang Bay and the open sea.

(1) Wind verocity

Dry season ------- south or south-west wind.
Rainy season ----- north or north-east wind.

(2) Atmospheric temperature and water temperature. The results are shown in the Fig. 7.

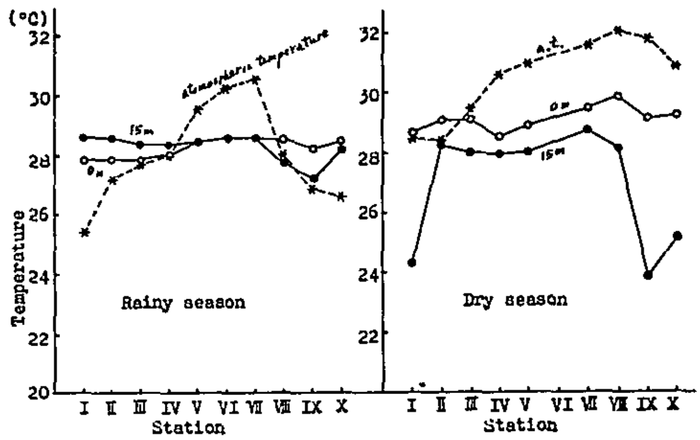


Fig.7 Atmospheric temperature and Water temperature at each Station.

The average atmospheric temperature was 30.4 °C in the dry season, and 27.9 °C in the rainy season, the difference being 2 °C which is nearly the same with the difference of temperature observed at the standing point, mentioned earlier.

The average water temperature of the surface was 29.1 °C in the dry season, and 28.2 °C in the rainy season. At the 15 m. layer it was 27.0 °C, and 28.25°C respectively.

The temperature of the surface water is higher in the dry season than that in the rainy season, while with the 15 m. layer it is conversly higher in the rainy season. This may be explained that, in the rainy season as the comparative temperature of the water is high, the temperature of the surface water gradually falls under the influence of the atmospheric temperature, while that of the under layer rises, influenced by the high temperature of the surface water.

(3) Dissolved oxygen

The amount of dissolved oxygen obtained through the survey at each station is shown in the Figure 8.

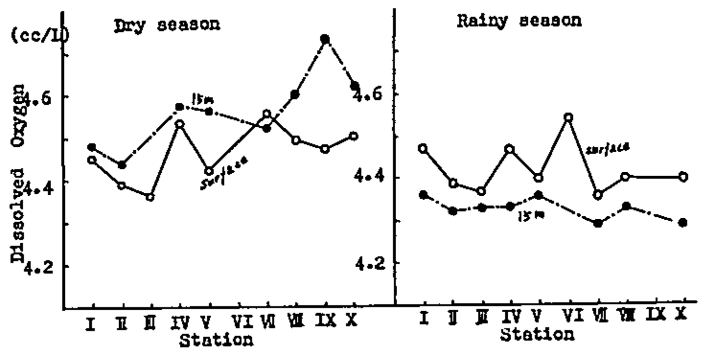


Fig.8 Dissolved oxygen at each station.

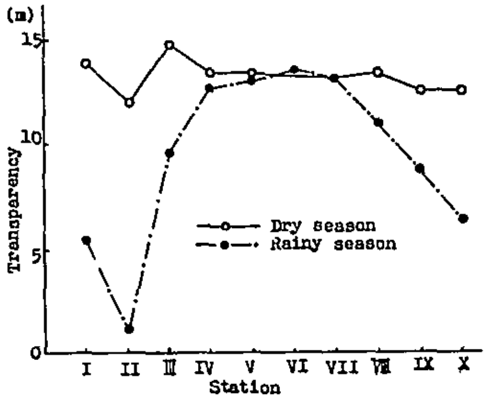
In the dry season, the average amount of oxygen was 4.46 cc/L with the surface water, and 4.56 cc/L with the 15 m. layer. In the rainy season, it was respectively 4.42 cc/L and 4.33 cc/L.

There is a great variety in the amount of dissolved oxygen with the surface water, the cause of which seems to be the waves on the surface. (The sample was taken with Kitahara's apparatus at 0.3 m. level from the surface.)

From this may be concluded that there is little difference in the amount of dissolved oxygen in the surface water, between the dry and the rainy seasons, though, with the 15 m. layer, the difference does exist, its amount of oxygen surpassing that of the surface water in the dry season and vice versa in the rainy season. This is an interesting fact in the light of the above-mentioned water temperatures. (As stated before, it is a general rule that the lower is the water temperature, the greater is the amount of dissolved oxygen.)

(4) Transparency

The Figure 9. shows the transparency in Nhatrang Bay and in the open sea both in the dry and the rainy seasons. It was known from this Figure that the transparency of both seasons greatly differs one another.



Transparency in the dry season was from 12 m. to 14.7 m. The station II showed the lowest value of all in this season, probably because it was near the estuary and so had the influence of the turbidity of the river. Meanwhile, in the rainy season, transparency differed at each station, and here again the St. II showed 1.2 m., which was the lowest throughout both seasons, probably influenced by the rivers again. St. I, II, III and VIII, IX, X had the lower transparency than that in the dry season, but St. IV, V, VI, VII showed 13 m., which is nearly the same with the dry season.

It is concluded from this that at the St. IV, V, VI, VII in the open sea transparency is almost constant throughout the two seasons. But at every station inside the Bay is found the strong influence of the rivers, and this influence is seen to decrease as we get nearer to the open sea, accompanying the growth in transparency.

(5) Alkalinity

Through the measurement of alkalinity can be obtained the amount of carbonic acid in the sea water, which of course has much relation to photo-synthesis, i.e. the growth of phyto-plankton.

Alkalinity of the surface water and of the 15 meter layer in the dry season was from 30 to 37 mg/L, the under layer having the tendency of being greater. In the rainy season, as shown in the Figure 10, the difference in the value of alkalinity between the surface and the 15 m. layer is apparent. Alkalinity of the 15 m. layer water had nearly the constant value of average 35 mg/L, while with the surface water, excluding the St. VI, VII, VIII in the open sea where the value is comparatively stable (about 35 mg/L), high alkalinity was found at every station. Especially at the St. II near the estuary, the highest value of 53 mg/L was obtained. This is reverse to the case of transparency, but the cause may be the same -- the influence of the rivers.

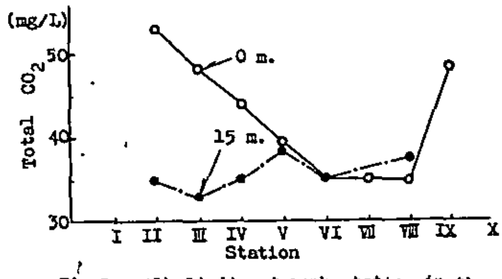


Fig.10 Alkalinity at each station in the rainy season.

(6) Density and Chlorinity

The difference between the surface water and the under layer water, which was mentioned before in relation to the influence of the rivers, was also confirmed through the measurement of the density of the sea water. As is shown in the Figure II, there exists between them an apparent difference in quality. Besides, different water masses were found in the dry and the rainy seasons.

In the dry season, Density (σ_{15}) of the surface water was 1.0267 - 1.0274, while in the rainy season the nearer to the estuary was the station in the Bay, the lower was the value of density, and at the St. II which was the nearest to the river; it was 1.0183. The value grows higher as the station gets nearer to the open sea where (Sts. VI, VII, VIII, IX) it had a constant value of about 1.0265. As to the 15 m. layer water, σ_{15} was 1.026 - 1.0269 throughout all researching areas, so the water mass was found to have nearly a constant value, without any influence, it seems, from the rivers or the fresh water.

The values of Chlorinity and Salinity calculated from σ_{15} shown in the Table 13. and the Figure 12, are as in the case of density, high in the open sea, and in the Bay was found a strong influence of the rivers. It has been proved from these results that there exist apparently different water masses in the dry season and in the rainy season, and that in the rainy season the surface water and the underlying water (15 m. layer) differ in quality.

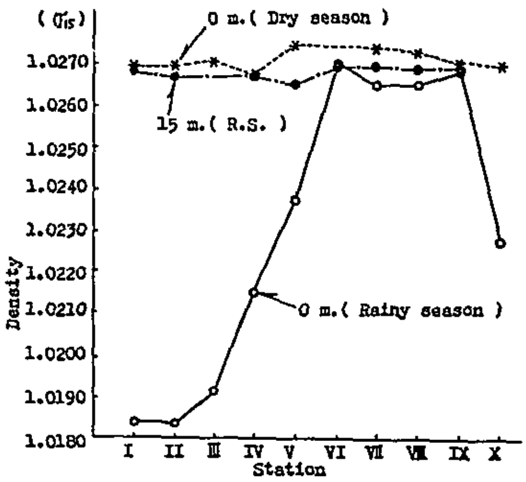
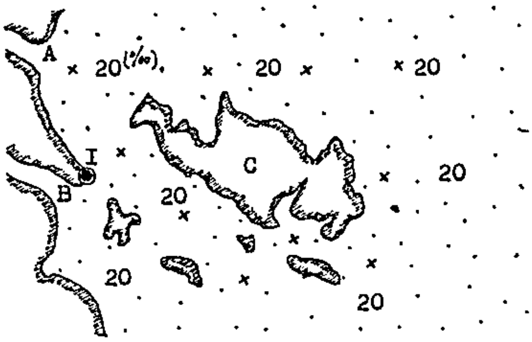


Fig.11 Density at each station.

Station	Season	Depth (m)	Density (15)	Chlorinity (°/oo)	Salinity (°/oo)
I	D.S.	0	1.0270	20.08	36.27
	"	15	1.0275	20.08	36.27
	R.S.	0	1.0185	14.00	25.30
	"	15	-	19.90	35.95
II	D.S.	0	1.0269	20.08	36.27
	R.S.	0	1.01835	13.86	25.04
	"	15	1.0267	19.86	35.88
III	D.S.	0	1.0270	20.11	36.33
	R.S.	0	1.0191	14.40	26.02
	"	15	-	-	-
IV	D.S.	0	1.0267	19.86	35.88
	R.S.	0	1.0215	16.13	29.14
	"	15	1.0267	19.86	35.88
V	D.S.	0	1.0274	20.39	36.83
	R.S.	0	1.0237	17.73	32.03
	"	15	1.0265	19.74	35.66
VI	D.S.	0	-	-	-
	R.S.	0	1.0268	19.96	36.06
	"	15	1.02695	20.07	36.26
VII	D.S.	0	1.0273	20.32	36.71
	R.S.	0	1.02645	19.70	35.59
	"	15	1.0269	20.08	36.27
VIII	D.S.	0	1.0272	20.25	36.58
	R.S.	0	1.02645	19.70	35.59
	"	15	1.0268	19.96	36.06
IX	D.S.	0	1.0269	20.08	36.27
	R.S.	0	1.0267	19.86	35.88
	"	15	1.0268	19.96	36.06
X	D.S.	0	1.0269	20.08	36.27
	R.S.	0	1.0227	17.00	30.72
	"	15	-	-	-

Table 13. Density, Chlorinity and Salinity at each station

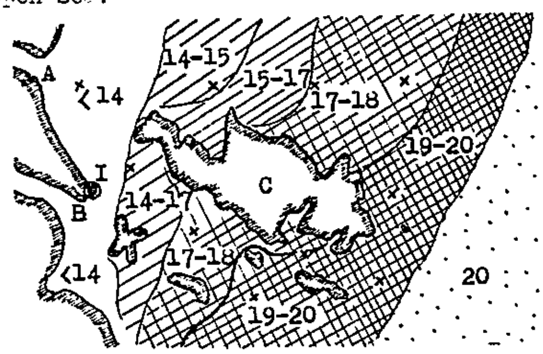
(1)



Surface layer

Chlorinity (‰) in the dry season, in Nhatrang Bay and the open sea.

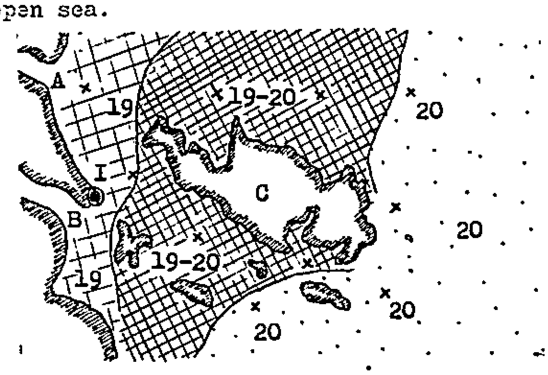
(2)



Surface layer

Chlorinity (‰) in the rainy season, in Nhatrang Bay and the open sea.

(3)



15 m. layer.

Chlorinity (‰) in the rainy season, in Nhatrang Bay and the open sea.

Fig 12. The variation of chlorinity in the dry season and the rainy season, in Nhatrang Bay and the open sea,
(A -- Cai River; B -- Cua Be River; I C -- Lon Island
I -- Oceanographic Institute of Nhatrang
x -- Researching Station)

(7) Plankton biomass

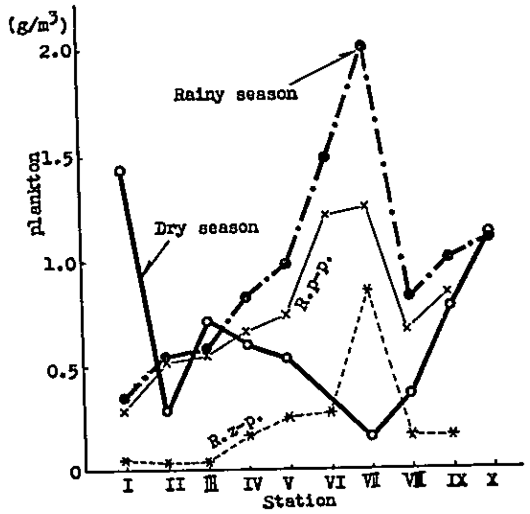


Fig. 13 The quantity of plankton in the dry and rainy season at each station.

R.p-p. shows Phyto-plankton of the rainy season.

R.z-p. shows Zoo-plankton of the rainy season.

Station	I	II	III	IV	V	VI	VII	VIII	IX	X
Dry season	1.42	0.28	0.7	0.59	0.52	0.32	0.15	0.37	0.77	1.12
Rainy season	0.35	0.55	0.59	0.82	0.98	1.48	2.01	0.82	1.0	1.10

Table 14. Total plankton biomass in the dry and rainy season at each station in the Nhatrang (Bay and the open sea). (Unit shows g/m^3)

Figure 13 and Table 14 shows plankton biomass in the dry and rainy season at each station by the wet weight (g/m^3)

The plankton biomass in the dry season ranged between 0.15 and 1.42 g/m^3, higher in the Bay (St. I, II, III, X) and decreasing towards the open sea (St. V, VI, VII). The maximum in the dry season was 1.42 g/m^3 at St. I and the minimum, 0.15 g/m^3 at St. VII. On the other hand, in the rainy season, the plankton biomass was within a range of 0.35 to 2.01 g/m^3, higher in the open sea (St. V, VI, VII) and decreasing towards the Bay. The maximum in that season amounted to 2.01 g/m^3 at St. VII as against the minimum of 0.35 g/m^3 at St. I.

Further, it turned out that the mean plankton biomass total mean plankton biomass up to 15 km from the beach) in the dry and rainy seasons was 0.56 g/m^3 in the case of dry season as against 0.97 g/m^3 in the rainy season or 1.8 times as high as the value in the dry season.

As above, it became apparent that plankton biomass in Nhatrang Bay and open sea presented the relations completely reversed in the dry and rainy seasons. To bring to light the cause of such relations, the environmental factors at the respective survey stations as mentioned above were taken up and the data averaged per Bay (St. I, II, III, X) and open sea (St. V, VI, VII) were compared with plankton biomass, the result of which is shown in the Table 15.

		Bay I, II, III, X		Open sea V, VI, VII	
Season		Dry	Rainy	Dry	Rainy
Plankton biomass		0.88g/m^3	0.65g/m^3	0.33g/m^3	1.49g/m^3
Water Temperature (°C)	Surface	29.0	27.95	29.1	28.5
	15 m	26.4	28.45	28.35	28.5
Oxygen (cc/L)	Surface	4.33	4.35	4.38	4.33
	15 m	4.40	4.22	4.43	4.22
Transparency		13.2 m	5.6 m	13.15 m	13.13 m
Alkalinity CO_2 (mg/L)	Surface	-	50.05	-	36.5
	15 m	-	34.0	-	36.5
Chlorinity (‰)	Surface	20.09	14.81	20.35	19.13
	15 m	20.0	19.87	20.0	19.96
Salinity (‰)	Surface	36.29	26.76	36.76	34.56
	15 m	36.13	35.89	36.13	36.06

Tble 15. Average plankton biomass and the environmental conditions in the dry and the rainy seasons in Nhatrang Bay and the open sea.

In the above Table, the mean measured values in the 15 cm layer were added for information only and the mean values for the surface layer only come into question in this case.

In the dry season, the mean plankton biomass in the Bay is 0.88 g/m^3 or about 2.7 times as high as the case of open sea (0.33 g/m^3). If the environmental conditions are examined to account for the cause of the above mentioned water temperature, dissolved oxygen and transparency represent similar values for both Bay and open sea while chlorinity (as well as salinity) is higher in the open sea, but these cannot be considered as the major factors affecting plankton biomass and it is assumed that the increase of Bay plankton in the dry season may be due to the quantity of organic matter which was not measured in that case, but might be increasing towards the beach.

On the other hand, the mean plankton biomass in the rainy season is 0.65 g/m^3 in the Bay as against 1.49 g/m^3 in the open sea, that is, the biomass is about 2.3 times higher in the open sea as compared with the case of Bay. The environmental conditions in that case were as follows:

(a) The water temperature in the Bay is 0.5^oC lower on an average as compared with that of open sea. (b) In respect of oxygen, it may be said that little difference exists between the Bay and the open sea in the surface layer. (c) Transparency in the Bay is 5.6 m or more than 1/2 lower than in normal cases. (d) Alkalinity in the Bay is 50.05 which is pretty high as compared with the open sea (36.5) and indicative of the existence of large volume of organic matter in course of decomposition. (e) Chlorinity is ordinarily about 20 $^o/_{oo}$ (Salinity : 35 - 36 $^o/_{oo}$), but the mean value in the Bay is 14.81 $^o/_{oo}$ (Salinity: 26.76 $^o/_{oo}$) which represents a considerable decrease. It became apparent from the above that in the rainy seasons, the environmental conditions in the surface layer of the Bay are different from those of the sea water at normal times. This is definitely due to the influences by the two rivers (Cai and Cua-Be Rivers) flowing into Nhatrang Bay. On the other hand, chlorinity in the open sea is about 0.9 $^o/_{oo}$ lower as compared with ordinary times, which, however, may be considered to be approximately equivalent to the environmental condition in the dry season.

Such being the case, in the rainy season, plankton decreased in the Bay whose environmental conditions were inappropriate for plankton to live in, but multiplied in the open sea whose environmental conditions were similar to those of the Bay in the dry season. That is to say, it can be considered that the plankton production in the Bay moved towards the open sea.

As to why the mean plankton biomass in the open sea in the rainy season surpasses that of the Bay in the dry season, a conclusion may be drawn that the influences of the river are controlling also in that case.

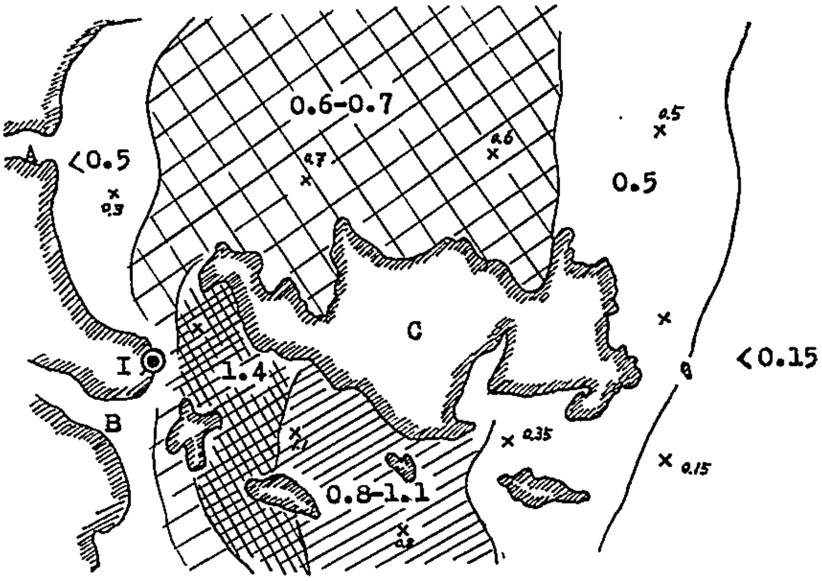
Total average plankton biomass (from beach to 15 km)		Ratio of plankton biomass
Dry season 0.56 g/m^3	Rainy season 0.97 g/m^3	Rainy season/Dry season 1.8
Maximum of the average plankton biomass in Nhatrang		Ratio of plankton biomass
Bay (Dry season) 0.88 g/m^3	Open sea (Rainy season) 1.49 g/m^3	Rainy season/Dry season 1.7

Table 16 Ratio of plankton biomass between the dry and the rainy seasons in Nhatrang bay and the open sea.

As indicated in Table 16, the ratio of mean plankton biomass between the dry and the rainy seasons in Nhatrang is 1.8 with the rainy season representing a higher value. As described above, the ratio between the maximum plankton biomass observed in the Bay and that in the open sea is higher in the rainy season or 1.7, which is near the former ratio of 1.8. From this, it is assumed that dissolved organic matter transported by the river water in the rainy season brought about a result in favor of the multiplication of plankton.

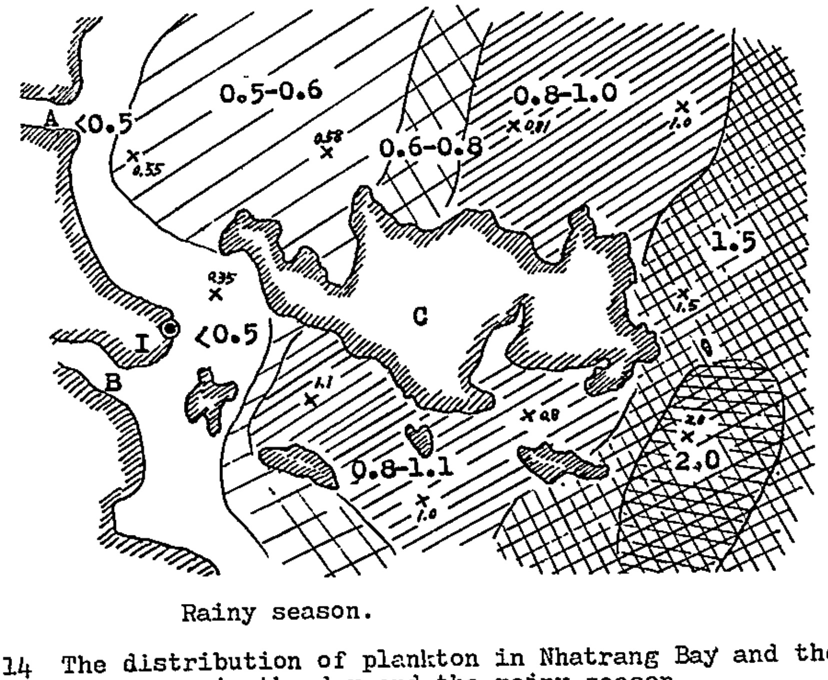
Finally, the distribution of plankton biomass in Nhatrang (including the Bay and the open sea) is summarized in Fig. 14.

(1)



Dry season.

(2)



Rainy season.

Fig. 14 The distribution of plankton in Nhatrang Bay and the open sea, in the dry and the rainy season.
A-- Cai River; B -- Cua Be River; C-- Hon Lon;
Number shows the quantity of plankton (g/m^3).

In the meantime, the result of measurement of plankton biomass per zoo-plankton and phyto-plankton is as indicated in dotted lines in Fig. 13, which is listed in terms of percentage in the following Table 17 which indicates that phyto-plankton is larger in quantity than zoo-plankton in both the Bay and the open sea, with zoo-plankton showing a tendency of slight increase in the open sea than in the Bay.

	Station	I	II	III	IV	V	VI
Phyto-plankton	g/m^3	0.29	0.52	0.55	0.66	0.74	1.21
	%	85	94.5	95	80	76	82
Zoo-plankton	g/m^3	0.05	0.03	0.03	0.16	0.24	0.27
	%	15	5.5	5	20	24	18

	Station	VII	VIII	IX	X
Phyto-plankton	g/m^3	1.25	0.66	0.84	-
	%	59	80	84	-
Zoo-plankton	g/m^3	0.85	0.16	0.16	-
	%	41	20	16	-

Table 17 Ratio between zoo- and phyto-plankton at the respective survey stations (Rainy season)

C. SUMMARY AND CONCLUSION

As a result of survey made in the dry season (May) and the rainy season (October) of 1963 in Nhatrang (Central Viet-Nam) Bay and the open sea as well as the environmental conditions at the standing points, the author obtained the following conclusions:

1. The observations at the standing point in the Nhatrang Bay

The following conclusion could be drawn from the fixed-point/ fixed-time observation from 5:30 a.m. to 8:30 p.m. of the same day:

As a result of survey made by taking an example of St. I in the Nhatrang Bay, it was found that both water quality and plankton biomass were changing constantly.

As for the quantity of plankton, the horizontal biomass, in the dry season, was 1.15 g/m^3 and the vertical biomass 10 g/m^3, the difference being very small, while in the rainy season, the horizontal biomass being 0.97 g/m^3 and the vertical biomass 0.63 g/m^3, the difference was great compared with that of the dry season. Investigations into the cause were made through the analysis of the water, and the difference was found in the rainy season between the density of the surface water and that of the underlayer water. (In the dry season the density of both was nearly the same, and the density of the 15 m. layer water in the rainy season was about the same with that in the dry season.) The density of the surface water in the dry season was 1.0260-1.0274, while in the rainy season it showed very low values, 1.0180-1.0190. This means that there exists over the surface the fresh water flowing in from the rivers, and the difference of the quality of the surface water and the 15 m. layer water is considered to have influenced the growth of plankton, bringing about the difference in the yield.

2. The observations in Nhatrang Bay and in the open sea

(1) The mean surface water temperature in the Bay reached 29.0°C in the dry season and 27.95°C in the rainy season as against 26.4°C in the dry season and 28.45°C in the rainy season in the case of 15 cm layer. On the other hand, the mean surface water temperature in the open sea was 29.1°C in the dry season and 28.5°C in the rainy season as against 28.35°C in the dry season and 28.5°C in the rainy season in the 15 m layer.

Thus, it was found that the difference in water temperature between the surface and the 15 m layer was larger in the dry season than in the rainy season.

(2) In respect of the mean dissolved oxygen in the surface layer, similar values were recorded for both the Bay and the open sea (4.33 and 4.35 cc/L respectively), except that in the open sea in the dry season (4.38 cc/L). The corresponding values in the 15 m layer were 4.40 and 4.43 cc/L for the Bay and the open sea respectively in the dry season as against 4.22 and 4.22 cc/L in the rainy season.

(3) Transparency measured in the dry season was some 13.2

m in both the Bay and the open sea whereas it varied remarkably in the rainy season, that is, 5.6 m on the average in the Bay.

In the rainy season, especially soon after rainfall, transparency decreased in certain cases down to 1 m or less at St. II located near the river mouth in the Bay while in the case of open sea, even the transparency of 8 m was recorded at St. VII (observed in December).

(4) Alkalinity showed a result completely contrary to the case of transparency. That is, the alkalinity in the surface water showed a tendency of decrease from the Bay (50,05 on the average) towards the open sea (36.5 on the average). However, in the 15 m layer, little differences were observed between the Bay and the open sea.

(5) The density in the Bay and open sea in the dry season was approximately constant in both the surface and 15 m layers, that is, $_{15} = 1.0270$. The sea water density in the rainy season was same in both the Bay (mean chlorinity: 20.0 $^{o}/_{oo}$) and the open sea (mean chlorinity: 20.0 $^{o}/_{oo}$). However, in the rainy season, the density in the surface water presented prominent variances similar to the case of transparency, that is, the minimum value of $_{15} = 1.0183$ (Cl: 13.86 $^{o}/_{oo}$, S: 25.04 $^{o}/_{oo}$) was recorded especially near the mouth of river, and he tendency of increase in density towards the open sea, gradually approaching the normal condition in the dry season or $_{15} = 1.0270$, was observed. In the meantime, the mean chlorinity in the surface layer of the Bay in the rainy season was 14.81 $^{o}/_{oo}$, being quite different from that in the 15 m layer (20.0 $^{o}/_{oo}$)

(6) The mean plankton biomass in Nhatrang is as follows:

Bay: 0.88 g/m^3 in the dry season and 0.65 g/m^3 in the rainy season.

Open sea: 0.33 g/m^3 in the dry season and 1.49 g/m^3 in the rainy season.

The mean plankton biomass in the Bay decreased gradually towards the open sea in the dry season, showing a value about 2,7 times as high as that in the open sea. As for the cause, it is considered that small quantities of filth from river, fish market and houses, etc. constantly flew into the part of the Bay near the beach and exercised influences upon plankton.

On the contrary, in the rainy season, the plankton biomass in the open sea was about 2.3 times higher than in the Bay. This is considered to have been caused by the environmental conditions, especially chlorinity and alkalinity in the Bay which varied remarkably as compared with the normal conditions and as a result, plankton multiplied in the open sea presenting the similar (ordinary) environmental conditions as in the Bay in the dry season. That is to say, the plankton production in the Bay decreased with the worsening of environment while it increased in the satisfactory ordinary environment in the off-shore open sea.

In the meantime, within the range from the beach to the open sea (15 m), the mean plankton biomass in the dry and the rainy seasons was 0.56 g/m^3 and 0.97 g/m^3 respectively, that is, 1.8 times higher in the rainy season, while the maximum plankton biomass observed in the Bay and open sea was 0.88 g/m^3 (dry season) and 1.49 g/m^3 (rainy season), that is, 1.7 times higher in the rainy season, from which it can be concluded that the total plankton biomass increases in the rainy season as against the dry season. The cause of such increase is considered to be the dissolved organic matter conveyed by the rivers.

Based on the above conclusions, it can be said that the measurement of organic matter (nitrate, nitrite and ammonia) and phosphate, etc. will have to be made in future for further detailed exmination.

D. APPENDEX TABLES

	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	m
15°C	26.00	25.98	25.95	25.93	25.91	25.88	25.86	25.84	25.82	25.79	1,000
16	25.77	25.75	25.72	25.70	25.68	25.65	25.63	25.61	25.59	25.56	1,003
17	25.54	25.52	25.49	25.47	25.45	25.42	25.40	25.38	25.35	25.33	1,005
18	25.30	25.27	25.25	25.22	25.20	25.17	25.14	25.12	25.09	25.07	1,007
19	25.04	25.01	24.99	24.96	24.94	24.91	24.88	24.86	24.83	24.80	1,009
20	24.78	24.75	24.73	24.70	24.68	24.65	24.62	24.60	24.57	24.54	1,011
21	24.52	24.49	24.47	24.44	24.41	24.39	24.36	24.33	24.30	24.28	1,013
22	24.25	24.22	24.19	24.16	24.13	24.10	24.08	24.05	24.02	23.99	1,015
23	23.96	23.93	23.90	23.87	23.84	23.82	23.79	23.76	23.73	23.70	1,018
24	23.67	23.64	23.61	23.58	23.55	23.53	23.50	23.47	23.43	23.40	1,020
25	23.38	23.35	23.32	23.29	23.26	23.23	23.20	23.17	23.14	23.11	1,022
26	23.09	23.06	23.03	23.00	22.95	22.93	22.90	22.87	22.84	22.81	1,024
27	22.78	22.75	22.72	22.68	22.65	22.62	22.59	22.56	22.53	22.50	1,026
28	22.46	22.43	22.39	22.36	22.33	22.29	22.26	22.23	22.20	22.16	1,027
29	22.13	22.10	22.06	22.03	22.00	21.96	21.93	21.90	21.87	21.84	1,029
30	21.80	21.77	21.72	21.70	21.67	21.63	21.60	21.57	21.54	21.50	1,031

Appendix Table I. The conversion table of marine density. (by Makalof)

Cl(°/oo)	S(°/oo)	σ_{15}	Cl(°/oo)	S(°/oo)	σ_{15}	Cl(°/oo)	S(°/oo)	σ_{15}
14.0	25.30	18.55	17.0	30.72	22.70	20.0	36.13	26.86
14.1	25.48	18.69	17.1	30.90	22.84	20.1	36.31	26.99
14.2	25.66	18.82	17.2	31.08	22.98	20.2	36.49	27.14
14.3	25.84	18.96	17.3	31.26	23.11	20.3	36.67	27.27
14.4	26.02	19.10	17.4	31.44	23.25	20.4	36.85	27.42
14.5	26.20	19.24	17.5	31.62	23.39	20.5	37.03	27.56
14.6	26.38	19.37	17.6	31.80	23.53	20.6	37.21	27.69
14.7	26.56	19.52	17.7	31.98	23.66	20.7	37.39	27.83
14.8	26.74	19.65	17.8	32.16	23.81	20.8	37.57	27.97
14.9	26.92	19.80	17.9	32.34	23.94	20.9	37.75	28.11
15.0	27.11	19.93	18.0	32.52	24.09	21.0	37.94	28.25
15.1	27.29	20.07	18.1	32.70	24.22	21.1	38.12	28.39
15.2	27.47	20.21	18.2	32.88	24.36	21.2	38.30	28.53
15.3	27.65	20.35	18.3	33.06	24.40	21.3	38.48	28.67
15.4	27.83	20.48	18.4	33.24	24.64	21.4	38.66	28.81
15.5	28.01	20.62	18.5	33.42	24.78	21.5	38.84	28.94
15.6	28.19	20.76	18.6	33.60	24.92	21.6	39.02	29.09
15.7	28.37	20.90	18.7	33.78	25.06	21.7	39.20	29.22
15.8	28.55	21.03	18.8	33.96	25.19	21.8	39.38	29.36
15.9	28.73	21.18	18.9	34.14	25.34	21.9	39.56	29.51
16.0	28.91	21.31	19.0	34.32	25.47	22.0	39.74	29.64
16.1	29.09	21.45	19.1	34.51	25.61	22.1	39.92	29.79
16.2	29.27	21.60	19.2	34.69	25.74	22.2	40.10	29.92
16.3	29.45	21.73	19.3	34.87	25.89	22.3	40.28	30.06
16.4	29.63	21.87	19.4	35.05	26.03	22.4	40.46	30.21
16.5	29.81	22.01	19.5	35.23	26.17	22.5	40.64	30.34
16.6	29.99	22.15	19.6	35.41	26.31	22.6	40.82	30.48
16.7	30.17	22.28	19.7	35.59	26.45	22.7	41.00	30.62
16.8	30.35	22.42	19.8	35.77	26.58	22.8	41.14	30.77
16.9	30.53	22.56	19.9	35.95	26.72	22.9	41.36	30.91

Appendix Table II. Knudsen's Table

CHAPTER VI. VARIATION OF CURRENTS AND MONSOON WINDS IN THE SOUTH CHINA SEA

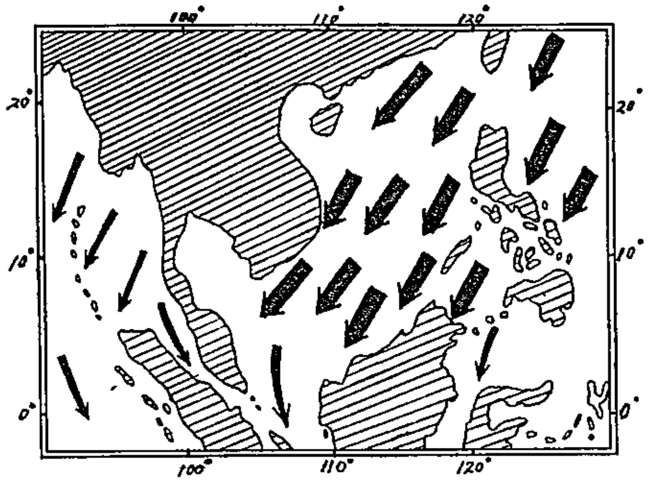


Figure 15 Northeast Monsoon Wind
(October - March)
(by the Naga report)

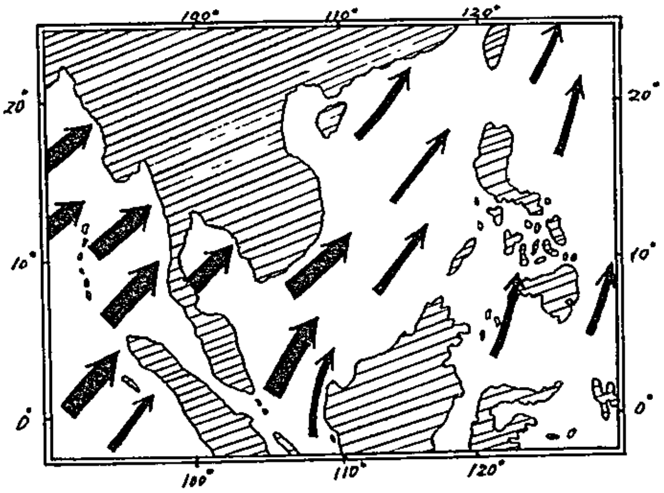


Figure 16 Southwest Monsoon Wind
(May - September)
(by the Naga report)

It seems to be very important to know the characters of the China Sea, which faces Viet-Nam; especially its currents, winds, salinity and the mutual relationships among them.

Therefore, in this chapter the results of Naga Expedition (1959 - 1961) is quoted as reference.

The character of the winds indirectly influences the life in the sea. Southeast Asia is dominated by two seasonal wind patterns; the northeast (Figure 15) and the southwest monsoon (Figure 16).

In summer the land mass, especially the area north of the Arabian Sea, is more heated than the sea and becomes a large, low-pressure area. This condition creates southwest monsoon winds, which generally blow from over the water toward the land or from the southwest. The stress of these monsoon winds on the water establishes the horizontal and vertical currents of the Southeast Asian marine environment.

In winter the land, especially the Plateau of Tibet in South China, becomes colder than the sea, and the wind direction is reversed as the air blows from the northeast toward the tropical seas. Since the winds are reversed, their effect on water circulation is nearly reversed. The west coasts of land masses then become upwelling centers and areas of nutrient enrichment.

The charts of the transports are constructed for every second month and are presented together with the charts of the surface currents, (Figures 17-22). The numerical values of the transports in the different current branches are given in the following Table 18 and Table 19.

Current	Feb.	Apr.	June	Aug.	Oct.	Dec.
South Asian Waters						
Luzon Strait, westwards positive	+2.5	0	-3.0	-2.5	+0.5	+3.0
Macassar Strait, southwards	1.5	1.0	1.0	1.5	1.0	0.5
China Sea, off Viet-Nam southwards positive	+5.0	+1.5	-3.5	-3.0	+2.0	+5.0

Current	Feb.	Apr.	June	Aug.	Oct.	Dec.
Java Sea, eastwards positive	+4.5	+0.5	-3.0	-3.0	+0.5	+4.0
Flores Sea, eastwards positive	+6.0	+2.0	-2.5	-2.0	+1.0	+4.5
Banda Sea, upwelling positive sinking negative	-2.0	-0.5	+2.0	+1.5	-0.5	-1.0
Timor Current, westwards	1.0	1.5	1.0	1.5	1.5	1.5
Halmahera Sea, southwards positive	-2.0	+1.0	+3.0	+3.5	+2.0	-1.5

Table 18 Transports (millions m^3/sec) of different currents in the Southeast Asian Waters. (by the report of Naga Expedition)

Current	Feb.	Apr.	June	Aug.	Oct.	Dec.
Pacific Ocean						
North Equatorial Current	41	32	41	39	37	37
Mindanao Current..	12	8	9	10	9	12
Formosa Current...	24.5	37.5	35	30.5	27	21.5
Indian Ocean						
Source of the South Equatorial Current..........	16	12	8	10	14	14
South Equatorial Current (southwest of the Sunda Strait resultant flow from the Indonesian....	20.5	19.5	16.0	16.5	16.0	17.0

Table 19. Transports (millions m^3/sec) of different currents in the Southeast Asian Waters. (by the Naga report)

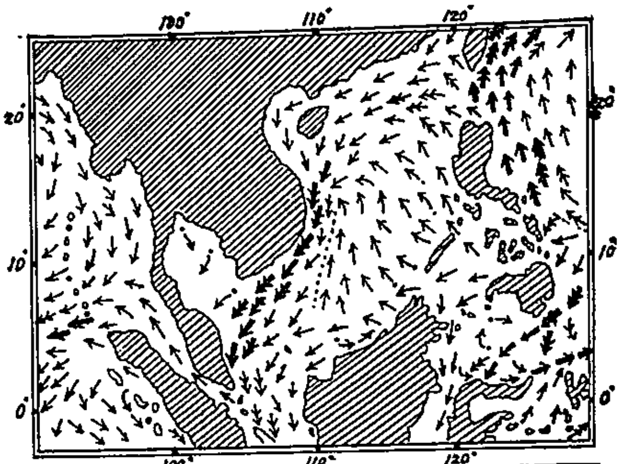


Fig. 17
Surface currents in February.

Fig. 18
Surface currents in April.

Fig. 19
Surface currents in June.

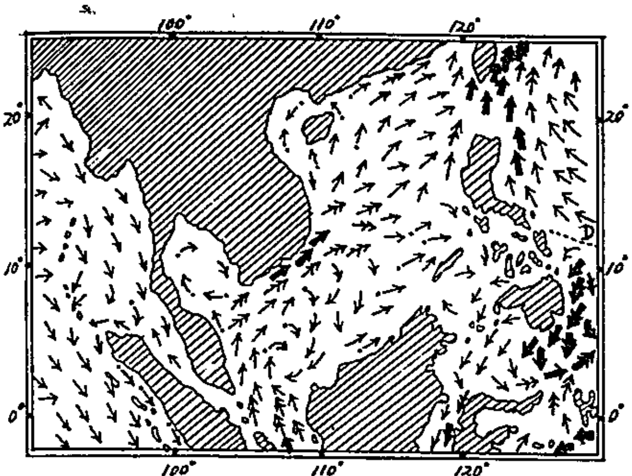


Fig. 20
Surface Currents in August.

Fig. 21
Surface currents in October.

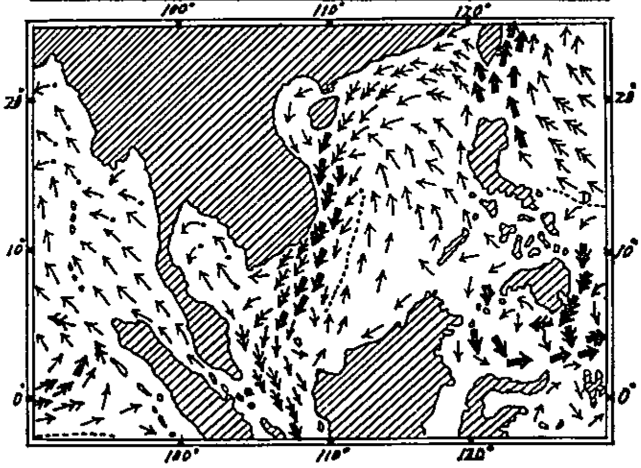


Fig. 22
Surface currents in December.

12 cm/sec
25 "
38 "
50 "
75 "
100 "
current boundaries
D .... Divergence
C .... Convergence

Three almost separate circulations are distinguished. The first is the circulation in the Pacific Ocean, which affects the eastern parts of the region, but enters the Eastern Archipelago only in the range of the Celebes Sea. The second is the circulation of the Indian Ocean, where only the South Equatorial Current is included but which has no influence on the Southeast Asian Waters. The third is the circulation within the Southeast Asian Archipelago, which is determined by the monsoons. This monsoon circulation, as it might be called, is connected with the circulation in the Pacific Ocean to a small extent and linked with that of the Indian Ocean only by the Timor Current.

The monsoon circulation develops chiefly along the China Sea - Flores Sea - Banda Sea line, because these regions lie with their axis almost in the direction of the winds during both monsoons.

During the full development of the north monsoon the transport of the Monsoon Current through the Java Sea is about 4 million m^3/sec. In the China Sea the transport of the strong current branch off the coast of Viet-Nam is larger, because the transport of the eddy in the central parts of the China Sea has been added. The water masses of the Monsoon Current come during the north monsoon out of the North Equatorial Current and enter the China Sea chiefly through the Luzon Strait, smaller parts enter through the Philippines and the Sulu Sea. A relatively small transport of water occurs also through the Formosa Strait.

During the change from the north to the south monsoon in April, the whole circulation within the Southeast Asian Waters is only weakly developed, (Figure 18). In the China Sea two big eddies are found with a transport of 1 to 2 million m^3/sec each. The current still flowing eastwards in the Java Sea transports only 0.5 million m^3/sec, joins the water coming out of the Macassar Strait and forms along the north coast of the Lesser Sunda Islands a rather strong current of 2 million m^3/sec. From the Pacific Ocean a weak transport occurs through the Philippines and the Sulu Sea into the China Sea.

During the south monsoon the conditions are nearly inverse to those during the north monsoon, but the average transports of the Monsoon Current are smaller. In the southern China Sea a small eddy exists, but its transport is weak.

In October the change from the south to the north monsoon takes place over most of the region, and over the northern China Sea the north monsoon has already strated with considerable strength. The Monsoon Current along the coast of Viet-Nam is already developed and transport 2 million m^3/sec southwards, but the larger part of this water turns northwards before entering the southern China Sea and is transported back along the coast of Borneo.

In December (Fig. 22) and February (Fig. 17) at the full development of the north monsoon a strong southward transport takes place in the whole China Sea, but not all its water can flow into the Java Sea. Consequently a pilling up of water occurs in the South China Sea and causes the development of counter-currents in the central and eastern parts. The deflection of the current to the right and the pilling up of water along the Asian coast with the highest sea level in the Gulf of Thailand are clearly seen. In the South China Sea at the equator where no slope exists, the currents are pure wind drifts.

Summarizing, the transport chart for October shows the formation of the Monsoon Current in the north monsoon season and the chart for April, the decay of this current. The Monsoon Current of the south monsoon season is formed in May and decays by the end of September. (Figure 15 -22).

The variation of Salinity in the China Sea.

The China Sea as the largest in these waters has a more oceanic character than the other seas. This is indicated by the relatively small annual variations of salinity in its northern and southern parts. The northern part receives water of high salinity from the Pacific Ocean during the northeast monsoon. These waters spread from the south of Formosa to the west and later along the coast of Viet-Nam to the south, The salinity gradually decrease in the direction of the flow, which gives the typical picture of a tongue-like spreading. The relatively dry air masses of the strong northeast monsoon also cause a considerable evaporation, which exceeds the rainfall from October to March, so this period has a surplus of evaporation of 620 mm. This would be sufficient to increase the salinity of a 70 m thick homogeneous layer by 0.3 $^o/_{oo}$. But the observed increase during this season is 0.7 $^o/_{oo}$, which shows that influx of water of high salinity also contributes to the increase of salinity. With the beginning of the southeast monsoon and the rainy season in May, the waters of high salinity are pressed back to the north, and their salinity is also decreased by the rain. The excess of the rainfall during this season is about 820 mm, which corresponds to a decrease of almost 0.7 $^o/_{oo}$ in salinity in a homogeneous layer of 40 m during this season. Off the south coast of China and along the coast of Viet-Nam the annual variation is larger, due to the river discharge and to the increase of rainfall towards the land.

In the central parts of the China Sea the annual variation of salinity is higher than in the regions north and south of it. Rainfall and evaporation can no longer be regarded as the dominant factors, especially as evaporation decreases rapidly towards the south while rainfall increases, so currents produce the variation of the salinity. The central parts of the China Sea are alternately filled with waters of higher and lower salinity. With the northeast monsoon, water of high salinity is transported along the coast of Viet-Nam to the south. In the central parts there is a counter-current flowing in the opposite direction and carrying less saline water to the northeast. This effect can clearly be seen in the chart of February (Figure 23). During the southwest monsoon the situation is reversed, that is water of about 32.5 $^o/_{oo}$ is transported along the coast of Viet-Nam to the north, and in the central parts a counter-current carries water of above 33.2 $^o/_{oo}$ to the southwest (Figure 24). Because on the average the rainfall exceeds the evaporation in this region, the salinity of the passing water is continuously decreased, though only by a small amount. The relatively big annual variation of about 1.1 $^o/_{oo}$ is caused by currents carrying water of different salinities during the two monsoons.

Off the mouth of the Mekong the annual variation increases to more than 2 $^o/_{oo}$, whereas in the Gulf of Thailand it amounts to about 1.3 $^o/_{oo}$, although this value is still uncertain because of the small number of observations. The salinity in the Gulf of Thailand varies between 30.5 $^o/_{oo}$ in January and 32.0 $^o/_{oo}$ in September. This means that the maximum occurs at the end of the rainy season, after which a decrease of the salinity is observed. But the maximal discharge of the rivers normally occurs at the end of the rainy season, which may explain this variation. On the other hand the waters of low salinity, formed off the mouth of the Mekong, are pressed by the winds into the Gulf from October to January and cause a low salinity.

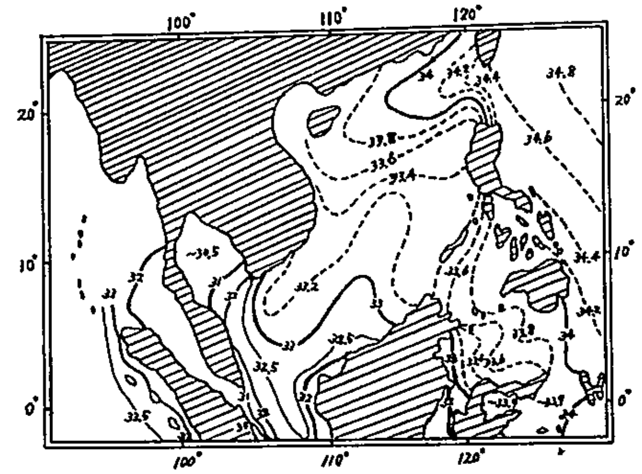


Figure 23. Average surface salinity (‰) in February, drawn from observations in the years 1950-1955.

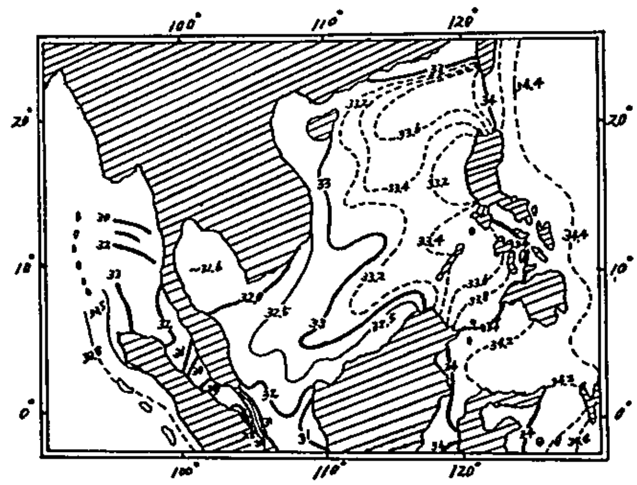


Figure 24. Average surface salinity (‰) in August, drawn from observations in the years 1950-1955.

CHAPTER VII. CONCLUSIONS AND PROSPECT FOR THE FUTURE OF PLANKTOLOGY IN SOUTH VIET-NAM

It may be concluded that in South Viet-Nam, fresh water plankton and marine plankton are abundant in species, but not in quantity.

A. FRESH WATER PLANKTON

From the results of the survey made by the author in and after 1963, a conclusion can be drawn that the mean plankton biomass in general lakes and marshes in South Viet-Nam is below 1.0 g/m^3 with 0.3 g/m^3 as the average.

Recorded as the greater plankton biomass were 14.3 g/m^3 (mostly Cladocera and Copepoda) in the case of Da-Nhim Dam in Dalat, over 40 g/m^3 (mostly Euglena) in a small reservoir at Cholon and 28.5 g/m^3 (mostly Cyanophyta) at Ca-Mau, the average being 8.0 g/m^3. The places at which such higher rates of biomass were observed are dams, small reserviors containing accumulated dusts or artificial swamps made by damming up a stream and and fall under the category of "special environment". In respect of PH, it was 6.5 (water temperature: 25.6°C) in the dam at Dalat, 7.9 (water temperature: 32.0°C) in the reservoir at Cholon and 7.2 (water temperature: 27.8°C) in the artificial marsh at Ca-Mau, all of which are pretty higher than the average PH of 5.8 for the entire Viet-Nam, and even by merely judging from the above mentioned PH values, it is apparent that phyto-plankton exists in great mass at these points (except the dam at Dalat) and photosynthesis is being carried on actively.

Though lakes and marshes having a low PH value of 4.0 can be found on rare occasions in South Viet-Nam, the mean PH 5.8 of lakes and marshes for the entire area is a lower value compared with the mean PH 6.8-9.0 in the case of other ordinary lakes and marshes. Generally, the range of PH suitable for plankton is 7.0 to 8.0. From such low PH, it can be judged that plankton biomass in Viet-Nam is smaller. It is therefore assumed that such low PH is adversely affecting the multiplication of plankton in the lakes and marshes, entailing the decrease of fresh water plankton biomass in Viet-Nam.

The cause of low PH in the fresh water lakes and marshes are not clear, but such acidic water is considered to be originating from organic corrosive acid or inorganic strong acid. However, even in the lakes and marshes having such low PH adversely affecting the multiplication of life, it is possible to promote normal multiplication of life by addition of lime, etc. to make neutral the water of such lakes and marshes.

Though the author did not apply neutralization test to all the waters having low PH, he tried the addition of lime, $NaHCO_3$ $Na_2S_2O_3$, etc. to a few lakes and marshes and ascertained that the normal multiplication of phyto-planktons (Scenedesmus) and zoo-planktons (Euglena of phyto-mastigophora and Moina as well as Daphina of Cladocera) could be achieved thereby. Needless to say, there may exist certain waters which do harm to life even after neutralization treatment, but in cases where it is desired to progressively multiply plankton as feed for larvae of fishes in a fish pond or to breed fish utilizing a lake or marsh, the PH of water will be one of the important problems to be considered.

B. MARINE PLANKTON

According to the survey (1963-1965) by A. Shirota, the plankton biomass in the South Viet-Namese coastal water (15 to 20 km from beach) is 1.0 g/m^3 or below, with 2.0 g/m^3 as the maximum and 0.3 g/m^3 or less as the average. On the other hand, it was found that the plankton biomass (in September) or the west side of Ca-Mau Peninsula, that is, in the Gulf of Thailand including Rach-Gia and Phu-Quoc was 0.6-0.8 g/m^3, a value 2 to 3 times higher than that in the South China Sea coastal water.

In the meantime, according to Naga Expedition (1959-1961), the plankton biomass in the South China Sea more than 100 km off-shore from the beach is 0.1 cc/m^3 in the case of zoo-plankton in the coastal waters ranging from the Hue (N. Lat. 16°30') to about E. Long. 110° including Nhatrang-Phan-Rang, 0.05 cc/m^3 in the further off-shore water and 0.15 cc/m^3 in the water within the range from Phan-Rang to the southern tip of Ca-Mau Peninsula which falls on N. Lat. 5-6° whereas the plankton biomass in the coastal waters ranging from the southern tip of Ca-Mau Peninsula to Phu-Quoc varies with the seasons, that is, 1.0-1.1 cc/m^3 in the rainy season (April, May) and 0.3-0.5 cc/m^3 in the dry season (August to Januaru).

Combining both results, it was found that the plankton biomass in the coastal water west of Ca-Mau Peninsula is 2 to 5 times higher as compared with that on the east side, that is, in the range from Hue facing South China Sea to the southern tip of Ca-Mau Peninsula, thus possessing a higher productivity.

The cause is considered to be lying in the topography of Ca-Mau Peninsula which is different from other areas. That is, as is clear from the picture included in Chapter X, it is considered that nutrient salts conveyed by numerous canals or rivers running lengthwise and crosswise through the Peninsula exerted influences upon the multiplication of plankton in the coastal waters. The tendency was more conspicuous in the rainy seasons.

Though the climate in South Viet-Nam is characteristic in it that the dry and the rainy seasons are controlled by monsoon, the quantity of plankton is also influenced thereby. Taking Nhatrang Bay and its open sea as the examples A. Shirota (1963b) looked into the changes in plankton biomass as well as the environmental conditions at the standing points in the dry and the rainy seasons and confirmed that (1) the plankton biomass in larger in the Bay in the dry season than in the open sea, (2) in the case of the rainy season it is larger in the open sea than in the Bay and (3) the total plankton biomass including both the Bay and open sea is larger in a rainy season as compared with the case of a dry season.

Though the species of plankton are similar to those in the temperate zone, Trichodesmium of Cyanophyta are found in the entire area, which often accounts for more than 80% of the total sample and is considered to be one of the characteristics of the southern zone. Further, Salpa, Doliolum, Oikopleura and Sagitta are the species able to be found most commonly while luminescent Sapphirina and Corycaeus too are discovered commonly over the entire area.

C. PROSPECT FOR THE FUTURE

It is generally said that the plankton biomass in the southern zone, that is, low latitude zone is approx. 1/5-1/10 as compared with the high altitude zone. This also applies to South Viet-Nam. If the volume of resources of fresh water and marine pisces, crustacea, mollusca, etc. is estimated on the basis of the above-mentioned plankton biomass, it may be given as a conclusion that the volume is quite small.

At present, some 1 ton fishing boats account for the greater part of the total fishing boats in South Viet-Nam and the fish catch amounts to 500,000-600,000 tons a year. If, however, the fishing industry makes progress and a modern catching method comes to be adopted, inland water and marine resources will be exhausted quite quickly. And yet, the recovery capacity of fishery resources after haul is considered to be quite small judging from the small standing crop of plankton. Accordingly, the future of South Viet-Namese inshore fishery is not very bright.

If, however, one reviews here again the following geographical environments of South Viet-Nam, that is,

1. Climate and natural features are subject to monsoon and can be divided clearly into the dry and the rainy seasons;

2. The temperature difference as well as water temperature difference is small throughout the year and the temperature is high;

3. The water temperature of 25-28°C affords an environment suitable for the growth of many aquatic animals; and

4. No typhoon nor natural calamity and little gale, it may be said that the above conditions are quite favorable in connection with the utilization of ocean, lake and marsh and especially with the fishing industry in it that the temperature is not so low as in a high latitute zone and the possibility of calamities due to typhoon as in the case of Japan does not exist in South Viet-Nam.

In short, the question is how to utilize these favorable conditions and the author thinks that the key to the solution of this question is breeding under positive artificial management. Of course the organism coming into question in this case should be (1) the species suited to the taste of people, (2) costly and (3) well manageable and further, in the sense of acquisition of foreign currencies, (4) the ones exportable.

For instance, in South Viet-Nam, the crustacea can be said to be the most promising species meeting the above requirements. The crustacea is one of the species most difficult to be cultured in the world. The difficulty consists, needless to say, in the environmental conditions in course of growth and especially in the feed to be furnished at the larval stage, and the survival rate of larvae of crustacea is determined depending on the quanti of plankton serving as their feed. It is said that naturally more than 95% of hatched larvae die. In the area abundant in plankton in South Viet-Nam, that is, on the west coast of Ca-Mau Peninsula not only pisces, but also considerable quantities of crustacea are caught and they were exported to the adjoining countries, U.S.A., etc. in former times while at present too, some crustacea are being exported. The fact that even a natural catch leaves a margin for export tells that if artificial culture were undertaken, the production scores of times higher could be expected.

Accordingly, the possibility of culture of plankton, especially Diatoms, Phyllopoda and Copepoda to serve as feed for the larvae can be said to be one of the keys to the success of crustacea culture. In this sense, the culture of plankton in large quantities has a great significance and in connection therewith, economical and low-priced feed will become the problem for future. For that purpose, the study of the physiology and primary production of plankton itself must be pushed forward actively.

If it were possible, in this way, to know the physiology of the organisms in question, utilize the favorable environmental conditions in Viet-Nam and progressively manage and breed such organisms, the future of the marine product industry of Viet-Nam would be quite bright and at the same time, the development of oceanographic and limnetic studies could be expected.