PLANKTON STUDIES IN A MANGROVE ENVIRONMENT

II. THE STANDING STOCK AND SOME ECOLOGICAL FACTORS

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SYNOPSIS

This work was undertaken to obtain information on seasonal variation of the plankton communities of the Cananéia mangrove system. The results provide a background for further investigations on primary and secondary productivity and the study of the interrelationships of ecological factors that affect the distribution and abundance of plankton. The correlation of data obtained shows that in the mangrove system under study there are different environments with distinct species.

INTRODUCTION

The waters of the mangrove environment have remained practically unstudied. Studies have been carried out on the flora and fauna, zonation and association of species, but little has been done in relation to primary and secondary productivity of these waters.

Brazilian mangroves extend from Santa Catarina State at about 27° Lat. S to Oyapoc river about 4° Lat. N (Gessner 1955, Tafel V).

Some observations on them, were made by Gerlach (1958) at Cananéia region (25° Lat. S), of about 280 square miles. Teixeira and Kutner (1963) made a preliminary assessment of standing stock of its waters and of principal ecological factors.

The scope of the present paper is to give the results of preliminary studies on the mangrove swamp waters environment, in particular the relationships between seasonal variation of standing stock and certain ecological factors.

A quantitative analysis of phytoplankton and zooplankton provided an estimate of the standing stock at selected stations. Quantitative analysis were made to determine the distribution of several organisms at different depths. Measurements of suspended matter and cultures of bacterioplankton were made to determine the concentration of leptopel and the degree of pollution of the waters.

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Observations were also made on pH, chlorinity and salinity, dissolved oxygen, transparency of water, water temperature, wind, annual precipitation and solar radiation.

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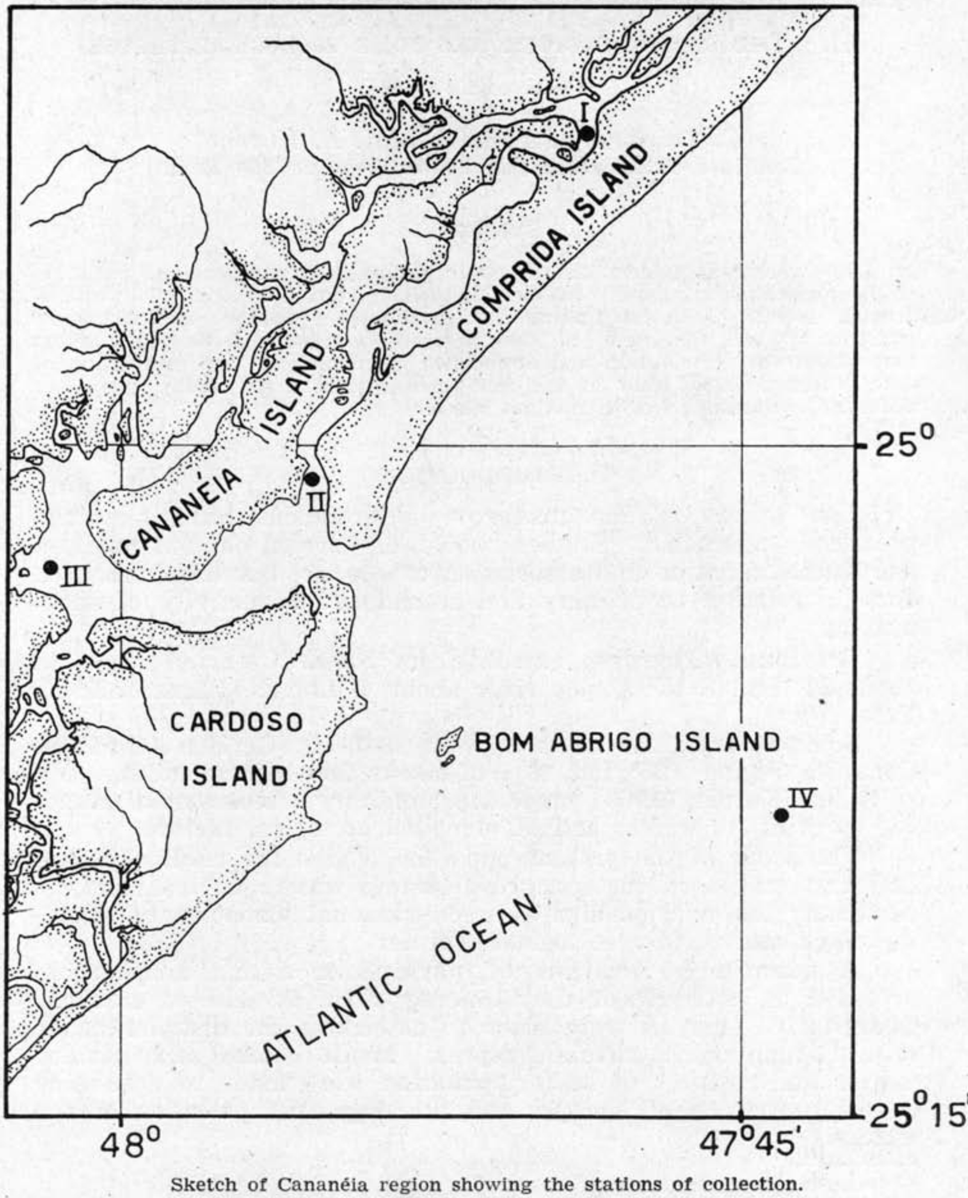

Sketch of Cananéia region showing the stations of collection.

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STATION COLLECTION

During 1962, collections were made in January, April, July and October at four stations: three in inshore waters, (St. I: Aroeira, St. II: Argolão, St. III: Arirí) and one in offshore waters (St. IV) (see sketch).

MATERIAL AND METHODS

An 8-litre bottle was used to collect the samples. Such bottles are more efficient in catching the smaller zooplankton organisms than the Hensen or the single conic nets.

Several authors (Hansen & Andersen, 1962) stressed the importance of considering the smallest herbivores in the role of productivity in the sea. From each point at all stations, samples were taken to determine salinity, oxygen, suspended matter, phytoplankton, bacterioplankton and net-plankton. Water for the net-plankton was collected with silk plankton net mesh no. 25. At the surface, 40 litres were taken and at others depths 24 litres. After the counts were made, the same material was used to determine the organic matter of the net-plankton.

The depths of sampling were as follows:

Station	I —	0.0; 1.5; 3.0 m
"	II —	0.0; 5.0; 10.0; 15.0 m
"	III —	0.0; 3.5; 7.0; 10.0 m
"	IV —	0.0; 5.0; 10.0; 15.0 m

The phytoplankton collected was preserved in neutral formalin and was allowed to set overnight in a 20 ml cylindrical chamber. Phytoplankton counts were made at 500 × magnification with Zeiss inverted microscope. Zooplankton counts were made with a magnification of 96 ×.

The standard plate count method was used for the bacteria.

THE PHYTOPLANKTON

a) Taxonomic observations.

The diatoms were always the most abundant constituents in the phytoplankton samples. The genus *Skeletonema* occurred in considerable numbers and dominated the population.

The Chlorophyta were the next in frequency of occurrence. Other phytoplankton organisms were: Dinoflagellates, Coccolithophorides, Silicoflagellates and Cyanophyta (Fig. 1).

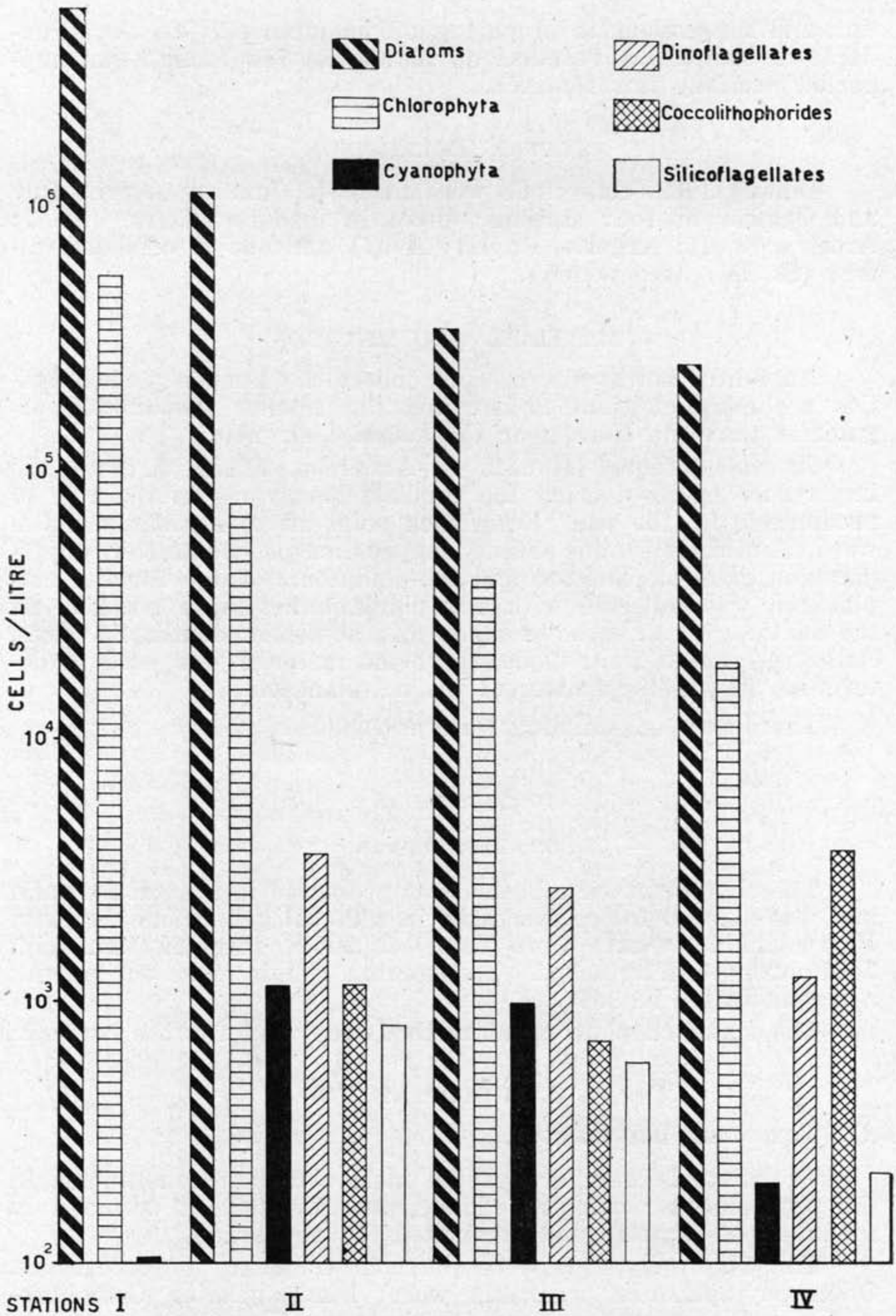

Fig. 1 — Phytoplankton organisms present at the four stations.

There are several reports on the diatoms flora of the Cananéia region (Carvalho 1950; Müller-Melchers 1955; Andrade & Teixeira 1957; Teixeira & Kutner 1961).

Thus the following observations have been confirmed for the lesser known groups.

Dinoflagellates — The dinoflagellates are not well represented and are here of minor importance as primary producers. The commonest and most abundant genus was *Ceratium* and sometimes for limited periods, *Noctiluca*. *Peridinium, Dinophysis, Prorocentrum, Exuviella, Goniaulax, Gymnodinium* and *Ornithocercus* were found in smaller quantities. Dinoflagellates were found at St. II, III and IV. None was found at St. I.

Coccolithophorides and *Silicoflagellates* — Neither of these seemed be quantitatively very important constituents of the inshore waters. In general the Cocooliths occurred regularly only in coastal waters (St. IV). The samples of stations I, II and III did not contain a characteristic Coccolith flora. The Silicoflagellates were the less abundant element of the population, and were found at St. I, II, III and IV. The following genera were observed: *Dictyocha, Hermesium* and *Distephanus*.

Chlorophyta — Some genera of the families Clamydomonadaceae, Chloroccocaceae and Chlorellaceae were found at all stations but the bulk of these organisms was present at St. I. The greatest part of them, were flagellates of unidentified genus. The important role played by these minute pigmented organisms in the energy flow in the sea has recently been emphasized by several authors. (Wood & Davis 1956; Yentsch & Ryther 1959; Collier & Murphy 1962). However, probably due to the technical difficulties, the group has been largely overlooked and species have usually remained unidentified.

Cyanophyta — Except for some references to blooms of *Trichodesmium* in coastal waters we have so far not been aware of any occurrence of planktonic blue-green algae. Several different species were found at inshore and coastal waters during these investigations. *Merismopedia* sp. was found at the four stations and occasionally some *Oscillatoria, Anabaena, Lyngbia* and *Spirulina* were collected but never abundantly in inshore waters.

b) Quantitative Analysis of the Phytoplankton.

The number of organisms present per given volume of water showed some evidence of seasonal variation. Analysis of the total

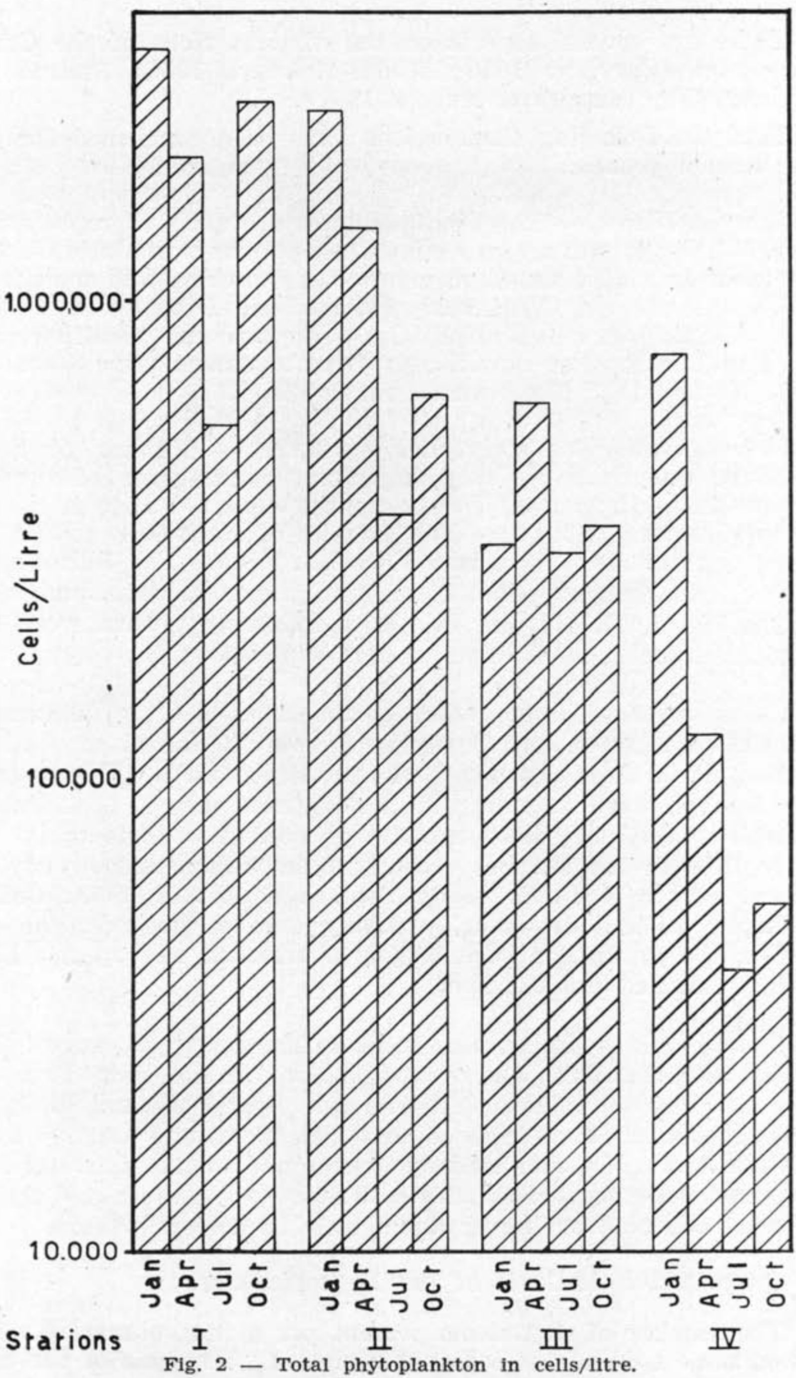

Fig. 2 — Total phytoplankton in cells/litre.

phytoplankton found during the entire period shows a great difference between the stations within the inshore and those that are located in coastal waters.

The planktonic populations at the four stations were dissimilar quantitatively and qualitatively. The mean phytoplankton standing stock during the period studied was of 1,249,756 organisms per litre at St. I, II, III within inshore waters, whereas there were 247,910 per litre at St. IV (coastal waters) (Fig. 2). This difference may be attributed to better eutrophic conditions within inshore waters associated with the hydrographical conditions of the whole region. The bulk of the phytoplankton taken measured in number of organisms per litre was composed of diatoms and Chlorophyta; the latter with a peak at St. I.

The diatoms of the genus *Skeletonema* were present during the four seasons when collections were made and almost always represented the dominant species, comprising from 18.2% to 63.6% of the total phytoplankton in the lagoon waters.

Comparatively *Skeletonema* is rare in the open coastal waters. By comparison, the species *Melosira* sp., *Cyclotella menighiniana, Chaetoceros pseudo-curvisetus, Navicula* sp., *Cyclotella* sp., *Asterionella japonica* and others species were present in smaller quantities (Fig. 3).

Neglecting the qualitative differences, the mean overall standing-stock at the stations, showed a well defined maximum in January and a minimum in July.

THE ZOOPLANKTON

a) Composition

The bulk of the zooplankton was composed of adults, immature and larval Copepoda. Sporadic maxima of Mollusca larvae and Tintinnoidea were observed. The other groups present in smaller numbers were Coelenterata, Cladocera, Chaetognatha and Copelata. Eggs of Copepods occurred at all stations except at St. IV in October.

The Copepod Population

Two Cyclopoid species were found: *Oithona ovalis* Herbst common in inshore waters and *Oncaea media* Giesbrecht which occurred in large numbers in coastal waters.

Three Calanoida were present in inshore waters: *Paracalanus crassirrostris* Dahl, *Acartia lilljeborghi* Giesbrecht, *Pseudodiaptomus acutus* Dahl. *Paracalanus crassirrostris* appeared in great abundance, *Acartia* and *Pseudodiaptomus* were present with spo-

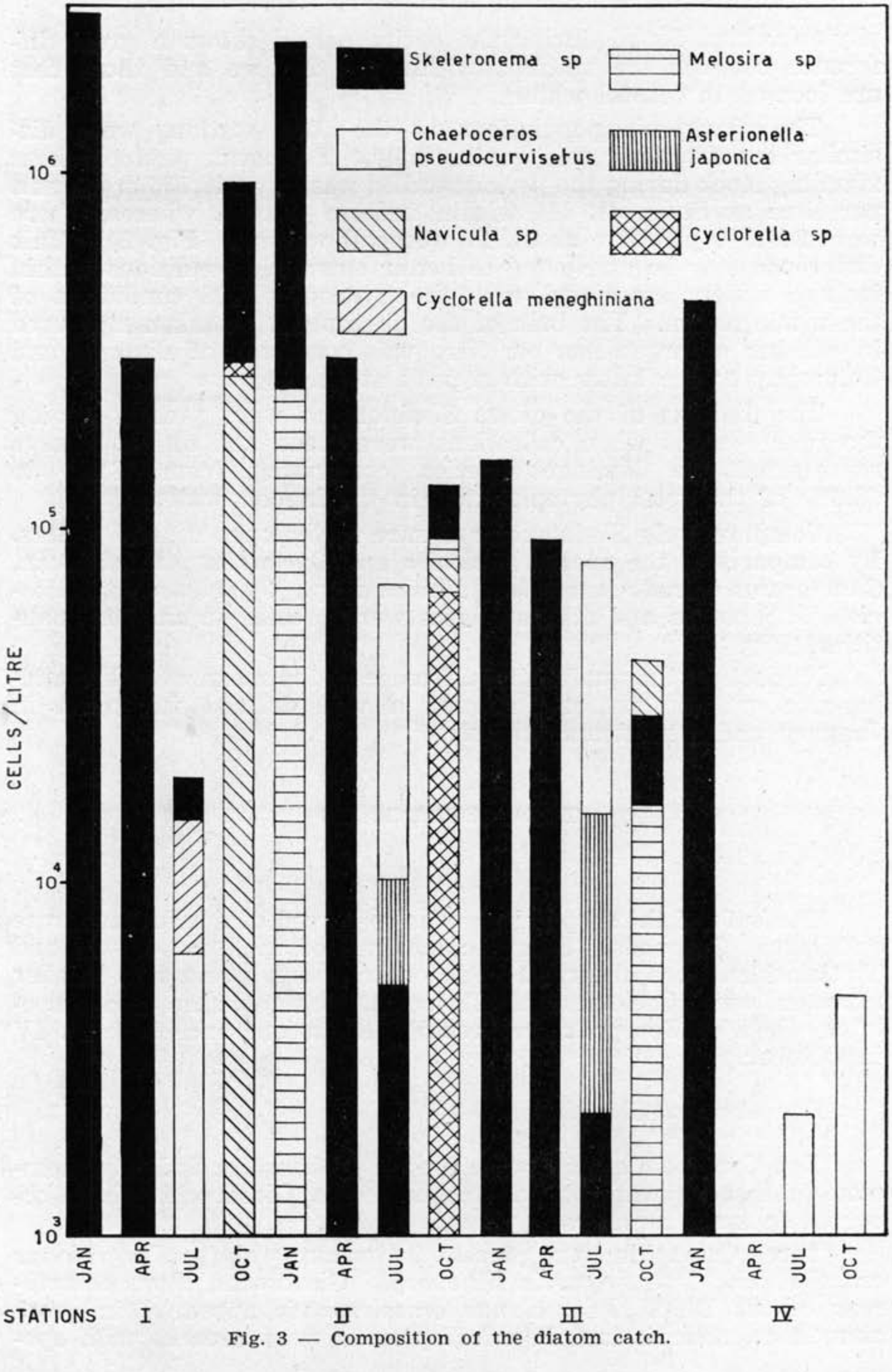

Fig. 3 — Composition of the diatom catch.

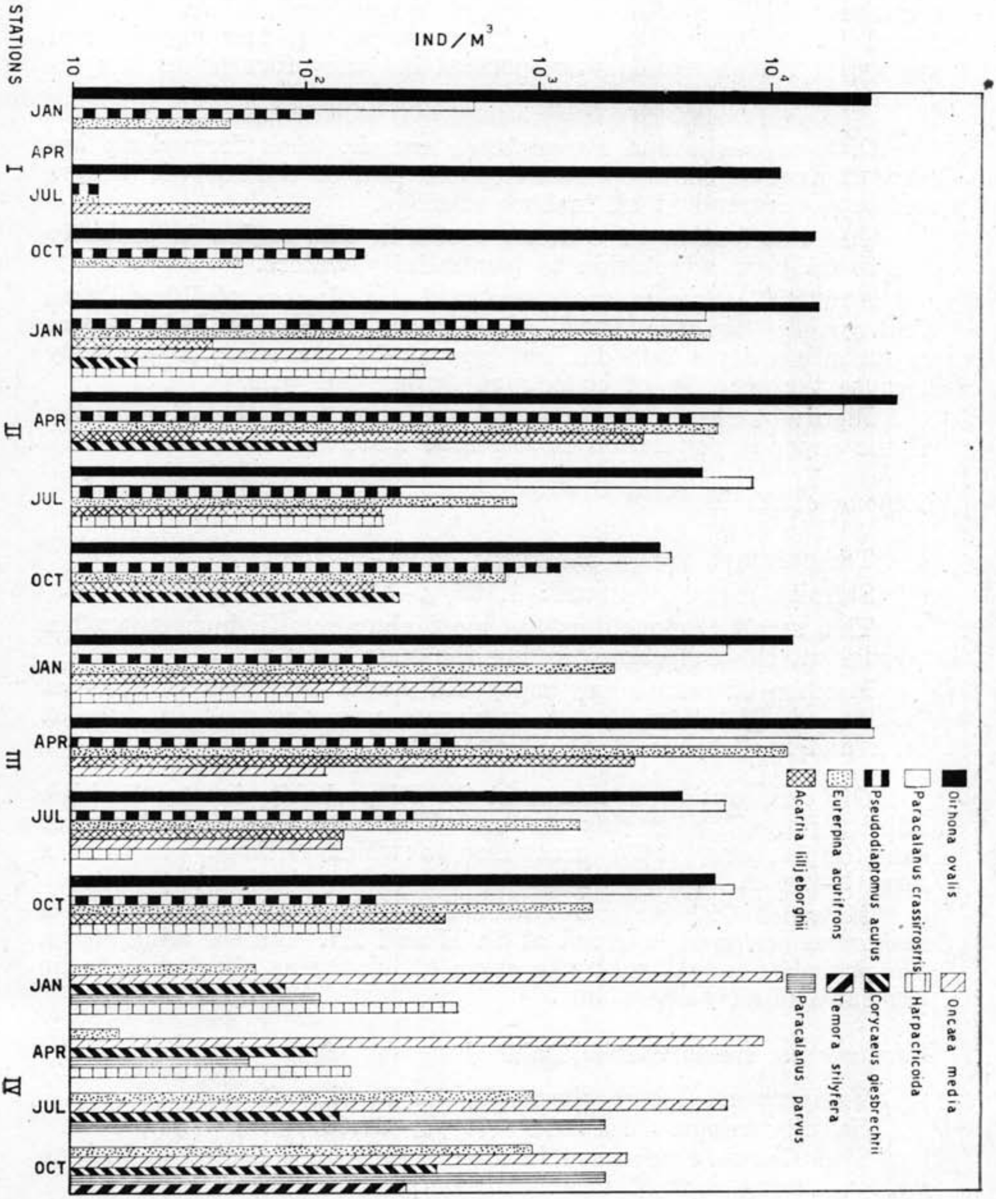

Fig. 4 — Seasonal variation of copepod population.

radic maxima in inshore waters. One Calanoid occurred only in coastal waters in our samples: *Paracalanus parvus* Claus.

Two Harpacticoids were identified: *Euterpina acutifrons* Dana, observed in coastal and inshore waters and *Microsetella* sp. found in small numbers in inshore waters. A few unidentified species of Harpacticoids were present but they formed an insignificant part of the population.

Oithona ovalis and *Paracalanus crassirrostris* formed an important part of the zooplankton population of the inshore waters and both occurred at all inshore stations.

The distribution of *Oithona ovalis* in this region is probably due to its good adaptation to low salinity waters.

At St. IV, other copepods occurred, e.g. *Temora stylifera* Dana, *Centropages furcatus* Dana. *Labidocera fluviatilis* Dahl occurs in inshore waters but did not appear in our samples probably because the scarcity of collections during the year.

Figure 4 shows the seasonal variation and the distribution of the copepod population in the four stations.

Oithona ovalis Herbst

Temperature range observed: 18.98 - 27.70°C.

Salinity range observed: 1.16 ‰ - 31.13 ‰.

This small Cyclopoid is the most abundant in inshore waters throughout the collections during the four seasons.

Maxima of adults and copepodid stages occurred in April at St. II and III (Fig. 5). A minimum was observed in July at St. I and in October at St. II and III.

Oithona ovalis was scarce at St. IV probably due to the high salinity prevailing at this station. The results confirmed earlier data (Björnberg, 1963) according to which *Oithona ovalis* is a form living in inshore waters.

Males of *Oithona ovalis* were found in small numbers and a maximum occurred in April at St. II and III. As the adult males are probably caught with the same efficiency as the females, the sex ratio observed was low.

Paracalanus crassirrostris Dahl

Temperature range observed: 18.98 - 27.70°C.

Salinity range observed: 3.60 ‰ - 31.60 ‰.

This Calanoid occurred in all the samples collected in inshore waters during each of the four months.

Large number of *Paracalanus crassirrostris* was observed at St. II and III. The presence of this species in coastal waters was observed by Björnberg (1963). Our results show that this species is more abundant per unit volume of water in inshore waters than in coastal waters.

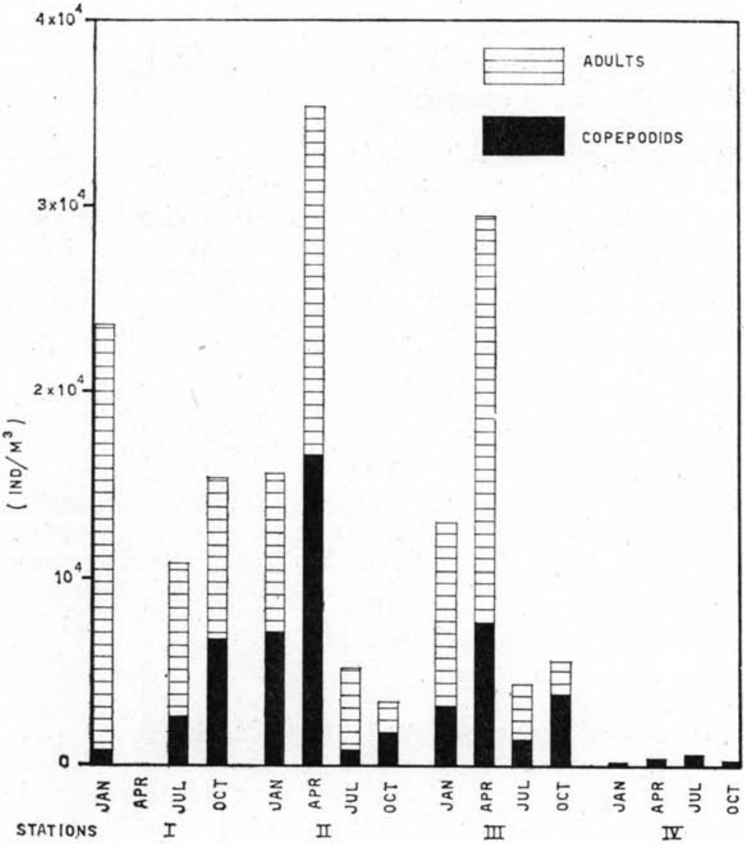

Fig. 5 — Number of adults and copepods stages of *Oithona ovalis*.

Oncaea media Giesbrecht

Temperature range observed: 18.45 - 27.75°C.

Salinity range observed: 23.35 °/₀₀ - 35.25 °/₀₀.

This species was present at St. IV in great abundance while only in small numbers in inshore waters. A maximum occurred in January. There was a gradual decrease of individuals per m³ of sea water throughout April and July and a minimum occurred in October. These results confirm the data of Björnberg (1963) showing that *Oncaea media* is a typical coastal species.

It is euryhaline and eurythermic for higher temperatures and salinity than those observed in our samples. Inshore waters are not the optimum habitat for this species. *Oncaea media* is an occasional visitor in inshore waters; it only occurred in samples from the bottom water, thus indicating the presence of coastal water in the lagoon region.

Acartia lilljeborghi Giesbrecht

Temperature range observed: 24.78 - 27.79°C.
Salinity range observed: 19.80 ‰ - 32.94 ‰.

The maxima of this species occurred in April at St. II and III. A minimum was observed in January at St. III and in July at St. II. The presence of *Acartia lilljeborghi* was limited to St. II and III in inshore waters. This species was absent at St. I probably because of the lower salinities.

Pseudodiaptomus acutus Dahl

Temperature range observed: 18.98 - 27.88°C.
Salinity range observed: 5.75 ‰ - 31.13 ‰.

This species was limited to St. I, II and III. A small number of individuals was observed at St. I. A minimum occurred in January at St. III and in July at St. I and II. The presence of this species in the mangrove region confirms the results obtained by Björnberg (1963).

Euterpina acutifrons Dana

Temperature range observed: 18.33 - 27.88°C.
Salinity range observed: 14.00 ‰ - 35.25 ‰.

Euterpina acutifrons was the only species observed at St. IV in large quantities and which also occurred in large quantities in inshore waters.

Maxima for this species occurred in April at St. II and III. At St. IV the maximum was in July and the minimum in April. At St. I the number of specimens was insignificant and they were probably occasional visitors. This species is typical of coastal (Björnberg, 1963) and inshore waters (Gerlach, 1958).

Paracalanus parvus Claus

Temperature range observed: 18.45 - 27.75°C.
Salinity range observed: 34.00 ‰ - 35.25 ‰.

It was found only at St. IV. A minimum occurred in July and a maximum in October. The present results confirm that *Paracalanus parvus* is typical for coastal waters (Björnberg, 1963).

Occurrence of Larval Stages

Most larval stages were copepod and cirriped larvae. Echinoderms and Polychaeta larvae occurred in small numbers.

Maxima of larvae occurred in January at St. II and in October at St. I, II and IV. A progressive increase of numbers of larval stages was observed at St. II and III. At St. I the population of larvae was composed chiefly of nauplii of copepods and barnacles. At St. II and III, other larval stages appeared sporadically. Since *Oithona ovalis* and *Paracalanus crassirrostris* were present at St. I, II and III, in large numbers, probably the majority of larval stages were nauplii of these two species.

Cirriped nauplii occurred during the four months. The maxima were observed in July at St. I (18,430 spec/m^3).

The distribution of Cirriped nauplii in lagoon waters is large. Thus they contribute considerable for the dispersion of the barnacle population in inshore waters.

Polychaeta larvae were present at all stations and minimum numbers occurred in April at St. III (13,665 spec/m^3) and in October at St. II (2,233 spec/m^3).

Ophioplutei and Echinoplutei occurred in small numbers in both inshore and coastal waters.

The greatest number of larvae (Copepod and Cirriped larvae) was found at St. I. A decrease was observed from St. I to St. IV. Thus in inshore waters the larval population was larger than in coastal waters, as already observed by many researchers of similar regions (Gunter 1961; Deevey 1956; Davis 1948).

Other Forms Present

Mollusca occurred at all stations. Two maxima were found both at St. I in July (13,099 spec/m^3) and another in October (58,735 spec/m^3). At St. IV the maximum occurred in April (2,087 spec/m^3).

Creseis sp. were present in small numbers in coastal waters. Tintinnoidea were abundant in April at St. II (17,031 ind/m^3) and at St. III (15,976 ind/m^3). The number of specimens at St. I and IV was insignificant.

A maximum of copepod eggs occurred at St. I in January (1,263/m^3) where they represented 2.7% of the total number of zooplanktonts.

Cladocera, Chaetognatha, Copelata and Coelenterata all occurred in small numbers. The Cladocera population was composed of *Penilia avirostris* and *Evadne spinifera* but the last species in smaller numbers. A maximum of *Penilia avirostris* was found in April at St. II and III. Only young stages of Chaetognatha were present at St. II and III probably *Sagitta friderici* and *S. enflata*. Coelenterata were scarce. Two species were observed in inshore waters, *Liriope tetraphylla* and *Clytia cylindrica*. These are eurythermic and euryhaline (Vannucci, 1957). *Euphysora gracilis* occurred in the deep layers of St. II and III in inshore waters. It is occasional in inshore waters and is a typical species from shelf waters, but has been registered in mixed coastal waters (Vannucci, 1963).

Copelata were present in small numbers. Two species were found, *Oikopleura dioica* and *O. longicauda;* the most abundant was the first. Young unidentifiable stages were also present. Radiolaria were found in small numbers at all stations. Only *Stycholonche zanclea* occurred in large numbers at the surface at St. IV in April (10,286 spec/m^3).

Quantitative Analysis

The differences in numbers of organisms per m^3 was large. Figure 6 summarizes the seasonal variation of the total zooplankton. The numbers increase in January and a maximum occurred in April. In inshore waters a minimum was observed in July and in offshore waters in October. A secondary maximum appeared in October in lagoon waters and in July in coastal waters.

The total zooplankton was more abundant at St. I, II and III, than at St. IV. The smallest number in inshore waters was 26,000 specimens per m^3 and the largest was 143,000 specimens per m^3. The minimum in coastal waters was 12,000 specimens per m^3 and the maximum 36,000 specimens per m^3.

Although the general size of the organisms decrease, the number of specimens increases in the inshore waters, as Deevey (1956) also noted at Long Island Sound. Small copepods formed a considerable proportion of the total zooplankton. Maximal numbers in April at St. I, II and III are due to the increase of the copepod population. The maximum in October was due to the great abundance of larval stages chiefly copepod nauplii. The amount of zooplankton per m^3 showed a similar seasonal cycle at the three stations sampled in inshore waters.

BACTERIOPLANKTON

Counts ranged from 21 to 13,000 bacteria per ml. No correlation was found between tide level and the amount of bacteria present. Sometimes there was a greater number at high tide, other times at low tide.

Cviic (1960) pointed out that the culture method has numerous disadvantages. The plate method used in the present work is very convenient for comparative studies of bacterial distribution.

A study of marine bacteria was incorporated in this survey to obtain:

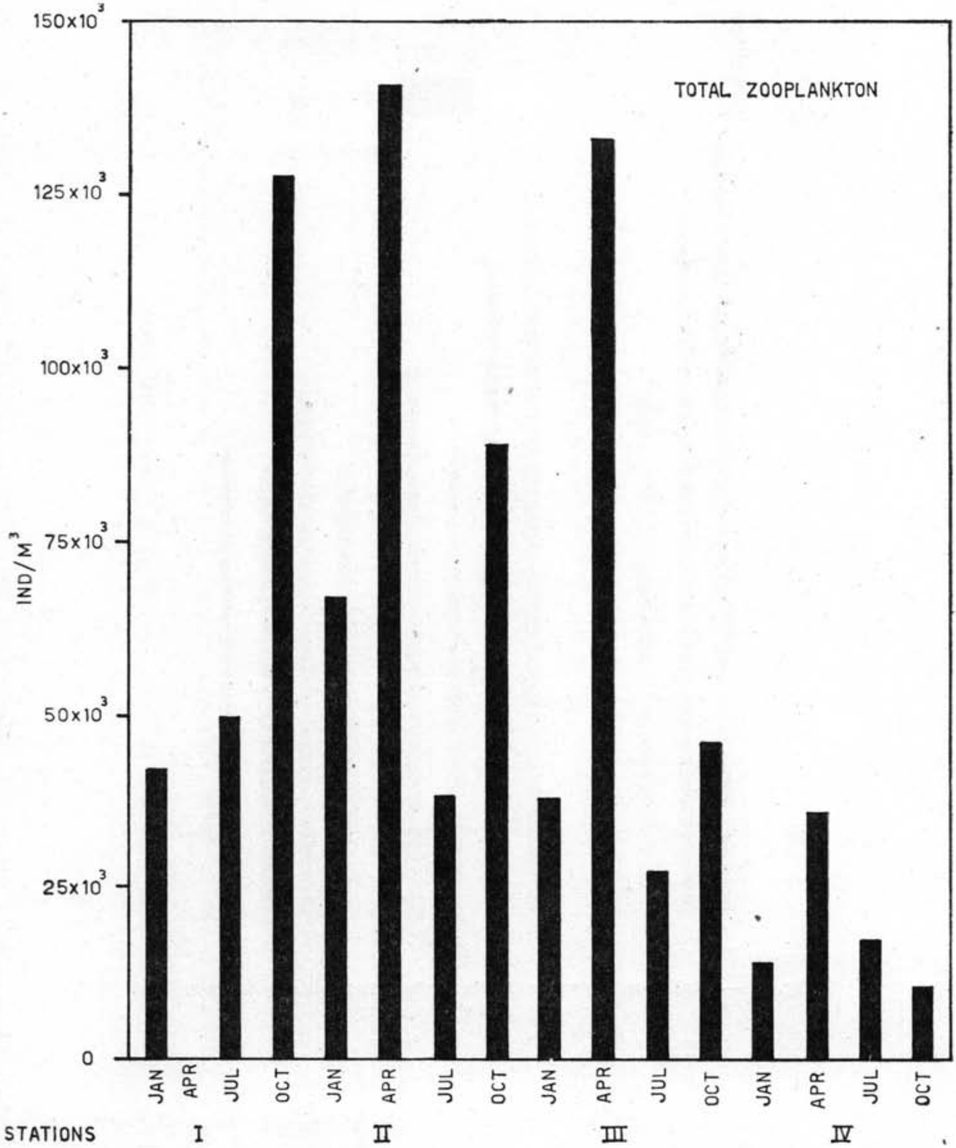

Fig. 6 — Total zooplankton in indiv./m³.

1) data on the amount of pollution at the points of collection;
2) the effect of bacterial respiration on primary productivity;
3) the relation of the bacteria with particulate organic matter and plankton concentration (Fig. 7).

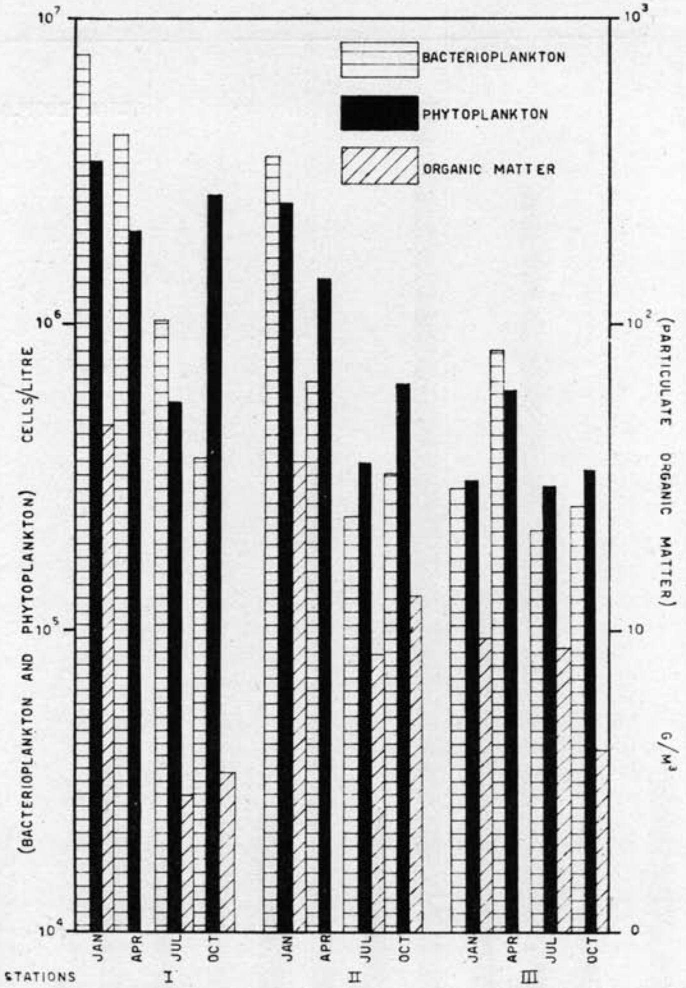

Fig. 7 — Relation between bacterioplankton, phytoplankton and particulate organic matter.

Particulate Matter and Organic Matter of Net-Plankton

The amount of matter present in each sample was determined in the laboratory by filtration and measurement of dry weight as described earlier (Teixeira & Kutner, 1963).

The total particulate matter varied from 5.0 g/m³ at St. III in October to 84.4 g/m³ at St. I in January. At St. IV the quantity of suspended matter was minimal and the values found have been disregarded above.

TABLE I — Suspended organic matter

Month	Station	Low tide (g/m²)	High tide (g/m²)
January	II	765.0	326.0
	III	71.25	127.0
	I	138.3	141.0
July	II	107.0	125.5
	III	75.8	97.65
	I	7.35	6.9
October	II	104.0	284.0
	III	48.5	38.25
	I	6.0	16.2

Table I shows the results for suspended organic matter in g/m² thus referring to the entire column.

The total amount of organic substance represented by plankton organisms plus detritus, suspended in the water (seston) is an important index of the productivity of the water. The nature and amount of seston sets a pattern of the feeding condition, and is a prominent ecological factor which influences a number of properties of the water itself (such as chemical, optical, etc.) (Sushchenia, 1963).

The total net-plankton varied from 0.243 g/m³ in April at St. IV to 4.682 g/m³ in July at St. II, and showed no correlation with the number of phytoplankton organisms.

Table II gives the results in g/m² for net-plankton organic matter.

Hydrographical and Climatological Data

The greatest part of the lagoon is from 6 to 7 m deep with maxima depths of 20 m (St. II). Mainly due to the interplay of tidal currents and runoff through several channels and rivers,

TABLE II — Total organic matter of net-plankton

Month	Station	Low tide (g/m²)	High tide (g/m²)
January	II	18.060	6.755
	III	1.625	3.226
	I	1.208	1.260
	IV	2.160	—
April	II	5.125	6.945
	III	—	2.570
	I	—	—
	IV	1.650	2.460
July	II	16.100	23.960
	III	4.453	4.982
	I	4.654	1.449
	IV	5.965	—
October	II	12.836	13.025
	III	2.267	2.047
	I	1.819	1.357
	IV	2.310	2.165

the inshore waters have a gradient of salinity from the open sea to the inner mangrove swamp (Teixeira & Kutner, 1961).

Chlorinity was determined by the argentimetry method. The salinity of inshore waters is influenced by the sea water entering during flow, the discharge of the rivers, the rainfall, evaporation, etc.

The maximum salinity found in the inshore waters was of 31.13 ‰ measured at St. III, while a minimum of 1.16 ‰ was observed at St. I. The salinity values (Table III) indicate that St. I is oligohaline and that St. II and III are polyhaline. These conditions present an ecological barrier to some organisms that might otherwise migrate to or from the sea waters into brackish waters, and this explains the distribution noted for some of the phytoflagellates and copepods.

Among the factors studied which influence the distribution and density of the plankton, salinity seems to be the most important, because it is the only physical factor which varies considerably from one station to another.

At St. IV situated in coastal waters, the salinity levels ranged from 31.70 ‰ to 35.25 ‰.

TEMPERATURE — Water temperature from 18.45°C to 27.88°C during the four months of the investigations. The temperature for inshore waters and offshore waters, were similar (Table III). The highest water temperature was recorded during January and April and a seasonal decline in temperature was observed in July, followed by a sharp rise in October.

The temperature of the swamp waters is affected by several factors: the temperature of the sea water, temperature of the river water and local heating and cooling. By the recorded temperature data during the time studied this factor seems not to be important in relation to the distribution of the plankton population.

OXYGEN AND pH — Winkler's method was used for oxygen measurements; pH was measured with a portable Metrohm pH Meter. The values found for dissolved oxygen ranged from 3.12 cc/l to 5.57 cc/l (Table III) and the pH varied from a minimum of 7.20 at St. I to a maximum of 8.0 at St. IV. The observed values for dissolved oxygen and pH showed a small variation during the months studied.

TRANPARENCY — It was measured with a white Secchi-disc (30 cm in diameter). The Secchi-disc readings were converted to extinction coefficients according to the Poole & Atkins (1929) formula: $K = 1.7/d$, where K is the extinction coefficient per meter, and d is the Secchi-disc reading in meters. The highest transparencies were observed in the parts of the lagoon nearest in the sea; and the highest value for the visibility of the Secchi-disc, i.e. 8.70 m, was observed at St. IV. The lowest transparencies occurred in the inner part of the lagoon (Fig. 8).

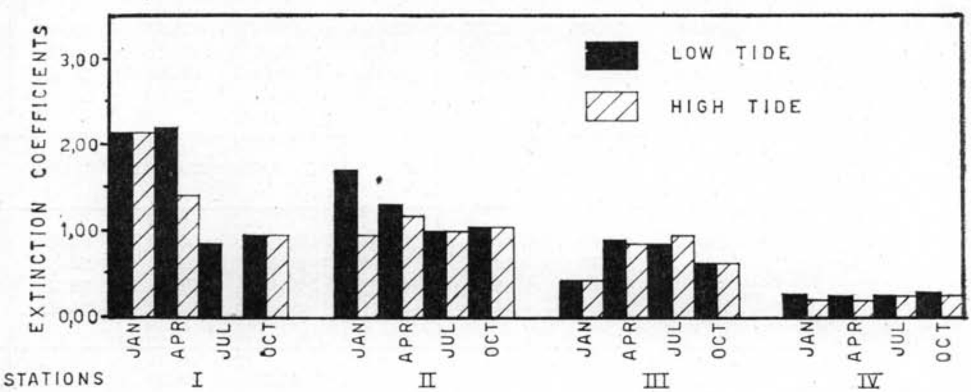

Fig. 8 — Extincton coefficients found in the stations of collection during low and high tide.

TABLE III — Hydrographical

Station	Tide	Depth m	S ‰				T °C		
I			20/1/62	5/4/62	19/7/62	4/10/62	20/1/62	5/4/62	19/7/62
	low	0.0	3.42	1.58	12.15	8.62	25.12	26.30	18.98
		1.5	4.78	1.42	11.85	7.92	25.10	26.20	19.10
		3.0	4.20	1.16	12.02	7.94	25.10	26.13	19.30
	high	0.0	3.60	1.48	8.13	5.78	25.80	26.70	19.09
		1.5	5.14	5.15	9.83	5.75	25.50	26.70	19.08
		3.0	3.57	7.07	14.00	5.91	25.40	26.65	19.08
II			21/1/62	2/4/62	16/7/62	1/10/62	21/1/62	2/4/62	16/7/62
	low	0.0	—	21.10	26.16	22.10	25.20	27.40	18.92
		5.0	20.75	21.15	26.54	22.72	25.10	27.35	19.00
		10.0	19.80	27.43	27.38	22.86	25.12	27.30	19.00
		15.0	21.49	30.88	27.99	23.24	25.10	27.00	19.00
	high	0.0	21.65	26.61	30.24	23.07	26.02	27.88	19.10
		5.0	25.99	29.14	30.58	22.21	25.28	27.55	19.08
		10.0	27.77	30.59	30.94	27.71	24.82	27.18	19.10
		15.0	27.61	32.94	31.26	28.89	24.78	26.45	19.10
III			19/1/62	3/4/62	18/7/62	2/10/62	19/1/62	3/4/62	18/7/62
	low	0.0	23.35	23.08	28.20	24.79	24.65	27.70	18.95
		3.5	25.00	24.77	28.59	25.54	25.00	27.70	18.90
		7.0	—	28.13	28.62	24.90	25.12	27.10	18.90
		10.0	26.24	31.11	28.65	25.47	25.80	26.70	18.92
	high	0.0	24.51	27.36	29.14	25.64	25.18	26.40	19.31
		3.5	26.49	28.50	29.96	26.29	24.70	26.35	19.10
		7.0	28.30	30.77	30.30	26.45	24.20	26.35	19.00
		10.0	28.59	31.13	20.43	26.66	23.80	26.30	19.00
IV			23/1/62	6/4/62	17/6/62	3/10/62	23/1/62	6/4/62	17/6/62
	low	0.0	32.25	33.90	34.00	31.70	25.10	25.75	18.75
		5.0	34.13	33.94	34.13	32.90	24.90	25.72	18.70
		10.0	34.54	34.08	34.04	33.47	24.85	25.72	18.60
		15.0	34.96	34.41	34.17	33.45	25.18	25.45	18.45
	high	0.0	33.41	33.95	—	32.74	25.55	24.75	—
		5.0	34.31	33.99	—	33.01	25.10	24.72	—
		10.0	34.67	34.31	—	33.27	24.95	24.70	—
		15.0	34.97	35.25	—	33.55	25.20	24.50	—

	O_2 cc/l				pH			
4/10/62	20/1/62	5/4/62	19/7/62	4/10/62	20/1/62	5/4/62	19/7/62	4/10/62
22.12	3.72	3.68	4.99	4.99	—	—	—	7.55
22.10	3.72	3.22	4.97	4.35	—	—	—	—
22.10	3.75	3.48	5.02	4.45	—	—	—	—
22.40	4.41	4.15	5.57	5.02	—	7.20	—	7.80
22.40	3.63	3.67	5.41	4.96	—	7.40	—	—
22.40	3.25	3.50	4.97	4.95	—	7.45	—	—
1/10/62	21/1/62	2/4/62	16/7/62	1/10/62	21/1/62	2/4/62	16/7/62	1/10/62
20.78	3.80	3.47	3.73	4.30	—	7.85	—	7.95
20.63	3.75	3.26	4.62	4.28	—	8.02	—	—
18.85	3.74	3.58	4.67	4.29	—	8.20	—	—
20.50	3.64	3.74	4.62	4.23	—	8.20	—	—
21.10	5.39	3.96	4.97	4.72	—	8.12	—	8.00
20.60	4.40	4.02	4.94	4.40	—	8.18	—	—
20.53	4.13	3.79	5.05	4.34	—	8.15	—	—
18.33	4.12	3.65	5.20	—	—	8.20	—	—
2/10/62	19/1/62	3/4/62	18/7/62	2/10/62	19/1/62	3/4/62	18/7/62	2/10/62
21.18	3.97	3.52	4.55	4.16	—	7.80	—	8.10
21.10	3.82	3.53	4.78	4.24	—	8.00	—	—
21.00	4.91	3.62	4.53	4.24	—	8.00	—	—
21.00	3.12	3.62	3.99	4.33	—	8.10	—	—
21.20	4.13	3.88	4.80	4.45	—	7.98	—	7.90
21.08	3.58	3.77	4.73	4.40	—	8.15	—	—
20.95	3.80	3.88	4.70	4.29	—	8.15	—	—
20.95	3.59	3.90	4.78	4.24	—	8.15	—	—
3/10/62	23/1/62	6/4/62	17/6/62	3/10/62	23/1/62	6/4/62	17/6/62	1/10/62
20.20	—	4.33	4.99	4.72	—	—	—	—
20.00	—	4.37	5.00	4.70	—	—	—	—
19.20	—	4.41	4.99	4.74	—	—	—	—
19.20	—	3.99	4.99	4.80	—	—	—	—
21.20	—	4.46	—	4.75	—	—	—	8.00
20.00	—	4.41	—	4.80	—	—	—	—
19.22	—	4.26	—	4.80	—	—	—	—
19.20	—	4.09	—	4.82	—	—	—	—

TABLE IV — Tidal values registered during the time when the samples were collected

MONTH	JANUARY				APRIL				JULY				OCTOBER			
DAY	19	20	21	23	2	3	4	6	16	17	18	19	1	2	3	4
	81	86	62	91	78	107	101	47	42	64	44	61	98	84	82	77
	74	89	68	62	61	98	101	73	47	54	42	54	75	68	71	78
Hourly height (in cm)	82	97	88	63	61	99	109	84	69	62	58	69	72	70	73	84
	146	166	152	155	165	206	206	93	178	—	181	196	141	134	130	114
	161	178	156	165	180	220	210	118	185	—	188	209	158	151	142	126
	160	174	147	161	172	204	186	155	168	—	183	200	176	164	144	132

The Secchi-disc readings were low in all parts of the swamp area because of the dissolved coloured substances, suspended organic matter and the high concentration of phytoplankton and zooplankton.

TIDES — The variation of the mean level was determined with a tide gauge placed at the Cananéia Marine Station. The tidal amplitude during the observation period varied from 9.0 to 155.0 cm; the minimum height was 42.0 cm and the maximum 220.0 cm (Table IV).

The influence of tidal currents in this region is important from many points of view because they influence the local salinity and produce horizontal and vertical gradients; they play a considerable part in the channel's physiography; they influence the pH and sometimes cause temperature variation and above all they introduce different plankton communities.

Occasionally abnormal levels are observed which may be associated with storm surges or meteorological tides. These phenomena, which modify the predicted tide, can affect the ecological conditions of the environment.

CLIMATOLOGICAL DATA — A general compilation of the more important climatological data of precipitation, wind and solar radiation in the region is presented here. The data are condensed from 5 years observations at the marine station. A more detailed account of the conditions is published elsewhere (Garcia Occhipinti, 1963).

PRECIPITATION — Cananéia is a region of very high rainfall. The average annual rainfall is 2,200 mm. The precipitation regime for this area shows more rain during the summer months, and a minimum precipitation during winter.

The precipitation especially through runoff by rivers, influences inshore waters salinity, mainly in the inner parts of the area.

WINDS — The prevailing winds blew from WSW in January, April and July while in October blew from SW. The maximum wind velocity was 9.0 m/s in October, while the main velocity was 3.5 to 4.0 m/s. Probably the influence of the wind on the environment contributes to promote vertical mixing, alter the distribution of population by vertical mixing and water piling up.

SOLAR RADIATION — The global radiation was measured throughout the day with a recording bi-metallic actinograph calibrated against a standard solarigraph (Table V).

From the data obtained and some experiments made in this region the solar radiation intensity acts as factor inhibiting photo-

TABLE V — Daily values of solar radiation

MONTH	DAY	Total cal cm-2 day-1	Maxima intensity cal cm-2 min-1	Mean value cal cm-2 min-1
April	2	454.14	1.03	0.642
	3	77.46	0.33	0.110
	4	145.92	0.52	0.207
	5	365.64	1.28	0.522
	6	463.26	1.05	0.662
July	16	158.87	0.73	0.248
	17	89.66	0.44	0.140
	18	220.30	1.00	0.343
	19	56.31	0.23	0.088
October	1	386.78	1.21	0.526
	2	164.11	0.56	0.222
	3	386.93	1.16	0.524
	4	306.62	0.91	0.414

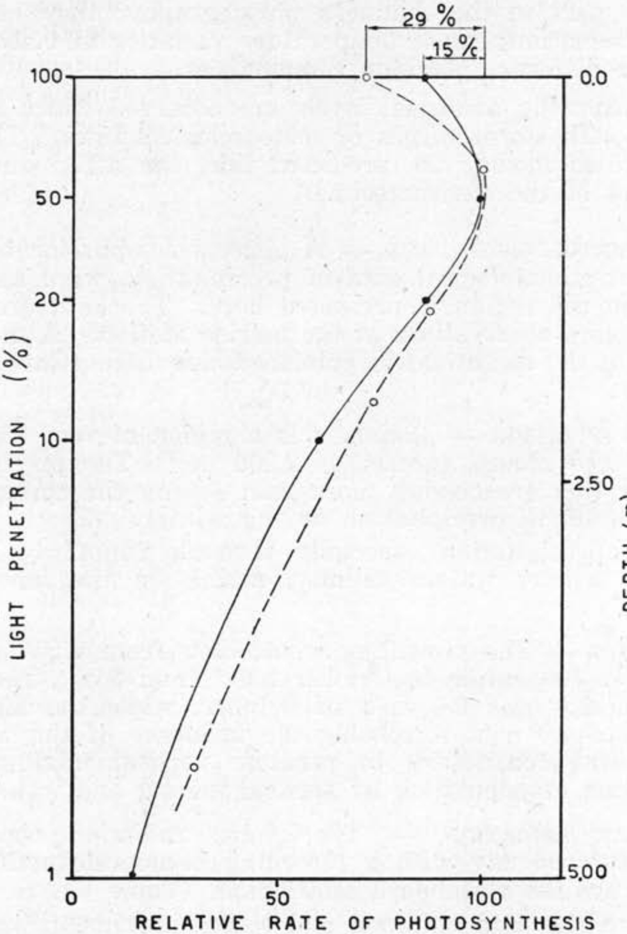

Fig. 9 — Inhibiting effect of solar radiation in surface layers.

synthesis in surface layers during the greater part of the year. On bright days the solar radiation produces a strong inhibitive effect on the phytoplankton photosynthesis in the surface layer for about 90% of the length of the diurnal part of the day (Garcia Occhipinti, Magliocca & Teixeira, 1961).

On cloudy overcast days, the inhibition effect is apparent in surface waters but with a reduced intensity (Fig. 9).

The total incident radiation ranged from 463.26 to 77.46 gram calories/cm^2/day, and the maximum instantaneous intensity observed was 1.21 cal/cm^2/min, occurring in October.

Despite the high solar radiation intensity, the vertical extent of the photosynthesis layer is low: some light measurements showed that 1% of the total blue-green light at the surface was found at a depth of about 5.0 m (in St. II where the depth is of 20 m).

The principal factor that causes a shallow photosynthesis layer is the strong attenuation by the water column mainly due to the large standing stock of plankton, detritus and coloured substances.

DISCUSSION

The phytoplankton was composed primarily of diatoms and was much more abundant than the zooplankton in number of organisms. The commonest species of diatom was *Skeletonema* sp. It is eurythermic and euryhaline present in the plankton throughout the year, although sometimes in small numbers. Flagellates occurred in abundance mainly in April at St. I.

Copepods generally formed the bulk of the zooplankton. Different species were found at the four stations. The dominant species were *Oithona ovalis* at St. I; *Acartia lilljeborghi* and *Paracalanus crassirostris* at St. II and III and *Oncaea media* at St. IV.

The crustacean zooplankton was dominated (in number of specimens) by a small number of species. This is in agreement with data of Cronin *et al.* (1962), who found the same, studying the plankton of the Delaware River estuary; small number of species but greater number of specimens per m^3 of water. Most of the zooplankton organisms of inshore waters are eurythermic and euryhaline. There are extreme eurythermic and euryhaline species such as *Oithona ovalis*. In contrast with oceanic waters, the Calanoid population in inshore waters is poor, probably because they are less euryhaline and eurythermic.

It can be noted the predominance of the herbivores over the carnivores in the zooplankton population.

The distribution of the zooplankton in the lagoon is not due exclusively to the gradient of salinity, but probably the food available is another important limiting factor.

Environmental conditions of inshore waters are more complex than those of coastal waters, and have therefore a selective action on the number of species.

The zooplankton population of coastal waters is limited by the admixture of low salinity waters from the mangrove areas and biological adaptations still undetermined decide on the success of the endemic species.

The abundance of bacteria in the sea appears to be more closely related to the abundance of phytoplankton than the other single ecological factors. They may be due partially to the presence of particulate organic matter and substratum which they provide to bacteria.

Bacteria have an important function in inshore waters as for instance in nitrification and denitrification processes. They also contribute to the total biomass.

There is also a considerable relationship between zoo-and phytoplankton, although we cannot correlate it precisely because our observations were limited to four collections during the year. But with these data we know that when nannoplankton was very abundant the larval stages and micro-crustaceans were also present in great quantities. A higher standing stock of phytoplankton coincided with a higher standing stock of zooplankton.

The high turbidity and large amount of coloured substance in inshore waters cause an accentuated reduction in light penetration, thus diminishing the extend of the photic zone. At St. II (20 m depth) a water column of 5.0 m reduces the surface solar radiation to 1%, however because of the hydrographical conditions of the region the plankton from an aphotic depth is brought up to the photic layer during some periods of the day. This probably accounts for the good physiological conditions of the plankton samples collected from 5 m to 15 m depth, below the compensation depth.

Among the hydrographical factors studied, tides, tidal currents and chlorinity are the chief factors that affect the general abundance and composition of plankton associations in the Cananéia region.

There is a gradient of salinity from St. I to St. IV.

The standing stock of the four stations diminishes gradually from St. I to St. IV, showing an inverse correlation with chlorinity. St. I (Aroeira) where the salinities are lowest, is the richest, i.e. has the highest standing stock. In this region the proximity of several rivers causes a mixing of fresh and salt water. Both fresh and sea water masses contribute as a favourable factor which assist the rapid growth of phytoplankton population (Légaré, 1957) and consequently of the zooplankton.

The tidal currents influence the distribution of plankton and they promote mixing of oceanic and inshore waters varying the salinities, oxygen contents and other conditions of these waters.

During ebb tide the nutrients and plankton are carried from the mangrove swamps outwards.

RESUMO

Durante 1962, em janeiro, abril, julho e outubro, foram feitas coletas em quatro estações oceanográficas, três na região lagunar de Cananéia e uma na região costeira.

O objetivo foi o de efetuar um primeiro levantamento do bactério, fito e zooplâncton, assim como estudar os fatôres ecológicos atuantes nos diferentes locais, em diferentes épocas do ano.

Amostras foram tomadas durante os períodos de maré alta e baixa, em superfície e profundidade, para determinação do plâncton, material em suspensão, salinidade e oxigênio.

Pelos resultados obtidos, verificou-se que o "standing stock" diminuiu gradualmente da estação I para a estação IV, mostrando uma correlação inversa com a salinidade. As condições extremamente variáveis da região lagunar constituem um fator seletivo para as diferentes espécies planctônicas.

No fitoplâncton foram encontrados: Diatomáceas, Dinoflagelados, Sìlicoflagelados, Fitoflagelados e Cianofíceas. As Diatomáceas sempre predominaram, exceto na estação I, no mês de abril, quando apareceram os Fitoflagelados em proporções superiores. O máximo de organismos do fitoplâncton foi na estação I, em janeiro, havendo um decréscimo durante os meses de abril e julho e um nôvo aumento em outubro.

O zooplâncton, constituído, predominantemente, por copépodos e estágios larvares, apresentou também Moluscos, Tintinoideos e em pequenas proporções Medusas, Chaetognatos e Cladoceros. O máximo de zooplâncton ocorreu em abril em tôdas as estações.

A quantidade de matéria orgânica em suspensão, apresentou altos índices, nas estações lagunares em comparação com a costeira, isto devido a detritos levados pelos rios que circundam a região, ao plâncton e à decomposição *in situ* da vegetação do mangue. Por outro lado, a matéria em suspensão, a concentração do plâncton e as substâncias coloridas provenientes da vegetação do mangue, mostraram bastante influência sôbre a transparência e coloração da água, diminuindo a extensão da camada eufótica.

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