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ZOOPLANKTON IN RELATION TO HYDROGRAPHY AND PELAGIC FISHERIES IN THE INSHORE WATERS OF VIZHINJAM, TRIVANDRUM

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ABSTRACT

The seasonal fluctuations in the total plankton biomass and in the abundance of major zooplankters in the Vizhinjam Bay and the adjacent open sea were studied for two years from February 1980 to January 1982 in relation to the hydrography and the pelagic fisheries of the region.

Copepods formed the major component of the zooplankton community for the greater part of the year. The other dominant groups were decapod larvae, cladocerans and chaetognaths. During certain months copepods were outnumbered by cladocerans, which swarmed during monsoon months only. Decapod larvae, appendicularians, fish eggs, fish larvae and *Lucifer* exhibited a sharp decline during south-west monsoon period. The revival started with the north-east monsoon and these groups attained their peak abundance in different months. The total zooplankton volume did not exhibit significant relationship with any of the hydrographic parameters investigated.

The peak periods in the zooplankton biomass were found to coincide with the peak seasons of pelagic fisheries in both the years of collection. The importance of zooplankters in the study of the pelagic ecosystem in general and the fisheries in particular is pointed out.

INTRODUCTION

A PRE-REQUISITE for the proper management of the fishery resources of the Vizhinjam area is an understanding of some of the basic biological factors, such as zooplankton, specifically its pattern of distribution, intensities and seasonal fluctuations in relation to environmental parameters, since zooplankters form the major food item of the pelagic fishes (Hornell and Nayadu, 1924; Chidambaram and Menon, 1945; Subrahmanyan, 1959; Rabindranath, 1966).

Information on the hydrography and plankton in relation to pelagic fishery of other areas of the west coast of India is available (Ramamurthy, 1965; Mukundan, 1967; Noble, 1968; Pillai, 1968; Annigeri, 1968, 1972; Bhargawa *et al.*, 1973). Along the northern part of the Trivandrum coast the general seasonal distribution of plankton has been studied by Menon (1945). Divakaran *et al.* (1980) also made a preliminary study of the plankton from the Vizhinjam Bay. However, both studies do not present a comprehensive picture of the relationships between zooplankton, pelagic fisheries and hydrographic factors, owing in part to the lack of statistical correlation of data and the insufficient number of sampling stations. Further, the second paper concentrates on the Bay waters, without considering the importance of the open sea zooplankton to the pelagic fisheries and aquaculture organisms. Hence investigations on the inshore zooplankton in relation to hydrographic parameters and pelagic fisheries were undertaken.

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MATERIAL AND METHODS

Studies were based on zooplankton samples, collected from Vizhinjam Bay, south-west coast of India for a period of 2 years from February 1980 to January 1982 from three stations of different depths – 15 m (Station I), 20 m (Station IIA) and 30 m (Station IIB); the first station was within the Bay, while the other two were in the open sea. Samples were collected fortnightly between 0400 and 0600 hrs by 10 minutes surface hauls with a net of 50 cm mouth diameter and made of nylobolt (400 μm, mesh size) which was towed from a 'catamaran'. The plankton samples were preserved in 4% buffered formaldehyde solution in sea water. Displacement volumes of the samples were estimated using a burette and calibrated 50 ml perspex filtering cylinder. Organisms greater than 2 cm in dimension, when present, were excluded from volume determination. Depending upon the size of the sample, it was sub-sampled with a Folsom splitter and an aliquot of at least 5 ml was analysed to determine the numerical abundance of various groups. The values for the whole sample were then computed for 100 m^3 of water. These data in numbers were converted into percentages based on monthly total numbers.

Hydrographic data were recorded by analysis of surface seawater samples following standard methods. Salinity was determined by Mohr's titration method. Dissolved oxygen was estimated by the Winkler method (Martin, 1968). Surface temperature at the time of collection was measured by using a centigrade thermometer.

Correlation co-efficients were worked out to study the relationships (a) between zooplankton groups, total displacement volume and the hydrographic factors (b) between zooplankton and pelagic fishery and (c) between pelagic fishery and hydrographical conditions. Regression equations were obtained for those which showed significant relationships.

To facilitate interpretation, the data obtained were analysed seasonwise as follows : February to May (inter-monsoon), June to September (southwest monsoon), October to January (northeast monsoon), based on the rainfall data from the Indian Meteorological Department, Trivandrum. The data on the landings of the pelagic fishery have been taken from the departmental records.

RESULTS

Data on hydrography, zooplankton abundance and distribution and pelagic fishery in Vizhinjam Bay and open sea revealed the following relationship between the parameters investigated.

HYDROGRAPHIC FEATURES OF THE VIZHINJAM WATERS

Temperature

The monthly average surface temperature values at the time of collection are shown in Fig. 5. The maxima were recorded during the March-April period and the minima in June in both the years, at all the stations. Thus there was a definite lowering of the temperature corresponding to the onset of the southwest monsoon; subsequently there was an increase and the temperature reached the highest values in the inter-monsoon months.

Salinity

Monthly mean salinity values for the surface waters collected from the three stations are given in Fig. 5. In the Bay, in both the years of collection a sharp dip in the salinity values was observed in June and also

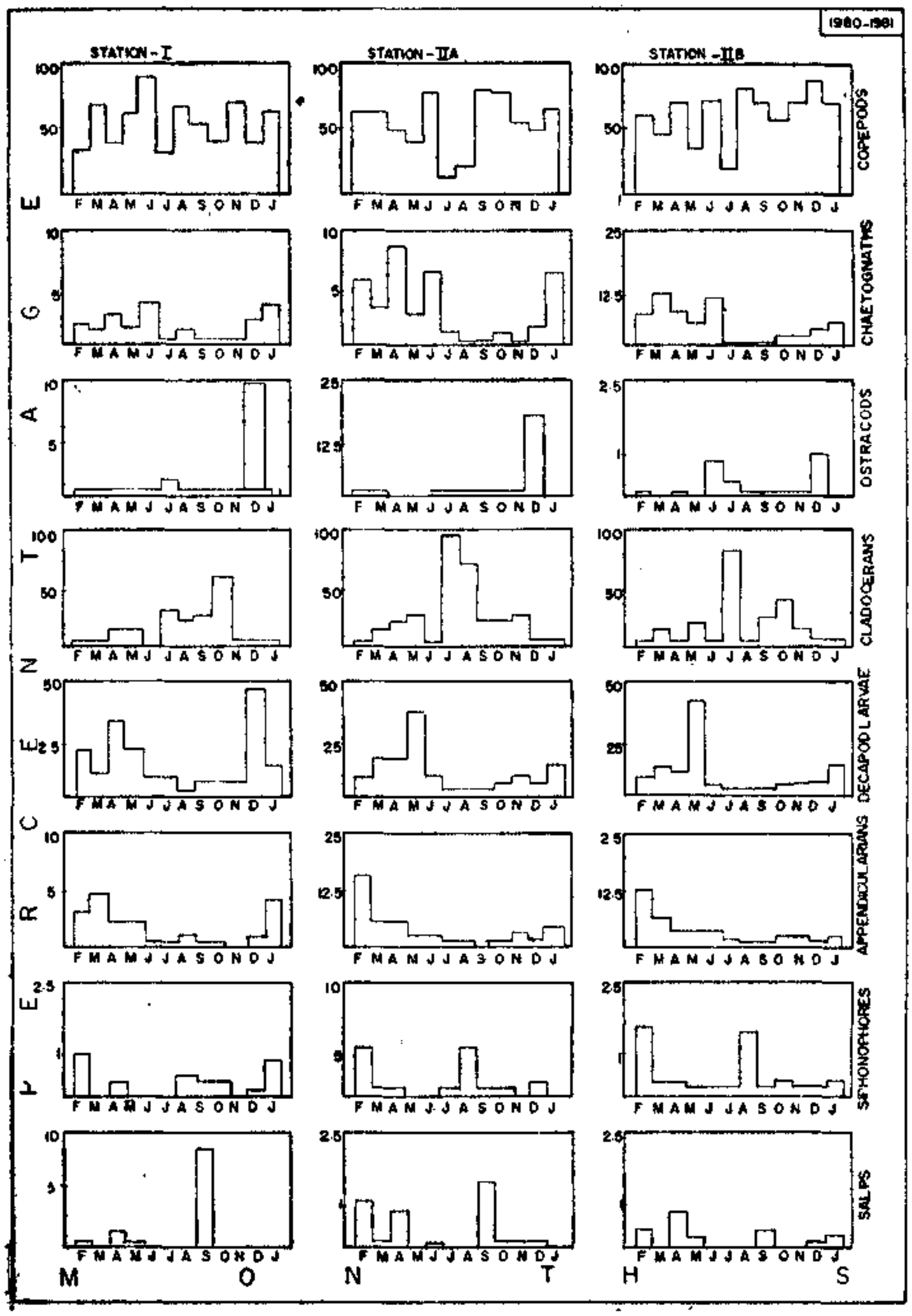

Fig. 1. Fluctuations in abundance of important zooplankton groups at stations I, IIA & IIB in 1980 - '81.

in October, immediately after the south-west and northeast monsoons respectively, but in the open sea this lowering was distinct only in June. In the first year of collections, the

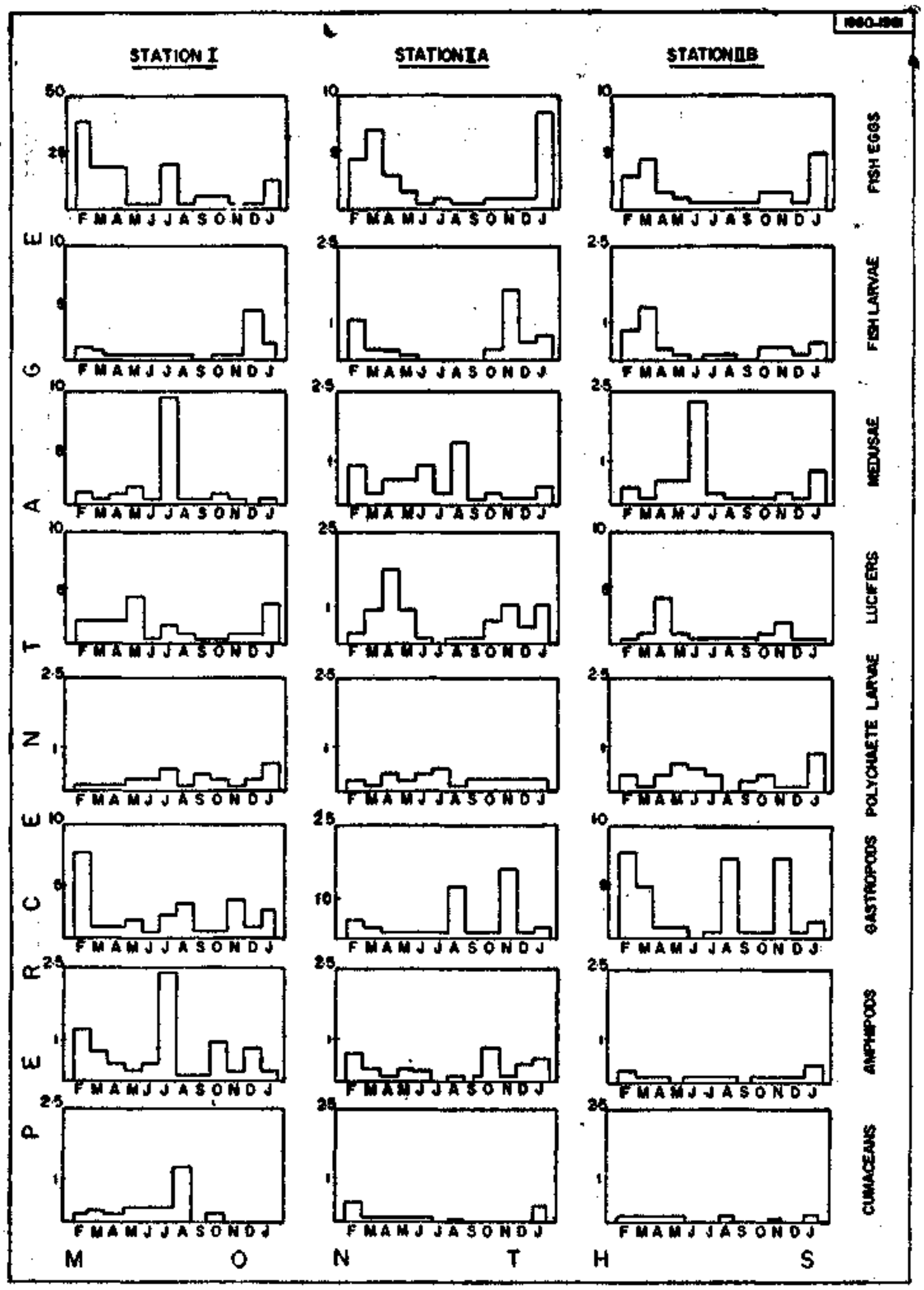

Fig. 2. Fluctuations in abundance of important zooplankton groups at stations I, IIA & IIB in 1980–'81.

maxima were observed in February, September and December-January in the Bay and in October and December in the open sea whereas in the second year, the maxima for

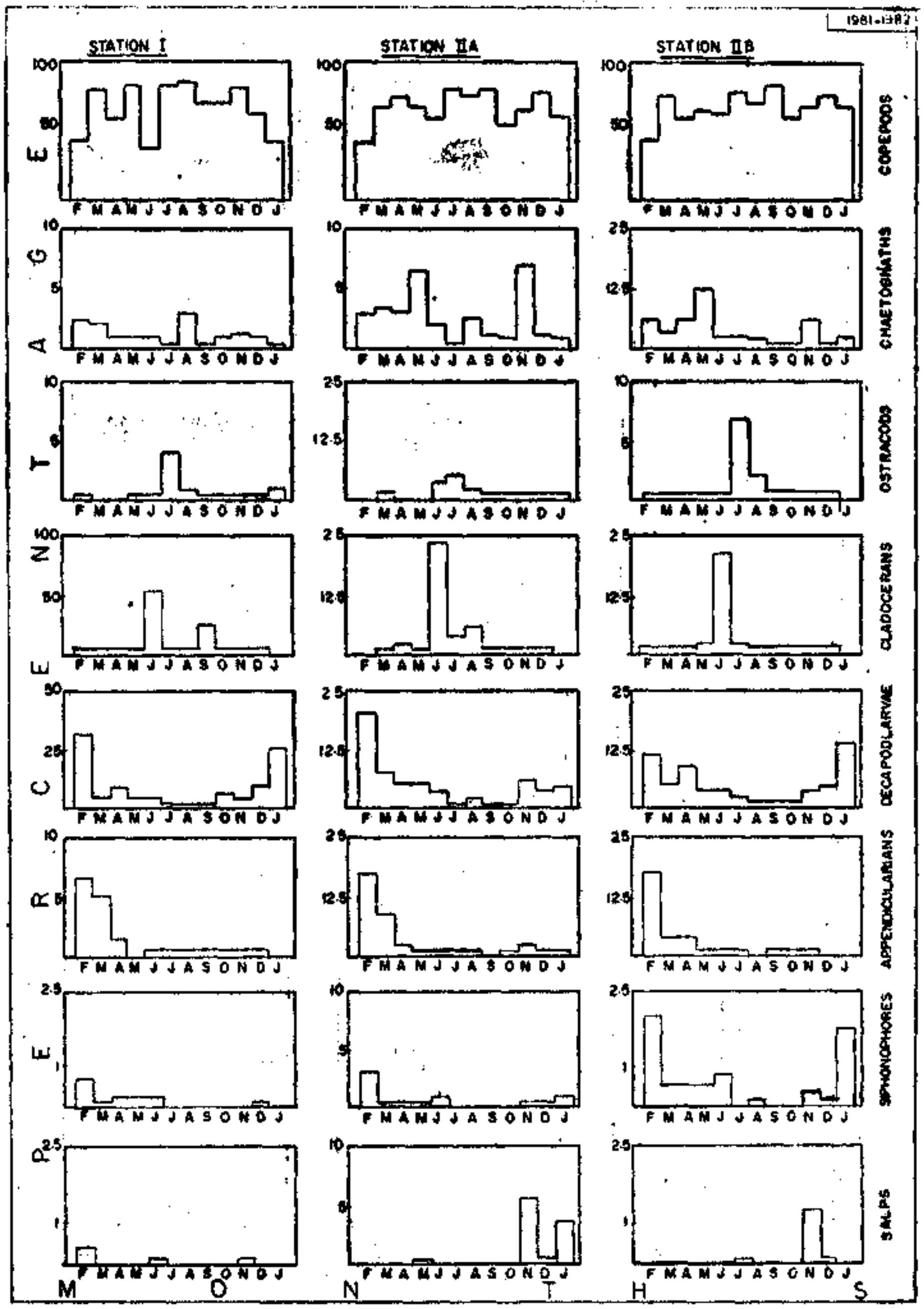

Fig. 3. Fluctuations in abundance of important zooplankton groups at stations I, IIA & IIB in 1981 – '82.

salinity were between March and May at all the stations.

Dissolved Oxygen

The monthly mean values for dissolved

oxygen are shown in Fig. 5. In the first year of observation minimum values for oxygen were recorded in April and in May in the Bay and open sea respectively whereas maxima were noted in December at all the stations. During the second year, at all the stations, minima were observed in October but the maxima were recorded in March and September in the Bay and July and September in the open sea.

The correlations between hydrographic factors and other variables considered, such as total displacement volume, zooplankters and pelagic fisheries will be discussed in the appropriate places.

Zooplankton

Total plankton volume

In Vizhinjam Bay (Fig. 5), the maximum value for displacement volume was recorded in September and the minimum volume in July in the first year of collection. In the second year, the volumes collected were higher, the maximum and minimum values falling in April and October respectively. Considering the open sea generally, two peaks of zooplankton abundance were recorded, the primary peak being in September. However, at Station IIA in the second year, although high values were recorded in September, the maximum was in November, mainly due to the swarms of copepods. Also a secondary peak period was noticed in April especially in the open sea area during the second year. Again a general finding was that low values in both the years in the open sea collections were recorded in May immediately prior to the commencement of the southwest monsoon.

At all the stations the total zooplankton volume did not exhibit significant relationship with any of the hydrographic factors investigated.

Data on the abundance and seasonal fluctuations of various zooplankton groups are presented in Fig. 1 to 4.

Copepods

The bulk of this group comprised calanoids. followed by cyclopoids and harpacticoids, Copepods specifically calanoids were recorded at all the stations all through both years of collection and could be termed the dominant element of the zooplankton except when swarms of cladocerans outnumbered them in the open sea during July in the first year of collection, while in the second year there was no such reduction due to cladoceran preponderance. In the Bay area copepods were outnumbered by cladocerans only in October and June during the first and second years of collection respectively.

Cladocerans

Cladocerans were noted in both the years at all the stations of collection with the highest values varying from June to October. Interestingly, during the peak, in both the Bay and open sea of the first year, *Evadne* swarms appeared a few weeks before *Penilia* swarms.

Decapod larvae

Decapod larvae available in Vizhinjam waters were nauplii, protozoea, mysis and post larval stages of penaeid and sergestid groups. Brachyuran zoea and megalopa were obtained, but sparsely. Except at Station I of the first year the period of maximum abundance was from January to May.

Lucifer

This group was present at all the stations in fairly conspicuous numbers. In Vizhinjam Bay the period of abundance was in May

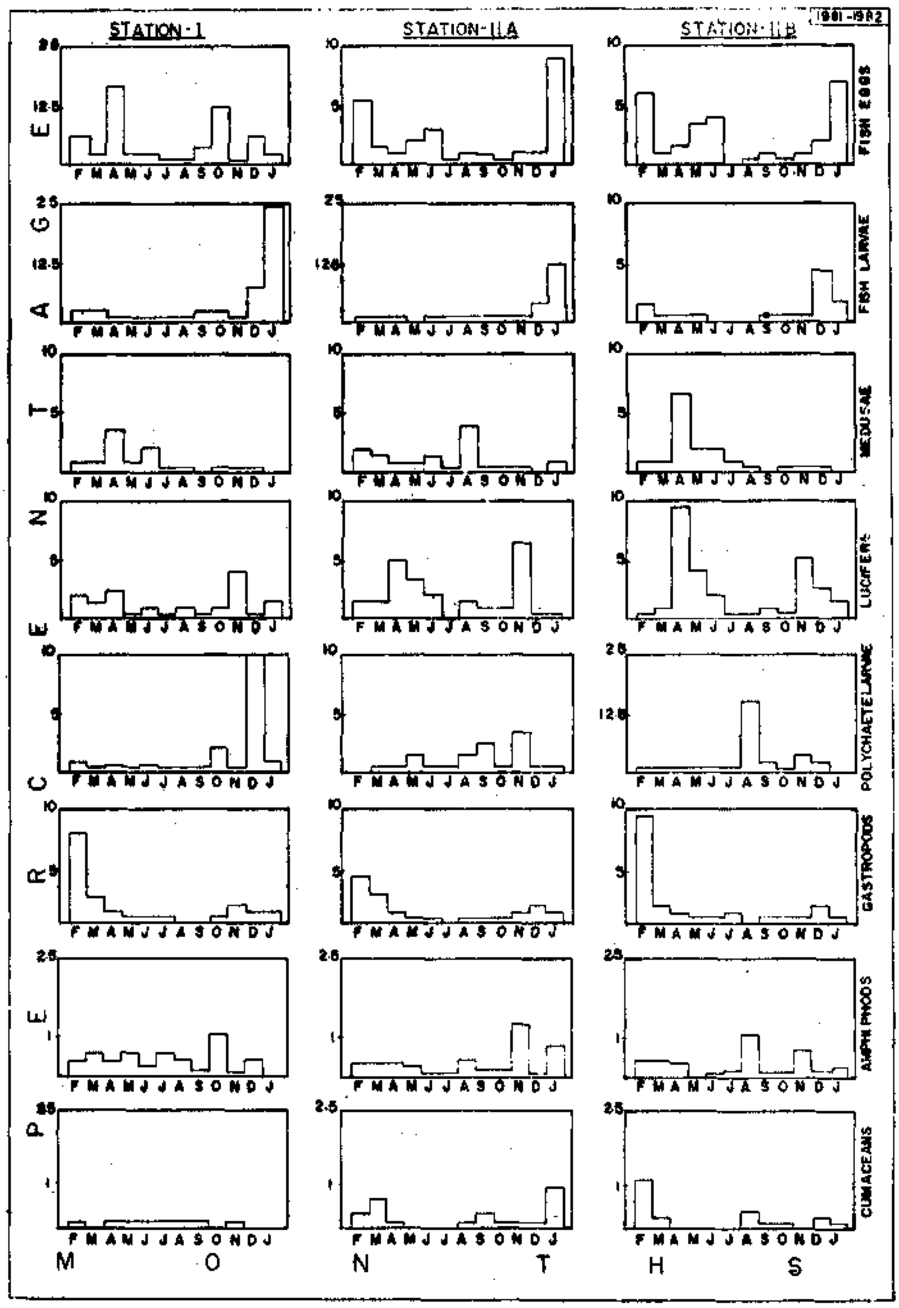

Fig. 4. Fluctuations in abundance of important zooplankton groups at stations I, IIA & IIB in 1981 - '82.

and November in the first and second years respectively whereas in the open sea collections, the peak period was in April and November in both the years of collection.

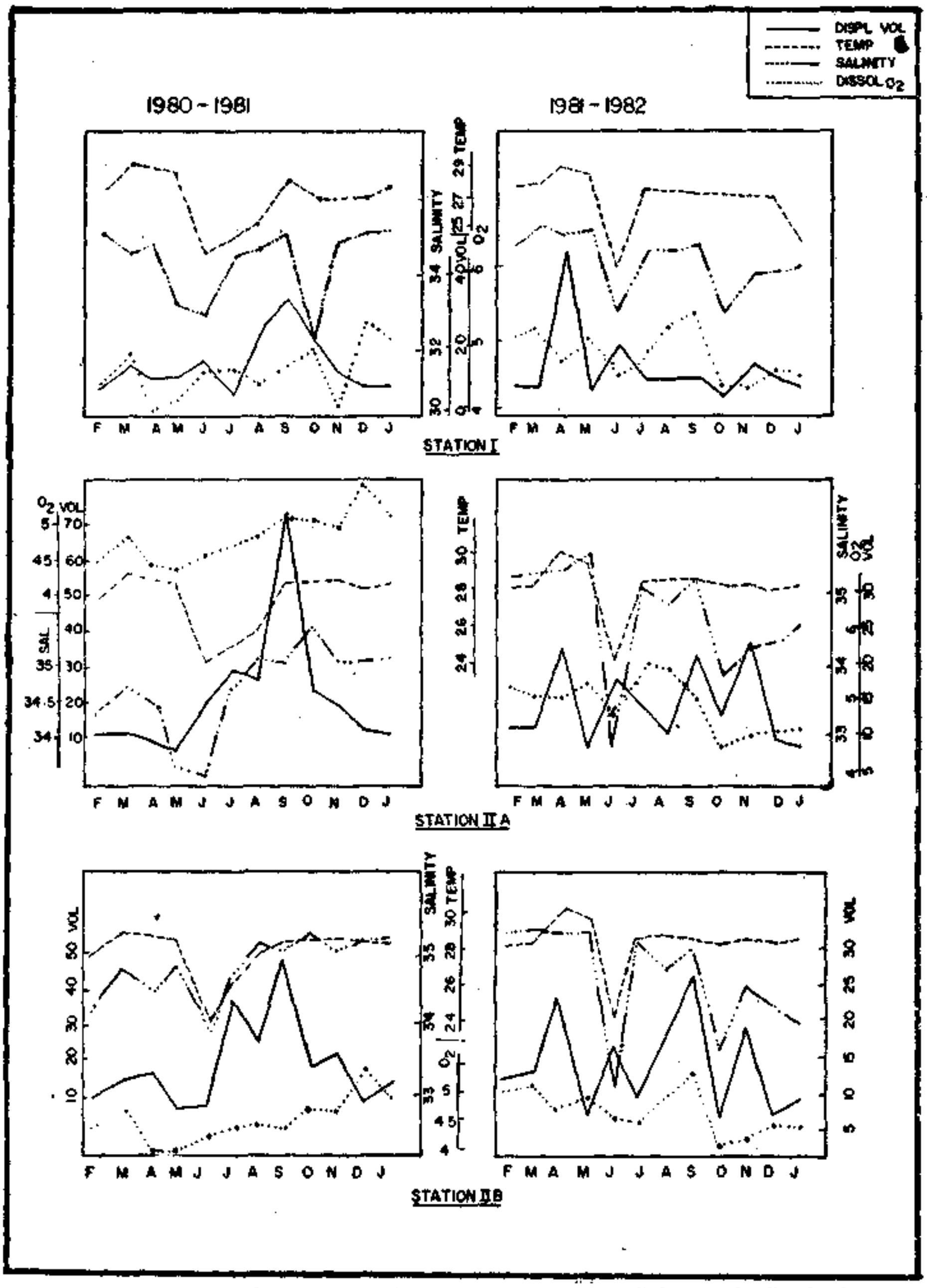

Fig. 5. Fluctuations of plankton volume, temperature, salinity and dissolved oxygen at stations I, IIA & IIB during 1980 – '82.

Chaetognaths

The important chaetognaths in the Vizhinjam area were *Sagitta* spp. The pattern of occurrence of chaetognaths was fairly uniform at all the stations in the first year with the highest values varying from January to June. During the second year of collection, open sea stations registered the major peak in May and November while Station I showed this in August.

Fish eggs

Though fish eggs were common throughout the year, in the Bay the peak was in February in the first year and April and October in the second year of collection. In the open sea stations the period of maximum abundance was from January to April in 1980-'81 and January, February, May and June in 1981-'82. *Stolephorus* eggs were particularly abundant in April and June of the second year. Eel eggs occurred in fairly good percentages during the January-March period of both the years. Considering numerical abundance, fish eggs were more in the Bay than in the open sea colletions.

Fish larvae

This group appeared in noticeable numbers from November to March in the first year. During the second year of collection at all the stations this group recorded peak occurrence in December and January. Carangid prolarvae were found in significant numbers in the December-February period of the second year. *Sardinella* larvae were dominant in the collections of April, 1981-'82. Post larvae of carangids, gobids, scombroids, leiognathids, flat fishes, lizard fishes and sciaenids appeared in small numbers only in certain periods of the year whereas larval forms of *Ambassis* were more or less uniformly distributed throughout the year.

Pelagic gastropods

Pelagic gastropods were available only seasonally in the inshore samples, consisting mainly of pteropods and heteropods. *Creseis acicula* was the commonest species of pteropod available in this area. Except at Station IIA in 1980-'81, gastropods exhibited a striking abundance in February.

Polychaete larvae

The bulk of this group was usually made up of spionid, nereid, eunicid and terebellid larvae. All the forms were more or less uniformly distributed at all the stations, though there was a slight increase in December in the Bay in 1981-'82 and in August, September and November during the second year of collection in the open sea. Adult polychaetes were rather rare in the Vizhinjam area.

Medusae

Among the coelenterates, hydromedusae were the most common at all the stations and occurred in varying numbers during several months of the year, the maximum period of abundance being from April to August. Schyphomedusae and Trachymedusae were present only in scanty numbers.

Siphonophores

In the Bay in both the years of collection the peak for siphonophores was recorded in February while in the open sea this was in February and August in the first year and January and February in the second year of collection.

Appendicularians

There was a striking similarity in the peak occurrence of appendicularians in the open sea and Bay collections of the two years (Fig. 1, 3).

Salps

Large swarms occurred in September at Station I in the first year. However, at intervals they totally disappeared from the plankton samples in both the years.

Amphipods

Amphipods appeared in noticeable percentages at Station I during July and October of first and second years respectively.

The period of abundance at open sea stations was in August, November and January in the second year and October, January-February in the first year of collection. Generally they sparingly were present in the plankton samples of these waters.

Ostracods

When compared to other groups, the percentage occurrence of ostracods in the plankton samples was small. However, they were quite prominent during December 1980 and in July 1981.

Cumaceans

In this region cumaceans appeared sparsely in plankton samples in certain months of the year at all the stations in the two years of collection.

Other groups

Many other groups such as ctenophores, mysids, cirripede larvae, stomatopod larvae, molluscan larvae, echinoderm larvae and cephalochordate larvae were represented, although inconsistently, in the plankton samples at all the stations.

Results of the correlation analysis did not show consistent relation between the zooplankton groups, temperature, salinity and dissolved oxygen in the Bay and open sea stations.

Pelagic fisheries

The ribbonfish fishery (*Trichiurus* sp.) ranked foremost among the different fisheries occurring in Vizhinjam waters. The other important pelagic groups in the order of their abundance were carangids, tunas, anchovies, sardines, seerfish and mackerel. In the two years, the period of abundance for ribbonfish fishery was from June to October, for tunas from February to June, for *Stolephorus* from April to November, for sardines from January to May, for mackerel from December to May and for seerfish from September to November. Only for carangids the peak season in the first year of collection was in August whereas for the second year it was in December, January and March. Similarly the period of abundance for pelagic fisheries (southwest monsoon season) coincided with the peak period of total plankton volume in both the years of collection (Table 1, 2).

Results of the correlation analysis between pelagic fishery, plankton and hydrography are given in Table 3. In Vizhinjam *Trichiurus* fishery showed significant relationship with total plankton volume and temperature of the open sea collections in the year 1980-'81 alone. Carangids and tunas exhibited significant relationship with salinity of the open sea collection in the year 1980-'81 alone. In the second year of collection only total pelagic fishery showed significant coerrlations with total zooplankters. Individually mackerel, sardines, *Stolephorus* and seerfish did not show any significant relationship with any of the hydrographic factors and total displacement volumes of plankton in both the years of collection.

Discussion

The zooplankton composition and its pattern of seasonal fluctuations in the Vizhinjam waters were observed to be more or less similar to those of the North Kanara Coast and Calicut waters (Ramamurthy, 1965; Mukundan, 1967).

Considering the total zooplankton biomass it exhibited a bimodal curve with peaks occurring during April and the September-November period in the open sea, in both the years, as found by Ramamurthy (1965) and Pillai (1968). The minimum values for total displacement volume in the open sea stations were in May as partly substantiated by Mukundan (1967) in Calicut waters. This indicates that, as suggested by Ramamurthy (1965), these regions constitute a common ecosystem.

TABLE 1. *Mean values of important zooplankters (%), total displacement volume (ml/100m³), temperature (°C), salinity (‰) and dissolved oxygen (ml/l.) in the intermonsoon, south-west monsoon and north-east monsoon seasons at Stations I, IIA & IIB for the period* 1980-'82

Zooplankton Groups and hydrographical parameters	Seasons	Station I 1980	Station I 1981	Station II A 1980	Station II A 1981	Station II B 1980	Station II B 1981
Copepods	I. M.	46.02	59.34	47.24	58.94	49.65	56.26
	S. W. M.	53.36	62.21	45.14	69.43	55.91	67.15
	N. E. M.	47.01	58.10	53.25	58.46	61.35	60.54
Chaetognaths	I. M.	5.37	5.96	11.83	10.84	15.23	13.45
	S. W. M.	4.55	4.69	5.03	5.38	5.83	5.48
	N. E. M.	4.77	4.39	6.46	7.07	8.08	7.05
Ostracods	I. M.	1.88	0.60	0.47	0.18	0.57	1.40
	S. W. M.	1.87	4.55	1.02	2.45	2.28	6.34
	N. E. M.	5.64	1.83	6.44	1.01	1.65	0.88
Cladocerans	I. M.	8.92	3.12	17.07	2.94	12.31	3.13
	S. W. M.	20.18	19.66	36.80	13.15	25.24	8.78
	N. E. M.	14.66	1.15	13.84	1.95	15.51	2.10
Decapod larvae	I. M.	23.34	16.71	22.61	15.21	20.70	13.69
	S. W. M.	8.12	5.69	5.49	5.00	3.24	5.02
	N. E. M.	19.73	17.20	11.84	9.40	11.42	11.15
Appendicularians	I. M.	8.60	7.96	12.70	12.19	12.68	11.27
	S. W. M.	2.24	1.81	2.81	0.97	4.98	1.23
	N. E. M.	4.07	0.90	4.70	1.98	4.82	1.27
Siphonophores	I. M.	1.76	2.36	3.79	3.79	2.98	3.96
	S. W. M.	1.14	0.62	3.36	0.85	2.20	1.35
	N. E. M.	1.76	0.32	1.78	1.37	1.29	1.56
Salps	I. M.	1.82	0.77	2.83	0.19	2.31	0.00
	S. W. M.	4.07	0.15	1.72	0.07	0.80	0.13
	N. E. M.	0.00	0.24	0.52	5.99	0.59	1.78
Fish eggs	I. M.	21.29	12.64	10.22	7.49	7.68	8.12
	S. W. M.	10.19	4.48	1.91	4.39	1.71	4.15
	N. E. M.	9.08	9.86	7.01	6.67	5.11	6.86
Fish larvae	I. M.	2.99	3.78	2.48	1.77	3.12	2.73
	S. W. M.	0.99	2.25	0.17	1.07	0.38	0.20
	N. E. M.	5.44	12.73	3.76	8.78	1.85	5.49
Medusae	I. M.	3.67	5.85	3.30	5.12	2.77	7.24
	S. W. M.	5.96	2.96	3.43	4.72	3.05	3.12
	N. E. M.	1.89	1.38	1.37	1.22	1.95	0.38
Lucifer	I. M.	7.94	5.61	4.38	8.35	4.75	8.73
	S. W. M.	3.33	2.70	0.98	4.38	0.97	3.08
	N. E. M.	5.32	5.55	3.98	5.58	3.80	7.01
Polychaete	I. M.	1.43	2.57	1.81	2.38	2.46	2.26
	S. W. M.	2.33	2.17	2.24	4.21	2.22	7.98
	N. E. M.	1.88	7.89	1.67	4.05	21.8	4.33
Gastropods	I. M.	7.24	6.91	5.77	6.00	8.39	6.99
	S. W. M.	5.02	0.77	5.27	1.03	4.12	1.40
	N. E. M.	5.56	3.55	8.22	3.84	5.93	2.51
Amphipods	I. M.	3.68	3.04	2.27	2.27	2.58	2.41
	S. W. M.	3.37	2.37	0.68	1.70	0.59	2.32
	N. E. M.	3.38	2.24	3.01	3.48	1.56	2.48

M. I. – Inter Monsoon S. W. M. – Southwest Monsoon N. E. M. – Northeast Monsoon

TABLE 1. *(Contd.)*

Zooplankton groups and hydrographical parameters	Seasons	Station I 1980	Station I 1981	Station IIA 1980	Station IIA 1981	Station II B 1980	Station II B 1981
Cumaceans	I. M.	2.40	1.14	2.80	1.86	1.51	1.90
	S. W. M.	2.82	1.05	0.40	0.79	0.30	0.92
	N. E. M.	0.27	2.38	1.35	1.93	0.64	0.92
Total displacement volume	I. M.	10.73	17.89	9.61	13.16	1.73	13.58
	S. W. M.	19.86	13.95	37.23	16.42	28.67	17.50
	N. E. M.	12.54	10.01	16.28	13.65	14.99	10.37
Temperature	I. M.	28.63	28.36	28.61	29.21	28.61	29.21
	S. W. M.	25.80	26.47	25.95	27.56	25.84	27.56
	N. E. M.	27.36	26.60	28.31	28.65	28.65	28.31
Salinity	I. M.	34.41	35.22	34.26	35.37	34.52	35.22
	S. W. M.	34.28	34.36	34.58	34.51	34.65	34.49
	N. E. M.	34.34	33.80	35.27	34.24	35.15	34.09
Dissolved oxygen	I. M.	4.36	5.02	4.51	5.13	4.32	4.98
	S. W. M.	4.62	5.01	4.77	5.24	4.52	4.88
	N. E. M.	4.88	4.50	5.18	4.50	4.98	4.4o

TABLE 2. *Catch composition of important groups of pelagic fishes (percentages) at Vizhinjam during the period* 1980-'82.

Major pelagic groups	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
1980-'81												
Trichiurus	0.00	0.00	0.00	36.86	61.11	1.49	42.65	0.00	0.00	0.00	0.00	0.00
Carangids	18.37	20.28	15.87	20.31	3.96	24.95	53.09	21.99	25.90	20.69	38.08	21.89
Tunas	22.72	45.85	43.65	34.08	45.25	0.03	0.90	5.72	10.96	15.32	7.24	15.17
Stolephorus	0.96	0.80	5.33	3.74	2.64	6.14	7.40	6.74	9.49	26.86	14.11	0.13
Sardines	22.14	1.47	7.92	22.33	1.53	1.03	1.12	0.46	13.52	4.68	0.51	30.66
Mackerel	9.34	7.32	11.17	11.83	0.36	0.30	6.59	6.20	7.60	5.19	26.33	7.90
Seer fish	0.14	1.26	5.06	1.53	1.38	0.00	0.00	5.23	12.95	13.47	0.44	0.00
Total pelagic fishery based on grand total	3.74	4.33	7.33	11.06	16.01	14.48	4.21	13.05	8.67	9.41	4.50	3.22
1981-'82												
Trichiurus	0.00	0.00	0.05	0.00	62.25	79.99	60.74	81.28	53.92	0.00	0.00	0.00
Carangids	20.76	34.13	22.19	17.98	4.31	6.97	19.28	8.71	9.55	19.96	32.47	35.58
Tunas	20.66	14.93	29.73	35.79	10.97	0.02	1.36	0.46	6.64	29.68	13.18	11.15
Stolephorus	0.08	0.07	4.55	3.72	14.80	10.31	12.21	6.36	13.77	1.11	0.90	0.00
Sardines	33.13	19.60	17.66	23.90	0.55	0.33	3.17	1.25	8.39	11.17	11.39	11.53
Mackerel	7.77	17.65	13.90	9.74	0.43	0.07	0.00	0.00	0.35	5.28	16.16	19.90
Seer fish	0.00	0.21	0.67	1.02	0.47	0.00	0.00	0.18	2.59	16.84	0.84	0.29
Total pelagic fishery based on grand total	2.47	2.62	4.36	9.04	12.76	14.90	10.50	23/13	13.02	3.33	2.00	1.85

TABLE 3. *Regression equation*

Year	Between variables	Regression Equation	Correlation Co-efficient
1980–'81	Y = *Trichiurus* X = Total displacement volume	Y = 0.9471 X — 6.8705	0.6403*
	Y = *Trichiurus* X = Temperature	Y = —8.4479 X + 246.0250	—0.6593*
	Y = Carangids X = Salinity	Y = 14.8035 X — 490.5275	0.6358*
	Y = Tunas X = Salinity	Y = —23.2935X + 829.8461	—0.6929*
1981–'82	Y = Total pelagic fishery X = Total Zooplankters	Y = 0.4887 X — 4.2596	0.7393**

* Significant (p ∠0.05)
** Significant (p ∠0.01)

Analysis of the patterns in the fluctuations of abundance in the major groups of zooplankton revealed that these could be categorised into three main types (in the Vizhinjam area). The first one comprised copepods which formed the dominant group in all the three seasons, *viz.* southwest monsoon northeast monsoon and inter-monsoon with the peak abundance during southwest monsoon (Table 1). Further during certain months, copepods were outnumbered by cladocerans. The second type consisted mainly of the cladocerans, *Evadne* and *Penilia* which swarmed during the monsoon months only. This phase was initiated by the sudden appearance of *Noctiluca* blooms, followed by swarms of *Evadne* and subsequently of *Penilia*. The third type which included decapod larvae, appendicularians, fish eggs, fish larvae and *Lucifer* exhibited a sharp decline during southwest monsoon period. The revival started with the northeast monsoon and the various groups attained their peak abundance in different months (Table 1 and Fig. 1 to 4).

Similarly Mukundan (1967) working on zooplankton of the Calicut waters, found that zooplankton abundance could be classified into two types, corresponding to the second and third type of the present investigation. However, Divakaran *et al.* (1980) in their preliminary study of zooplankton of Vizhinjam Bay, categorised plankton into two types corresponding to categories two and three of the present classification. However, their typical example of the third category, medusae, could not be included in this group in the present study since they did not decline in numbers during the southwest monsoon period. Further, in their studies *Penilia* swarms were not mentioned as following *Evadne* swarms and *Noctiluca* bloom. Nevertheless, that *Evadne* occurs as swarms during Jnly-October period is substantiated by Menon (1945).

A noteworthy feature was that the cumaceans, though benthic, were found in the plankton samples, especially those collected from the Bay area. This upward vertical migration of these organisms during certain periods has been attributed by Kurien (1973) to oxygen depletion in the bottom waters.

Considering the relationship between hydrographic factors and zooplankton, Shomura *et al.* (1970) has shown a close relationship only between salinity and zooplankton biomass. However, during the present study, as in the findings of King and Hida (1954, 1957) no significant correlations between zooplankton biomass and salinity were evident. Further neither temperature nor oxygen was significantly correlated with total zooplankton biomass in the present study and also in the findings of the workers cited above.

Correlating the pelagic fishery and hydrography, Pradhan and Reddy (1962), Ramamurthy (1965) and Mukundan (1967) have stressed the importance of temperature and salinity conditions to explain the fluctuations in the abundance of mackerel and sardines. However, during the present investigations abundance of mackerel and sardine did not show any significant relationship to temperature or salinity, although significant correlations between ribbonfishes and temperature and also between salinity and carangids and tunas were derived.

The studies by earlier workers suggest a close relationship between plankton and fishery. In the present study the peak periods in the plankton biomass were found to coincide with the peak seasons of pelagic fisheries, a finding substantiated by the significant correlations derived between plankton abundance and pelagic fishery. Prasad (1969) and Nair *et al.* (1978) are also in agreement with this, specifically the conclusion that a direct relationship exists between zooplankton biomass and pelagic fisheries of the Indian coastal waters. Individually only *Trichiurus* showed significant correlations with total plankton volume in the first year of collection. However, the data collected during these investigations are not extensive enough to draw definite conclusions.

Again, Vizhinjam is a rich ground for mackerel where the cladoceran and copepod population were found to be relatively high; the positive influence of copepods and cladocerans on mackerel fishery has also been established by Ramamurthy (1965), Rabindranath (1966) and Selvakumar (1970).

The present study also shows that the peak period of abundance of sardines a phytoplankton feeder (Rabindranath, 1966) coincides with the diatom peak in May (Menon, 1945; Mathew *et al.*, 1980), but the relation between the two becomes inverse in the later stages probably owing to grazing of phytoplankton by sardines. Following the same reasoning, the zooplankton peak in April, followed by a decline in May in the open sea stations could be due to grazing on herbivorous zooplankters by carnivores as reflected by the peak in anchovy fishery, an exclusive zooplankton feeder, during the succeeding months. This, in turn, is followed by the peak in the major fishery of ribbonfishes (June-October) for which the anchovy forms the main food item. These factors thus emphasise the importance of zooplankters in the study of the pelagic ecosystem in general and the related fisheries in particular.

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