Proceedings of the

FIRST WORKSHOP ON SCIENTIFIC RESULTS OF FORV *SAGAR SAMPADA*

5-7 June, 1989, Cochin

Sponsored by

DEPARTMENT OF OCEAN DEVELOPMENT
&
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI

Organized by

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
&
CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY
COCHIN

OCTOBER, 1990

Published by

Dr. P.S.B.R. JAMES
DIRECTOR
Central Marine Fisheries Research Institute
COCHIN - 682 031

Edited by

Dr. K.J. MATHEW
Central Marine Fisheries Research Institute
COCHIN - 682 031

Proc. First Workshop Scient. Resul. FORV Sagar Sampada, 5-7 *June*, 1989 : 297 - 303 (1990)

BIOPRODUCTIVITY STUDIES IN THE SOUTHWEST COAST OF INDIA AND EQUATORIAL REGION

PON. SIRAIMEETAN

Central Marine Fisheries Research Institute, Cochin-682 031

ABSTRACT

This paper embodies the observations on the Isaacs- Kidd Midwater Trawl collections made in the zone 03°S-11°N and 71°- 86°E. The depths in the area of study were recorded in the range 50 - 3,727 m. Significant variations in the occurrence and distribution of major zooplanktonic organisms and other pelagic fauna were noticed between stations. The percentage composition of planktonic organisms was comparatively high, being 49.6 in the stations covered south of the equatorial line. The average volume of plankton was high around Lakshadweep Islands, being 586 ml for a 30 minutes horizontal haul in the Deep Scattering Layer. Among the organisms, fish larvae and juvenile fishes, euphausiids and decapods, stomatopods (alima larvae of Squilla), copepods, caridian prawn *Pasiphus* sp. and pelagic squids were dominant in the collections of deep waters off southwest coast. *Bregmaceros mcClellandi* and decapods were common in the zone, 11°N and 73°-75°E. Similarly, the occurrence of Leptocephali was found in high percentage in the collections made at 08°00'N and 73° 35'E, off Ashtamudi estuary, revealing the spawning grounds of eels. In the Wadge Bank area, myctophids (*Diaphus* sp.) constituted 7% of the total collection. *Charybdis edwardsia* was found in swarms in deep waters off the southwest coast of India. The resource potentials of major pelagic organisms of commercial value from the less exploited deepsea waters have been studied and discussed.

INTRODUCTION

Considerable work has been done in India on the productivity studies of the coastal waters and several new concepts about the resources have been developed. Valuable data obtained from *Galathea* Exdpedition and cruise reports of R.V. *Varuna* , R.V. *Vityaz* and *Anton Brunn* have been pooled to compute the productivity of the comparatively highly fished inshore region within 50 m depth and rarely fished shelf region and deeper oceanic region (Nair *et al.*, 1973). However, attempt has not been made to obtain intensive data to follow the organic matter through different trophic levels. The objective of marine resource studies is mostly to determine the factors influencing the harvest or fishing and to explore new grounds for profitable fishing. Subrahmanyan (1973) assessed the magnitude of production in the Indian coastal waters and reviewed the studies onthe vertical distribution of the biomass of zooplankton at different depths. In the present account, the data collected by participating in the cruises of the Fisheries Oceanographic research Vessel *Sagar Sampada* on secondary production in relation to Deep Scattering Layer are analysed to assess the resource potentials of the less known deep sea waters.

MATERIAL AND METHODS

A survey of young fish and bathy and mesopelagic fauna of the southeastern Arabian Sea, including the Wadge Bank and the Lakshadweep and bioproductivity studies in the equatorial region of Indian Ocean were made by participating in the cruises 6 and 12 of FORV *Sagar Sampada* during the period 31-7-'85 to 13-8-'85 and 21-1-'86 to 18-2-'86. Twenty seven stations in the zone 05° - 11°N and 71°43'- 77°31'E and 41 stations on either side of the Equator extending between 03°N and 03°S and 76° and 86°E were fixed (Fig. 1) and the plankton samples were collected by employing Isaacs-Kidd Midwater Trawl. Trawling time of this net was maintained at 30 minutes. Hauling was horizontal and time for completing the operation varied from 5 to 10 minutes according to the depth of the DSL. The depths in the area of study were recorded in the range of 50 - 3,727 m. The position of the Deep Scattering Layer varied between 20 and 400 m in these grounds and most of the samples were obtained during day time and that too from depths below 100 m. The volume of the samples was taken by displacement method and the samples were preserved in 5% formalin. The percentage composition of various organisms was recorded and the specimens

Present address : Minicoy Research Centre of CMFRI, Minicoy.

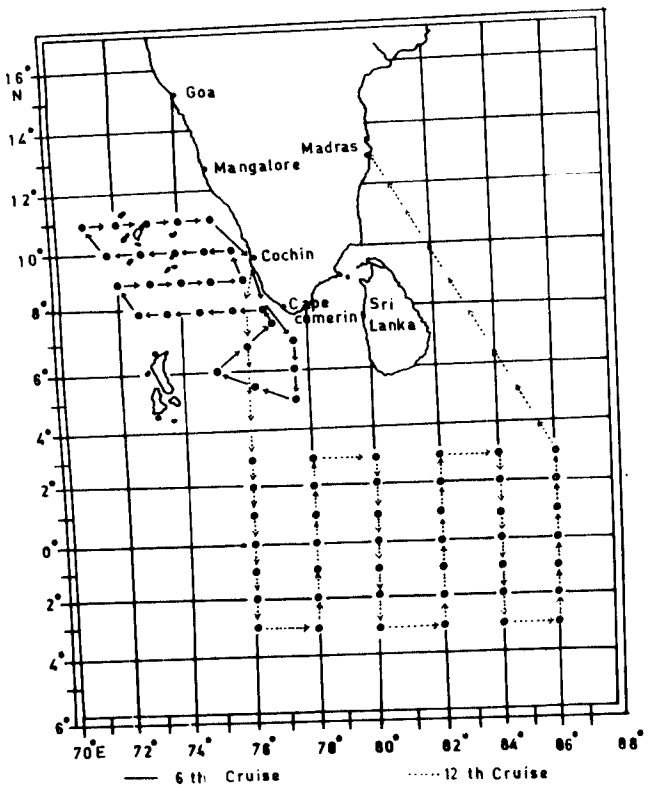

Fig. 1. IKMT collections were made at differnt stations during the 6th and 12 th cruises of FORV Sagar Sampada.

were identified upto genera or species levels wherever possible. Area-wise and depth-wise occurrence and distribution of different group of fishes and plankters were recorded.

Biomass Production

Riley (1944, 1950) and Clarke (1946) have accounted the total organic production for various waters and for the hydrosphere as a whole. Subrahmanyan (1959a, b) evaluated the production rate for the tropical environment and suggested for an increase in exploitation or harvest by 3 to 10 times the then level. Positive correlation between plankton crop and fisheries, as well as identification of indicative organisms have been made in temperate and Arctic regions, whereas little has been contributed in tropical waters, particularly around India due to paucity of investigations in deeper waters.

The biomass recorded at different depths of the Deep Scattering Layer are presented in Fig. 2. It may be seen that the average volume of the standing crop of zooplankton was rich in euphotic layers of 20-50 m depth accounting to 32.5% in the total. The average volume was 138 ml at 250 m and accounted

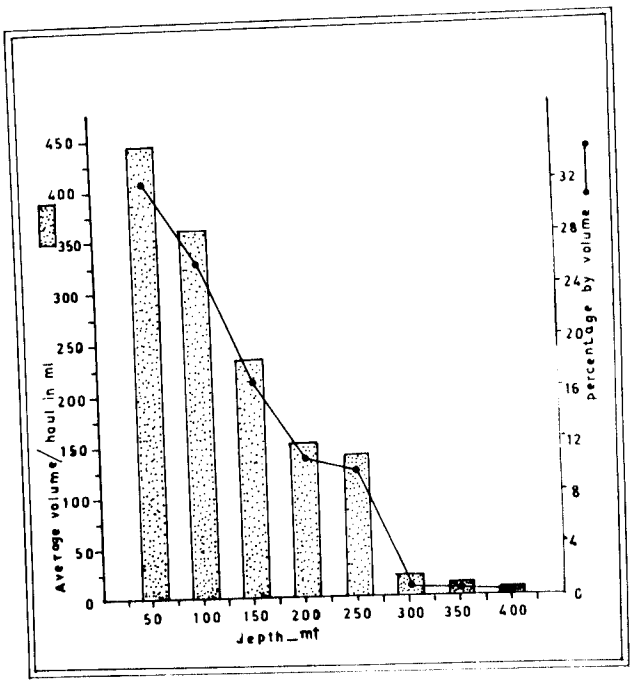

Fig. 2. The distribution of biomass recorded at different dapths of the deep scattering layer.

to 10.2% in the total. It is significant to note that the biomass production decreased as the depth of the DSL increased. The percentage contribution of standing crop was observed to be the lowest at the depth of 400 m being 0.4 (average 6 ml).

Subrahmanyan (1960) and Bogorov and Vinogradov (1961) observed rich standing crop inthe Arabian Sea and have attributed the cause to the upwelling or water mass circulation in the Arabian Sea during southwest monsoon. The present study also confirmed this observation as seen in Table 1. The distribution of major organisms in different zones revealed distinct variations both in number and volume. The standing crop was high inthe Lakshadweep Sea during July-August, and the average volume of collection was 586 ml, of which the plankton contributed 48.4% and micronekton 14.5%. Crabs, *Charybdis edwardsia* were found in high percentage (35.6%) in this ground. This species was dominating in the catches (58%) made inthe Wadge Bank area. The average volume of standing crop in the Wadge Bank was recorded as 414 ml. Plankton was next in importance (27%).

The standing crop of the equatorial region was comparatively less and the average volume varied from 138-148 ml. The percentage composi-

TABLE 1. *Biomass of the major organisms in different zones*

Area	No. of stations	Plankton (ml)	Young fishes (ml)	Prawn (ml)	Crab (ml)	Total organisms (ml)
Wadge Bank (05° - 09° N and 72° - 77° 31' E)	17	1,909.1	911.2	137.7	4,080.0	7,038.0
Average		112.3	53.6	8.1	240.0	414.0
Percentage		27.1	12.9	2.0	58.0	
Lakshawdeep Sea (10° - 11° N and 71° 43' - 75° 45' E)	10	2,837.0	848.0	88.0	2,091.0	5,864.0
Average		283.7	84.8	8.8	209.1	586.4
Percentage		48.4	14.5	1.5	35.6	
North of Equator (01° - 03° N and 76° - 86° E)	14	835.8	719.6	379.4	-	1,934.8
Average		59.7	51.4	27.1	-	138.2
Percentage		43.2	37.2	19.2	-	
Equator (00° and 76° - 86° E)	6	395.4	408.6	85.6	-	889.6
Average		65.9	68.1	14.3	-	148.2
Percentage		44.4	46.0	9.6	-	
South of Equator (01° - 03° S and 76° - 86° E)	21	850.5	1,476.3	751.8	-	3,078.6
Average		40.5	70.3	35.8	-	146.6
Percentage		27.6	48.0	24.4	-	

tion of plankton and young fishes was more or less equal (around 40%) but the occurrence of deep sea prawns was recorded at 19-24% on either sides of the Equator, whereas in upper latitude this was recorded in negligible percentages. It is interesting to note that the deep sea crabs recorded in high percentages in the Wadge Bank and the Lakshadweep (05° - 11°N and 71° - 77°E) was completely missing in the equatorial region (03°N - 03°S and 76° - 86°E).

OBSERVATIONS ON THE STANDING CROP

Information on the standing crop of zooplankton is available mostly for the nearshore region on the west coast of India. The Indian Ocean Biological Centre (IOBC), Cochin published the plankton atlas for the Arabian Sea. The richness of the standing crop has been noticed during southwest monsoon season along the Somali coast, Arabian coast and southwest coast of India upto Mangalore, between 0°-25°N and 45°-80°E (Prasad, 1966; 1968 a, b; Ponomareva and Naumov, 1962 and Wooster *et al.*, 1967).

Subrahmanyan and Sharma (1960) observed the bulk of standing crop on the west coast to contain a few species, unlike the composition noticed in the east coast, where a multiple species predominate the collection. A similar picture is reflected in the present study also (Table 2). The common zooplankters, young fishes, prawns, cephalopods and crabs observed in the collections have been tabulated and a distinct variation in oc-

TABLE. 2. *The numerical abundance of different organisms collected by Isaacs - Kidd Midwater Trawl*

Area covered	Wadge Bank 05°-09° N and 72°-77° 31' E	Lakshawdeep Sea 10°-11° N and 71° 43' - 75° 45' E	North of Equator 01°-03° N and 76° - 86° E	Equator 00° and 76° - 86° E	South of Equator 01°-03° S and 76° - 86° E
No. of stations :	17	10	14	6	21
Organisms	Number	Number	Number	Number	Number
Zooplankters :					
Euphausiids & decapods	17,195	30,965	5,677	4,046	11,042
Siphonophores	3,924	3,411	10,070	3,855	13,451
Copepods	332	1,226	1,613	872	2,625
Lucifer	-	-	1,369	359	2,105
Chaetognaths	859	1,921	646	422	696
Amphipods	382	463	415	144	814
Fish larvae	821	980	203	47	531
Pteropods	590	626	118	97	430
Stomatopods	496	20,317	8	24	63
Medusae	221	381	-	-	-
Gastropods	-	-	289	67	479
Leptocephali	340	165	105	12	91
Polychaetes	-	-	84	19	72
Fish eggs	-	-	29	5	25
Phyllosoma	-	-	8	1	7
Miscellaneous	457	787	1,851	330	1,224
Total	25,617	61,242	22,580	10,316	33,741
Fish, Prawn, Crab and Cephalopod :					
Myctophum elucens	1,864	1,012	353	30	70
M. evermanni	146	111	40	14	43
Caranx sp.	12	326	-	-	-
Stomias sp.	112	97	-	-	-
Bregmaceros mcClellandi	6	192	-	-	-
Diplophus taenia	77	-	-	-	-
Polypnus spinosus	43	22	20	4	5
Trichiurus sp.	6	10	-	-	-
Nemichthys scolop	3	-	6	1	20
Vinciguerria lucetia	-	-	3	1	20
Pasiphus sp.	425	211	37	9	59
Oplophorus sp.	-	-	202	3	18
Hymnopenaeus sp.	-	-	82	25	100
Charybdis edwardsi	381	148	-	-	-
Pelagic squid	125	52	-	-	-
Sepia sp.	3	1	-	-	-
Miscellaneous	54	56	187	46	155
Total	3,255	2,236	930	133	490
Grand Total	28,872	63,478	23,510	10,449	34,231

currence in different grounds was noticed. Among zooplankters, euphausiids and decapod larvae were the predominant groups in most of the stations and recorded in the range of 24-60%. Siphonophores were next in importance, except in the Lakshadweep Sea, where they exhibited a fall to 5.4%. Copepods and *Lucifer* were in negligible ratio in the Wadge Bank and Lakshadweep area but found more common in the collections made around the equatorial region (3-6% and 2-4% respectively). Chaetognaths and amphipods were noticed more or less in uniform strength in most of the stations. Fish larvae constituted 1.5 - 2.8% in the total collections made in the zone 05° -11°N and 71° - 77°E, whereas in the equatorial belt it was less. However, the samples made south of the Equator (01° - 03°S) contained an increased composition of fish larvae. Stomatopod larvae (alima larva of Squilla) were found in high percentage (32%) in the Lakshadweep sea only. Leptocephalus accounted for 1.2% in the samples obtained from the Wadge Bank area and in the rest of the ground they were in very low percentages. Similarly, phyllosoma larvae were noticed only from the collections of equatorial regions.

Among the teleosts, *Myctophum elucens* and *M. evermanni* were more common in the deep water collections of southwest coast of India. Cephalopods were noticed only in these stations and completely missing in equatorial grounds. Among deep sea prawns, *Pasiphus* sp. constituted 1.5% in the samples of the Wadge Bank and comparatively less in other stations. *Oplophorus* sp. and *Hymnopenaeus* sp. were noticed in increased percentages, being 0.9% and 0.3% respectively in the stations north of the equatorial line, but in poor combinations in the lower latitudes. It may also be seen that the deep sea crab, *Charybdis edwardsia* were more common (1.3%) in the Wadge Bank and the Lakshadweep waters but not so in the oceanic waters south of Kanyakumari.

Vinogradov (1962) and Voronina (1962 a,b) have dealt with the species distribution as well as quantitative distribution of some species of the Arabian Sea down to the Equator. The distribution patten of major organisms in these five zones at different depths of the DSL were analysed and is presented in Table 3. Euphausiids, decapods and siphonophores did not exhibit any distinct variation in their occurrence as they were recorded in all depths upto 400 m. A fall in the composition of copepods was noticed in depths below 300 m. *Lucifer* were recorded only in the upper 200 m depth level. Chaetognaths, stomatopods, amphipods, pteropods and leptocephali appeared in low per-

TABLE 3. *Percentage composition of major zooplankton groups at different depth of the Deep Scattering Layer*

Zooplankton groups	Depth of DSL (m)							
	50	100	150	200	250	300	350	400
Euphausiids & decapods	42.4	41.0	33.1	61.9	35.8	59.3	33.6	23.5
Siphonophores	17.0	32.7	22.6	14.3	27.7	10.1	28.2	52.9
Copepods	4.4	3.6	12.6	3.6	7.5	0.4	4.9	1.2
Lucifer	2.7	2.2	8.2	1.3	-	-	-	-
Leptocephalus	0.2	1.0	0.2	0.3	0.5	0.6	0.2	0.3
Phyllosoma	0.01	0.02	0.04	-	-	-	-	0.02
Fish larvae	1.3	1.9	2.7	1.8	8.5	1.4	1.8	0.9
Other plankters	29.7	12.3	14.8	9.1	13.8	15.4	13.3	7.7
Diaphus (Myctophid)	1.0	3.3	0.3	3.3	2.4	8.3	14.5	4.5
Prawns	0.2	0.6	2.5	1.9	0.7	2.5	2.7	5.4
Crabs	0.5	0.1	-	0.1	-	0.3	-	-
Cephalopods	0.1	0.2	0.3	0.6	-	-	-	-
Other fishes	0.4	1.1	2.8	2.4	3.1	1.7	0.7	3.5
Total organisms	58.2	24.1	3.1	4.0	1.2	5.7	1.2	2.5

centages but in all depths. Leptocephali were found entangled in the entire pelagic trawl net operated during night hours. The collection of Leptocephali in large numbers (average 9-21 per haul) from the ground at 50-100 m depth, off Ashtamudi estuary in southwest coast of India during July-August, revealed the spawning behaviour of eels at the onset of southwest monsoon in this zone. They measured 1.0 - 32.5 cm in length and were found common upto 100 m depth. Phyllosoma larvae were recorded from the collections of upper 150 m depth level. Fish larvae concentrated upto the depth of 250 m although it was noticed in still deeper waters. High concentration of deep sea fishes like myctophids were seen between 300 and 350 m and poorly represented in the upper layers. The cephalopods were obtained from the maximum depth of 200 m. It is interesting to note that the deep sea prawns occurred in increased percentage, below the depth of 300 m (2.5 - 5.4%). The portunid crabs were also more common from the depth of 300 m. Similar to the variations noticed in the volume of standing crop at different depths, the total organisms also exhibited distinct differences at different depth level. The surface waters upto 50 m depth contained 58.2% whereas it gradually declined and reached 2.5% at 400 m depth.

General Remarks

Subrahmanyan (1973) while reporting the observations made by Silas, stated that the standing crop of zooplankton fluctuated from 100 to 700 ml/1000 m^3 in the shelf waters and that the volume decreased in the deeper waters, and identified very rich area between Quilon and Calicut and the Wadge Bank in the south. The maximum production coincided with the southwest monsoon. The value for the oceanic area was recorded as 144 ml/1000 m^3. The same trend of fertility, revealing a high volume of standing crop at 414-586 ml/haul of 30 minutes was noticed in the Wadge Bank area and Lakshadweep waters during July-August.

Ponomareva and Naumov (1962) studied the vertical distribution of biomass of zooplankton and observed rich volume in the upper 100 m depth than 200-100 m or 500-200m. Vinogradov (1962) also found bulk of the plankton in the surface layers upto 100 m. This is in conformity with the present findings.

The euphausiids form the major food item of tunas which abound in the offshore waters and high seas. Vinogradov and Voronina (1961) opined, that tuna grounds are located in the areas where larger zooplankters and micronekton abound. Submarine ridges and banks and other irregular structures in the bottom hinder the flow of underwater currents and cause eddies which ultimately result in rapid sinking of plankton and become food for demersal fishes. Mendis (1965) correlated such causes to the potential resources of the Wadge Bank. Subrahmanyan (1973) remarked the convergence zones as indicators of potential fishing grounds, those about the equatorial region as is now known, are tuna long-line fishing zones. In the present study , the euphausiids, as they were found in high values (30-60%) in the Wadge Bank, Lakshadweep waters and the equatorial region can be considered as the indicator organism of tuna. The resource potential of tuna as they are directly related to this dietary organism in these grounds can be well recognised.

In the present investigation, *Hymnopenaeus* sp. and *Oplophorus* sp. were found common in the deep waters of the equatorial region, whereas *Pasiphus* sp. appeared in large numbers in the Wadge Bank . Mohamed and Suseelan (1973) have noticed these species in deep waters of the southwest coast of India, besides other dominant species. Rao *et al*. (1973) reported the existence of deep water crabs, *Charybdis (Goniohellenus) edwardsia* Leene and Buitendijk in large quantities from the western part of the Indian Ocean. As observed in the present exploratory survey, there is great possibility of tapping such hitherto unexploited oceanic resources of portunid crabs in the zone 05° - 11°N and 71° - 77°E. The rich fertility of the waters of the southwest coast, the Lakshadweep region and the equatorial region should be quite obvious from the data presented and support the views of earlier workers. It is apt to quote the statement given by Jones (1967) in this context. "There is evidence of significant fish resources in open parts of the Indian Ocean, first of all in waters of the Arabian Sea".

Acknowledgements

I have great pleasure in recording my sincere thanks to the following : Dr. P.S.B.R. James, Director, Central Marine Fisheries Research Institute, Cochin for the keen interest shown in the study, to my colleague Mr. R. Marichamy for useful discussion and suggestions offered for the improvement of this manuscript.

References

BOGOROV, V.G. AND M.E. VINOGRADOV 1961. Some features of plankton biomass distribution in the surface waters of the Indian Ocean during the winter of 1959-'60. *USSR Acad. Sci. Okeanol. Issled.*, (4) : 66-71.m

CLARKE, G.L. 1946. Dynamics of production in a marine area. *Ecol. Monogr.*, **14** (4) : 322-335.

JONES, S. 1967. Conservation of the tuna and billfish resources of the Indian Ocean. *Proc. Symp. Scombroid Fish.*, MBAI, Pt. III : 1184-1189.

MENDIS, A.S. 1965. Resources of the Wadge and Pedro banks. *Bull. Fish. Res. Stn. Ceylon.*, **18** (2) : 47-52.

MOHAMED, K.H. AND C. SUSEELAN 1973. Deep sea prawn resources off the southwest coast of Indian. *Proc. Symp. Living Resources of the seas around India.* CMFRI, Spl. Publ: 614-633.

NAIR, P.V. RAMACHANDRAN, SYDNEY SAMUEL, K.J. JOSEPH AND V.K. BALACHANDRAN 1973. Primary production and potential fishery resources in the seas around India. *Ibid.*, 184-198.

PONOMAREVA, L.A. AND A.G. NAUMOV 1962. Distribution of zooplankton biomass in the Arabian Sea and Bay of Bengal during period of monsoon change. *Dokl. Akad. Nauk. SSSR.*, **142** (2) : 449-452.

PRASAD, R.R. 1966. Recent advances in the study of production in the Indian Ocean. *2nd Internat. Oceanogr. Congr. Moscow., Abst.*, 293.

PRASAD, R.R. 1968 a. Maps of the total zooplankton biomass in the Arabian Sea and the Bay of Bengal. *I.O.B.C. Plankton Atlas*, 1 (1).

PRASAD, R.R. 1968 b. Maps on the total zooplankton biomass in the Indian Ocean. *Ibid*, 1 (2).

RAO, P. VEDAVYASA, M.M. THOMAS AND G. SUDHAKARA RAO 1973. The crab fishery resources of India. *Proc. Symp. Living Resources of the seas around India.* CMFRI, Spl. Publ., 581-591.

RILEY, G.A. 1944. The carbon metabolism and the photosynthetic efficiency of the earth as a whole. *Amer. Sci.*, Spring Issue, **32** (2).

RILEY, G.A. 1950. Food from the sea. *Scientific American*, October, 1950.

SUBRAHMANYAN, R. 1959 a. Studies on the phytoplankton of the west coast of India Pt. I. Quantitative and qualitative fluctuation of the total phytoplankton crop, the zooplankton crop and their interrelationship, with remarks on the magnitude of the standing crop and production of matter and their relationship to fish landings. *Proc. Indian Acad. Sci.*, **B 50** (3) : 113-187.

SUBRAHMANYAN, R. 1959 b. Studies on the phytoplankton of the west coast of India. Part II. Physical and chemical factors that influence the production of phytoplankton with remarks on the possible limiting factors, cycle of nutrients in the water and relationship of phosphate content to fish landings. *Ibid.*, **B 50**: 189-252.

SUBRAHMANYAN, R. 1960. Observations on the effect of the monsoon in the production of phytoplankton. *J. Indian bot. Soc.*, **39** (1) : 78-79.

SUBRAHMANYAN, R. 1973. Hydrography and plankton as indicators of marine resources. *Proc. Symp. Living Resources of the seas around India.* CMFRI Spl. Publ. , 199-228.

SUBRAHMANYAN, R. AND A.H. SHARMA 1960. Studies on the phytoplankton of the west coast of India. Part III. Seasonal variation of the phytoplankters and environmental factors. *Indian J. Fish.*, 7 : 307-336.

VINOGRADOV, M.E. 1962. On the quantitative distribution of deep water plankton in the northern part of the Indian Ocean. *Okeanologia*, **2** (4) : 577-592.

VINOGRADOV, M.E. AND N.M. VORONINA 1961. Distribution of some widespread species of copepods in the Indian Ocean. *Dokl. Acad. Nauk. SSSR.*, **140** (1) : 219-222.

VORONINA, N.M. 1962 a. On the surface plankton of the Indian Ocean. *Trud. Inst. Okeanol. Akad. Nauk. SSSR.*, **58** : 67-79.

VORONINA, N.M. 1962 b. Distribution of macroplankton in the northern Indian Ocean. *Okeanol.*, 2 (1) : 119-125.

WOOSTER, W.S. *et al.* 1967. Atlas of the Arabian Sea for fishery oceanography. *Univ. Cal. Inst. Mar. Res.* , 67-120.