ANNUAL REPORT FOR 1970

Central Marine Fisheries Research Institute
COCHIN-11
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

CONTENTS

INTRODUCTION

Brief historical introduction

The catches of fish from the oceans of the world have been increasing at a rate of some 7% per year (doubling every 10 years or so). While in some oceans, like the North Atlantic, the increase has been very fast, in others, like the Indian Ocean, it has been extremely slow. The proper appraisal of fish resources of the Indian Ocean has been one of the long-term objectives of the Central Marine Fisheries Research Institute.

The seas around India have many fishery resources, some of them of local importance while others of national importance. The development of marine fisheries is dependent upon adequate knowledge and assessment of these fishery resources; and since no State agencies are engaged in undertaking researches on the assessment of these resources, it has become the sole responsibility of the Central Marine Fisheries Research Institute.

Objectives

The objectives of the Institute have recently been redrawn and these are primarily directed towards:

1. Estimation of existing yield from the exploited fishery resources and the effort expended to obtain the yield.
2. Assessment of the level of exploitation and its effect on the resources.
3. Estimation of the maximum sustained yield and formulation of management measures.
4. Studies on life-history and biology of *important* species.
5. Estimation of recruitment, growth and mortality rates of commercially important species.
6. Environmental studies (physical, chemical and biological features) in relation to distribution, reproduction, migration and abundance of fish populations.
7. Environmental pollution and its effect on fishery resources.
8. Production processes and the efficiency of food conversion at the primary and secondary stages of the food chain.

9. Mapping and detailed knowledge of such areas in the sea which are of special fishery interest.

10. Location of spawning grounds of important species and studies on fish eggs and larvae.

11. Magnitude of untapped resources and their commercial potentialities.

12. Coordination of existing knowledge on major fisheries and suggesting gaps in the knowledge or new lines of investigations.

13. Forecasting fishing seasons and informations on harvesting.

14. Laboratory and field studies on breeding, survival, feeding and growth of some animals at different stages of their life cycles.

15. Development of culture techniques in salt-water of cultivable species.

16. Strengthening the cooperation and collaboration with other institutions in scientific investigations.

17. Prompt distribution of information (unclassified) to all concerned agencies and to the public.

During the year, 96 research projects were undertaken and all round progress have been maintained by the staff at Headquarters and subordinate establishments. The scientific work of the Institute has been carried out under three major Divisions:

(1) Fishery Survey and Statistics
(2) Fishery Biology
(3) Marine Biology and Oceanography

The present report is intended to serve two main purposes: firstly, to provide some basic information on the assessment and exploitation of fishery resources and to indicate possibilities for development of new fisheries; secondly, to facilitate the planning and to provide an early warning of the need for conservation and management if any over-exploitation occurs. Inevitably, from many areas of the country the information available is not sufficient to produce accurate estimates. However, from the collection of basic data such as catch statistics, environmental studies and basic informations on the biology of fishes, more accurate and realistic estimates can hopefully be derived.

Organisational structure and changes

Library

During the year, 110 new books and 500 volumes of periodicals were added to the library. The printing of the Indian Journal of Fisheries

Vol. XII, No. 2 and Vol. XIII, No. 1 and the 'Proceedings of the Symposium on the living resources of the Seas around India' is in progress.

Numbers 1, 2, 3 and 4 of the Volume IV of 'Advance Abstracts of Contributions on Fisheries and Aquatic Sciences in India' were issued during the year. Numbers 17 to 24 of the Bulletin of the Central Marine Fisheries Research Institute were also published.

As usual, library books were sent on inter-library loan to the Marine Biological Station, Porto Novo; Department of Fisheries, Madras; Indo-Norwegian Project, Mandapam Camp; Department of Zoology, Andhra and Madurai Universities; Department of Marine Biology, Kerala University; INSDOC, New Delhi; local units of the Central Salt and Marine Chemicals Research Institute and the Central Electro-Chemical Research Institute. In addition, visitors from Colleges and Universities made use of the library.

List of distinguished visitors to the Institute and its Sub-Station

1. Shri K. V. Ahmed Bavappa, Director, Central Plantation Crops Research Institute, Kasargode, Kerala.
2. Mr. Ivan Genei, visiting Scientist from Hungary.
3. Dr. K. K. Iya, Deputy Director-General (AS), Indian Council of Agricultural Research, New Delhi-1.
4. Dr. J. S. Kanwar, Deputy Director-General (SAE), Indian Council of Agricultural Research, New Delhi-1.
5. Hon'ble Shri Farook Maricar, Chief Minister, Pondicherry.
6. Mr. John C. Marr, Director, Indian Ocean Programme, FAO, Rome.
7. Shri K. P. A. Menon, I. A. S., Secretary, Indian Council of Agricultural Research, New Delhi-1.
8. Shri Rabindranatha Menon, I. A. S., Chairman, Marine Products Export Promotion Council, Cochin.
9. Mr. Steinor Olsen, FAO, Rome.
10. Dr. N. K. Panikkar, Director, National Institute of Oceanography, Mirmar, Panaji, Panjim, Goa.
11. Dr. Atma Ram, Director-General, Council of Scientific and Industrial Research, New Delhi.
12. Shri Y. P. Rao, Deputy Director-General, Observatory, Poona.
13. Shri T. C. A. Srinivasaramanujam, I. A. S., Deputy Financial Adviser, (Agriculture), Government of India, New Delhi.
14. Shri M. A. K. Tayab, I. A. S., Director of Fisheries, Tamil Nadu.

Research Collaboration with other organizations

1. Survey of the Chank and Pearl Oyster beds in the Gulf of Mannar in collaboration with the Department of Fisheries, Tamil Nadu.

2. Marine Biology, Oceanography and Exploratory Surveys with the Indo-Norwegian Project, Deep Sea and Offshore Fishing Stations, Government of India.

Advisory Service Received and Provided

1. The Director of the Institute served as a member in the Madras State Fisheries Research Council, Kerala State Fisheries Research Committee and Kerala State Fisheries Advisory Board.

2. Dr. S. Z. Qasim attended SCOR/IBP Working Group 24 Meeting in Nanaimo, B. C., Canada in November 1970 for finalising the Report of the Working Group 24 which was constituted in 1967 to suggest the best methods of measuring Primary Production under special conditions. He also undertook a study tour of the United States, Canada and Japan and delivered lectures.

3. Dr. S. Z. Qasim served as Examiner in Oceanography of the Andhra University and M. Sc., and Ph. D., examiner in Fisheries of the Aligarh University.

4. Shri S. K. Banerji, Senior Fishery Scientist was deputed on Foreign Service with the FAO of the United Nations for a period of three months from September 28 to December 27, 1970 to serve as a Consultant in Fisheries Statistics in the Indian Ocean Development Programme.

5. Shri S. K. Benerji's term as Consultant in Fisheries Statistics for the Fishery Survey undertaken by the Indian Institute of Foreign Trade, New Delhi ended in March 1970.

6. Shri S. K. Banerji served as an examiner in Fishery Statistics for the 1970 annual examination conducted by the Central Institute of Fisheries Education, Bombay.

Fellowships, Studentships and Training facilities received and provided

During the year 5 Research Scholars have been undergoing training at this Institute under the scheme of scholarships instituted by the Government of India, Ministry of Education & Youth Services.

Two staff members of this Research Institute (Shri V. Sriramachandra Murty, Research Assistant and Shri A. Chellam, Junior Scientific Assistant) have been selected by the Indian Council of Agricultural Research for the award of Senior and Junior Fellowships respectively in fisheries under 1969–70 programme.

Shri S. K. Dharmaraja, Assistant Fishery Scientist, Shri A. K. Kesavan Nair, Research Assistant, Shri T. S. Krishnan, Research Assistant and Shri G. Balakrishnan, Research Assistant underwent training in Intensive Course in Computor Programming and Statistical Processing for Agricultural Research Workers conducted by the Institute of Agricultural Research Statistics, New Delhi.

Mr. Fawzy A. Boraey, a Trainee from the U. A. R. was given training in Fishery Biology at this Institute.

Shri V. Ramamoorthy and Shri M. S. Shahabdeen, Inspectors of Fisheries, Department of Fisheries, Tamil Nadu were given training in Fisheries Statistics.

Conference and Symposia

1. The staff of the Institute participated in the Symposium on "Development of Deep Sea Fishing" conducted by the Ministry of Food & Agriculture at the Central Institute of Fisheries Operatives, Cochin in February 1970.

2. The Institute participated in the 'Open House' Exhibition conducted at the Indo-Norwegian Project, Cochin in November 1970.

Finance

The budget allotment of the Institute for the financial year ending 31-3-1971 has been Rs. 8.04 lakhs under Plan and Rs. 25.47 lakhs under Non-Plan (Revised Estimate).

PROGRESS OF RESEARCH

FISHERY SURVEY AND STATISTICS

Summary of salient findings

During 1970, the total marine fish production in the country for the first time crossed the million tonne mark and was provisionally estimated at 1075,402 tonnes. The percentage contribution of landings by mechanised vessels showed some increase but no significant change was noticed in the night landings. Except for Andhra, Tamil Nadu and the Centrally Administrated regions like Pondicherry, Goa, Andamans and Laccadives, where no significant change in total fish production was recorded, the total catch in all other maritime States of India registered a significant increase.

The total input of fishing effort increased from 177 million man hours in 1969 to 179 million man hours in 1970. The catch per unit effort at the national level also increased from 4.91 kg. to 5.73 kg. The number of operations of trawl net showed an increase over that of 1969. While the

number of operations of small shore seines increased, there were less number of operations of big shore seines (Rampans) and boat seines.

The remarkable recovery of mackerel fishery reported in 1969 was not only maintained but an all time record catch of 147,038 tonnes was obtained in 1970. The oil sardine fishery was also very successful. These two together with Bombay duck and prawns formed more than 52% of the total catch. A general assessment of these fisheries shows that the annual fluctuations in the catches are brought about by the changes in the availability of the fish and as long as the fishing is restricted to the inshore area, it is doubtful whether a further increase in fishing effort will bring about any significant increase in the yield.

Researches in hand

I. Annual Production of Marine Fish

During 1970 the total marine fish production in the country crossed for the first time one million tonne mark and was provisionally estimated as 1075,402 tonnes. The fish production in 1969 was 913,630 tonnes. The increase in production in 1970 from the previous year was about 18%. Table I gives the State-wise marine fish production for the years 1969 and 1970. The table also shows the division of the total catch according to mechanised and non-mechanised crafts and also in relation to catches by day and night.

In 1970, the percentage of landings from the mechanised boats showed an increase over those of 1969. Landings by the mechanised units showed an improvement in all the maritime States of India, excepting in Andhra Pradesh where a minor decline was noticed. As compared to 1969, no significant change was noticed in the percentage landings during the night. Excepting in Andhra Pradesh, Tamil Nadu and the Centrally Administered areas of Pondicherry, Goa, Andamans and Laccadives where either no change or some marginal decline in the total production was recorded, the total catch in all the other maritime States of India registered a significant increase.

The landings in West Bengal and Orissa increased by about 8,500 tonnes (37%). The improvement in landings resulted from an output of more effort as well as from better returns per unit effort (vide Table 10). There were increased yields in respect of many varieties of fish, especially in clupeoids other than sardines, sciaenids and mackerel. An unusually large catch of mackerel in the last quarter was the most significant event during the year.

In Andhra, the decline in the total catch was only marginal. The return per unit effort was lower than in 1969. Thus in spite of a slightly higher input of effort, a marginal decline in the production was observed. No significant difference in the catches of individual varieties was noticed during the year.

The decline in the total landings in Tamil Nadu was again nominal. Though there was a slight fall in the input of effort, the increased return per unit effort maintained the total yield more or less constant. While the catch of elasmobranchs increased slightly, *Anchoviella* recorded a reduced yield. No other significant changes were noticed in respect of other fishes.

In Pondicherry, the total yield as well as the effort expended remained virtually constant during the year with the result that the catch per unit effort also did not change substantially. The variation in the catches of different fishes was also nominal.

The landings in Kerala showed an increase of about 101,900 tonnes (35%). The effort put in as well as the return per unit effort expended were higher as compared to 1969. The traditional fisheries of the oil sardine and mackerel were better; the catches of these fishes showed an increase of about 51,500 tonnes and 24,700 tonnes respectively. The landings of cat-fishes also increased substantially.

TABLE I. *State-wise marine fish landings*

Provisional estimate of landings (in tonnes) during the years 1969 and 1970 according to mechanised and non-mechanised boats and in relation to catches by day and night.

States	Day		Night				Total	
	By non-mechanised units		By mechanised units		(Combined)			
	1970	1969	1970	1969	1970	1969	1970	1969
1. West Bengal & Orissa	30589	18467	600	580	236	3832	31425	22879
2. Andhra	69795	75503	1867	1986	314	37	71976	77526
3. Tamil Nadu	104661	114750	36783	27678	7670	9448	149114	151876
4. Pondicherry	9979	10174	395	316	250	147	10624	10637
5. Kerala	326039	252475	52571	28177	18123	14135	396735	294787
6. Mysore	98495	66291	14742	9094	1596	408	114833	75793
7. Maharashtra	62187	75933	98280	74062	21603	18725	182070	168720
8. Gujarat	32135	35013	40528	36104	16364	11131	89027	82248
Percentage	70.17	73.33	23.50	20.13	6.33	6.54	100	100
9. Goa							28000	27559
10. Andaman Islands							400	412
11. Laccadive Islands							1200	1193
Grand Total							1,075,402	913,630

The increase both in the input of effort and the return per unit effort resulted in a substantial increase in fish production in Mysore State. The percentage increase in production of 1970 over that of 1969 was 51. While the landings of oil sardine did not show much change, those of mackerel, cat-fishes and penaeid prawns recorded a significant increase. The landings of lesser sardines showed a decrease.

In Maharashtra, although there was a significant decrease in the input of effort during 1970, the total landings showed a considerable increase. This was mainly because the return per unit effort showed a large increase. While the catches of penaeid prawns increased substantially, those of non-penaeid prawns recorded lower landings. The landings of cat-fishes also increased.

The higher input of effort in Gujarat could not bring in an appreciable increase in the total production, as there was a substantial fall in the return per unit effort during the year. However, the landing of *Hilsa* showed a significant increase. The catch of *Harpodon nehereus* registered some decline. There were no significant changes in the catches of other varieties of fish.

II. Variety Composition

The marine fisheries of India are based on more than 200 species. For the statistical presentation, these 200 or more species have been conveniently grouped. Table 2 presents the landings of these groups of fish for the year 1970. The figures for 1969 have also been included in the table for comparison. An examination of table 2 will reveal that (1) oil sardine, mackerel, *Harpodon nehereus* and prawns form the principal fisheries and their landings contribute more than 52% of the total marine fish production of India; and (2) as compared to the 1969 season, the catches of oil sardine, mackerel, penaeid prawns, cat-fishes, *Thrissocles* and elasmobranchs increased substantially and those of *Harpodon nehereus* and *Anchoviella* showed a slight decline during 1970. A summary of the main fisheries is as follows:

1. Oil Sardine

Table 3 gives state-wise landings of the oil sardine. It will be seen from the table that nearly 85% of the oil sardine landings take place in Kerala. Hence a successful fishery in Kerala will determine the fishing prospect of oil sardine for the country as a whole. Excepting for the years 1962 and 1963, the fishery of oil sardine was by and large satisfactory in all other years of the last decade. But even then the fishery was characterised by wide annual fluctuations in the catches. These fluctuations were largely due to the differences in the availability of the fish within a limited fishing region along the coastal belt.

A tentative assessment of the effect of fishing on oil sardine has shown that the maximum value of yield per recruit Y/R is obtained at fishing effort corresponding to the fishing mortality rate F=1.4 as against the present average fishing mortality F=0.75. But the computed yields at these two levels show that by almost doubling the fishing effort, the yield will increase only by about 12%. This indicates that no substantial increase in oil sardine is possible by a further increase in fishing effort, as long as the fishery is restricted to the inshore waters.

TABLE II. *Composition of total marine fish landings in India during 1969 and 1970 (quantity in tonnes)*

Sl. No.	Name of fish	1970	1969
1.	Elasmobranchs	43,439	35,442
2.	Eels	4,454	3,052
3.	Cat-fishes	50,725	26,903
4.	*Chirocentrus*	9,407	9,337
5. a)	Oil sardine	225,690	174,249
b)	Lesser sardines	51,309	52,467
c)	*Hilsa ilisha*	1,052	661
d)	Other *Hilsa*	9,448	7,873
e)	*Anchoviella*	23.830	31,436
f)	*Thrissocles*	13,812	9,009
g)	Other clupeids	28,460	26,316
6. a)	*Harpodon nehereus* (Bombay duck)	72,103	76,276
b)	*Saurida & Synodus*	2,809	3,043
7.	*Hemirhamphus & Belone*	1,679	981
8.	Flying fish	2,844	4,039
9.	Perches	14,096	12,865
10.	Red mullets	2,130	3,475
11.	Polynemids	7,185	3,480
12.	Sciaenids	40,556	35,041
13.	Ribbon fish	26,394	31,722
14. a)	*Caranx*	18,939	21,415
b)	*Chorinemus*	1,939	2,443
c)	*Trachynotus*	143	149
d)	Other carangids	930	7
e)	*Coryphaena*	254	237
f)	*Elacate*	518	309
15. a)	*Leiognathus*	46,681	44,038

Table II *(Contd.)*

Sl. No.	Name of fish	1970	1969
b)	*Gazza*	148	102
16.	*Lactarius*	4,697	4,546
17.	Pomfrets	22,679	24,176
18.	Mackerel	147,038	91,837
19.	Seer fish	13,206	11,516
20.	Tunnies	3,172	3,445
21.	*Sphyraena*	1,470	1,996
22.	Mugil	2,357	2,693
23.	*Bregmaceros*	1,978	1,684
24.	Soles	13,324	11,991
25. a)	Penaeid Prawns	88,972	72,133
b)	Non-penaeid prawns	26,229	33,964
c)	Other crustaceans	9,947	5,670
26.	Cephalopods	1,177	769
27.	Miscellaneous	38,182	30,843
	Total	1,075,402	9,13,630

TABLE III. *Landings of oil sardine during the years 1969 and 1970 in the States of Kerala, Mysore and other States combined*

Year	Landings (in tonnes) in			
	Kerala	Mysore	Other States	Total
1969	139,938	33,580	686	174,249
1970	191,523	33,821	346	225,690
Average (1960–1970)	175,311	30,002	1,247	206,560
Percentage (1960-1970)	84.87	14.52	0.61	100

TABLE IV. *Landings of mackerel during the years 1969 and 1970*

Year	Landings (in tonnes) in			
	Kerala	Mysore	Other States	Total
1969	29,981	13,253	48,603	91,837
1970	54,704	44,737	47,597	147,038
Average (1960-1970)	22,511	20,364	17,412	60,287
Percentage (1960-1970)	37.34	33.78	28.88	100

TABLE V *Landings of Bombay duck during the years 1969 and 1970 (quantity in tonnes)*

Year	Landings of Bombay duck in			
	Maharashtra	Gujarat	Other States	Total
1969	25,171	49,484	1,621	76,276
1970	27,398	43,618	1,087	72,103
Average (1960-1970)	26,531	55,545	1,254	83,330
Percentage (1960-1970)	31.84	66.66	1.50	100

2. Mackerel

The mackerel fishery of India is based on a single species, *Rastrelliger kanagurta* and is mainly confined to the coastal waters of the west coast, between Quilon (Kerala) and Ratnagiri (Maharashtra). Table 4 gives state-wise landings of mackerel for the two years 1969 and 1970. Like oil sardine, the mackerel fishery is equally important to the States of Kerala and Mysore. Like the oil sardine, the annual landings of mackerel also fluctuate widely. The catch in 1960 was 133,655 tonnes but during the next 8 years, barring 1963, the catches fluctuated between 21 to 43 thousand tonnes only. The fishery made a remarkable recovery in 1969 and this was not only maintained during the current year but an all time record catch of 147,038 tonnes was obtained in 1970.

The annual fluctuations in the mackerel fishery are well known. For mackerel the existing fishing mortality rate is estimated at $F = 1.40$ and the maximum yield per recruit Y/R is obtained at $F = 1.55$. This shows that we are almost exerting the maximum effort and are nearer to the optimum yield and that any further increase in the fishing effort within the inshore fishing area exploited at present, may fetch only a nominal increase in the catch.

3. Bombay Duck

The Bombay duck fishery is based on a single species, *Harpodon nehereus* which predominantly exists along the coasts of Maharashtra and Gujarat. The fish is also caught in small quantities along the West Bengal and Andhra coasts. Table 5 shows the total landings of Bombay duck during the years 1969 and 1970. While the annual landing of Bombay duck in Maharashtra did not show much change, those in Gujarat showed some fluctuations. In fact, a decrease in the annual landings was seen in Gujarat. A critical study is being carried out to determine whether the decrease was in spite of an increase in fishing effort or not.

4. Cat-fishes

Cat-fishes are landed in all the maritime States of India. Table 6

gives the annual landings for the years 1969 and 1970. During 1969 the annual catch of cat-fishes was 26,903 tonnes. The catch in 1970 was about twice that of the previous year. This improvement was mainly due to more mechanised boats being used for fishing in different States.

TABLE VI. *Landings of Cat-fishes during the years 1969 and 1970*

Year	Landings (in tonnes)
1969	26,903
1970	50,725
Average (1960-1970)	24,106

TABLE VII. *Landings (in tonnes) of Penaeid prawns during the years 1969 and 1970*

Year	Kerala	Maharashtra	Mysore	Other States	Total
1969	34,334	14,545	3,980	19,274	72,133
1970	37,993	27,407	6,760	16,812	88,972
Average (1960-1970)	26,053	11,445	2,266	15,846	55,610
Percentage (1960-1970)	46.85	20.58	4.08	28.49	100

TABLE VIII. *Landings (in tonnes) of Non-penaeid prawns during 1969-1970*

Year	Maharashtra	Other States	Total
1969	31,235	2,729	33,964
1970	22,820	3,409	26,229
Average (1960-1970)	31,213	2,094	33,307
Percentage (1960-1970)	93.71	6.29	100

5. Elasmobranchs

Landings of elasmobranchs in 1970 showed an improvement over those of 1969 by more than 20% mainly because of an increase of catches in Tamil Nadu, Kerala and Gujarat. Lower catches of elasmobranchs were obtained in Maharashtra.

6. Thrissocles

The average landings of *Thrissocles* during the last few years was 7,100 tonnes. Landings during 1970 showed an increase over the average by about 95%. This was due to an unusually good fishery of this particular fish in Kerala and Mysore.

7. Anchoviella

As compared to 1969, the landings of *Anchoviella* showed a decrease by 7,606 tonnes mainly because the fishery was poor in Kerala and Tamil Nadu.

8. Crustaceans

For the purposes of analysis the landings of all marine crustaceans are grouped under three broad heads: (1) penaeid prawns, (2) non-penaeid prawns and (3) other crustaceans. The per cent contribution of these were 60%, 36% and 4% respectively. Landings of crustaceans formed about 11% of the total marine fish production of India and they were landed in all the maritime States. While large quantities of penaeid prawns were landed in Kerala, Maharashtra and Mysore, the quantity of non-penaeid prawns was maximum in Maharashtra. Though the major portion of the landings of prawns was from the indigenous fishing units, the contribution from the mechanised shrimp trawlers was continually on the increase. Table 7 gives the landings of penaeid prawns during the years 1969 and 1970. This table indicates that the total landings of penaeid prawns increased in almost all the States during 1970.

Table 8 gives the landings of non-penaeid prawns during the years 1969 and 1970. The annual catch decreased from the previous year. It can also be seen from table 8 that Maharashtra State alone accounts for 94% of the total production of non-penaeid prawns in India.

The other crustaceans include lobsters and crabs the maximum landings of which were in Tamil Nadu and Maharashtra. During 1970, the total landings of other crustaceans increased substantially as compared to previous years.

III. Seasonal Variation

Table 9 shows the seasonal variations in total fish landings of different maritime States of India. It can be seen from the table that about 41% of the total marine fish production occurred in the fourth quarter. Excepting Gujarat, the bulk of the catch along the west coast of India was landed in the fourth quarter. While along the east coast, excepting West Bengal and Orissa where highest landings were recorded during the fourth quarter, the maximum yield was obtained during the first quarter.

IV. Input of Effort

1. Man hours expended and return per unit effort

Table 10 shows the total effort in terms of man-hours expended in each maritime State by the indigenous boats (both mechanised and non-mechanised) and catch in Kg per man hour. The corresponding figures for 1969 have also been included for comparison.

It is seen from table 10 that for the country as a whole, the catch per unit effort showed some increase from that of 1969. Excepting Tamil Nadu and Maharashtra all the other maritime States of India expended a greater effort in terms of man hours. Mysore recorded the highest catch per unit effort, followed by Maharashtra and Kerala. Along the east coast the catch per man-hour did not show much change.

2. Effort in terms of number of operations of unit gear during 1969 and 1970

The choice of unit of effort depends on the purpose for which it is used. The unit "man-hour" is useful from the economic point of view, especially to show if the man-hours effort expended in fishing over the years has increased or decreased. But in fishery biology study, the unit of effort should be such that each additional unit should increase the instantaneous rate of fishing mortality by about the same account. For this purpose, it is necessary to collect data on effort in terms of number of operations of different types of gear. Tables 11 and 12 show the effort figures for 1969 and 1970. It is seen from the tables that the number of operations of trawl net increased during 1970 as compared to that of the last year. The trawl operations were less in Andhra, Tamil Nadu and Gujarat, but in other maritime States, the number of operations increased, perhaps to meet the increasing demand of shrimps. There were significantly less number of operations of boat seines in Andhra Pradesh during 1970 as compared to that in 1969. While the national average shows that the number of operations of small shore seines increased, there were less number of operations of big shore seines (Rampans) possibly because of a greater availability of mackeral and oil sardine and the consequent glut in the market. The number of operations of fixed net increased in Andhra. The "dol" net showed a decrease in the number of operations in Maharashtra and Gujarat. There was also a decline in the number of operation of hand lines and traps during 1970 as compared to that of 1969.

Researches contemplated

All the items of research work reported above will be continued during the ensuing year. In addition it is proposed to start a Fishery Data

TABLE IX. *Quarterly marine fish landings in different States of India during 1970 (quantity in tonnes)*

State	I quarter	II quarter	III quarter	IV quarter	Total
1. West Bengal & Orissa	2,979	2,643	10,568	15,235	31,425
2. Andhra	25,571	13,203	15,864	17,338	71,976
3. Tamil Nadu	42,132	34.041	39,123	33,818	149,114
4. Pondicherry	5,338	2,025	1,603	1,658	10,624
5. Kerala	68,492	58,870	97,773	171,598	396,733
6. Mysore	42,624	6,743	7,737	57,729	114,833
7. Goa	2,000	1,000	1,000	24,000	28,000
8. Maharashtra	41,246	33,996	12,107	94,721	182,070
9. Gujarat	33,468	24,483	2,514	28,562	89,027
10. Andamans	100	100	110	90	400
11. Laccadives	420	205	135	440	1,200
Total	264,370	177,309	188,534	445,189	1075,402
Percentage	24.58	16.49	17.53	41.40	100.00

TABLE X. *Fishing effort in man hours and catch in Kg per man hour*

State	Effort in 1000 man hours		Catch in Kg per man hour	
	1970	1969	1970	1969
1. West Bengal & Orissa	15,887	13,683	1.94	1.63
2. Andhra	33,249	30,219	2.12	2.51
3. Tamil Nadu	44,235	46,359	3.37	3.27
4. Pondicherry	4,014	3,969	2.65	2.68
5. Kerala	39,691	36,308	9.74	8.00
6. Mysore	7,824	7,608	13.58	8.84
7. Maharashtra	17,401	25,545	10.32	6.50
8. Gujarat	16,213	12,986	5.49	6.33

TABLE XI. *State-wise effort figures in terms of number of operation of unit gear during 1970*

S. No.	Name of unit gear	West Bengal & Orissa	Andhra	Tamil Nadu	Pondi-cherry	Kerala	Mysore	Mahara-shtra	Gujarat	Total
1.	Trawl net	—	126	79,567	3,327	117,494	26,858	65,212	12,236	304,820
2.	Boat seine	145,615	430,741	442,163	83,707	733,684	—	—	—	1835,910
2. 1	Dip net	—	—	2,252	—	—	—	—	—	2,252
2. 2	Encircling net	—	—	—	—	37,835	—	—	—	37,835
3. 1	Big shore seine	—	—	—	—	—	2,453	—	—	2,453
3. 2	Small shore seine	40,464	91,514	172,721	17,345	91,576	18,973	15,982	13,016	461,591
4.	Set gillnet	242,148	563,627	1151,957	111,038	319,387	132,255	78,671	232,799	2831,882
5.	Drift gillnet	5,497	54,422	311,194	42,461	292,568	9,350	—	85,998	521,490
6.	Fixed net	—	115,693	44	—	—	—	37,498	—	153,235
6. 1	Dol net	—	—	—	—	—	—	187,863	67,032	254,895
6. 2	Stake net	9,479	3,356	1,811	—	—	—	35,788	55,650	106,084
6. 3	Chinese dipnet	—	—	—	—	12,315	—	—	—	12,315
7.	Long lines	—	211,503	459,442	11,686	95,973	23,418	71,086	8,701	881,809
8.	Hand lines	—	2,302	—	—	—	—	302	—	2,604
9.	Traps	—	—	2,296	—	—	—	—	5,801	8,097
10.	Cast net	—	13,973	4,990	—	25,405	14,333	14,058	11,018	83,777
11.	Others	79,743	—	14,913	1,088	55,980	1,420	1,722	19,790	174,656

TABLE XII. *State-wise effort figures in terms of number of operation of unit gear during 1969*

S. No.	Name of unit gear	West Bengal & Orissa	Andhra	Tamil Nadu	Pondi-cherry	Kerala	Mysore	Mahara-shtra	Gujarat	Total
1.	Trawl net	—	572	87,801	1,852	115,436	9,792	45,472	23,631	284,556
2.	Boat seine	179,760	640,282	402,003	77,144	762,026	3,014	—	—	2064,229
2. 1	Dip net	—	—	5,128	—	—	—	—	—	5,128
2. 2	Encircling net	—	—	—	12,031	—	—	—	—	12,031
3. 1	Big shore seine	—	—	—	—	—	6,825	—	—	6,825
3. 2	Small shore seine	39,205	59,386	141,937	14,899	109,691	9,386	9,701	4,928	389,133
4.	Set gill net	191,764	492,582	1014,295	137,377	348,237	60,532	71,034	164,209	2480,030
5.	Drift gill net	—	17,435	265,567	27,937	179,461	5,865	295	79,182	575,742
6.	Fixed net	—	73,870	105	—	—	—	—	—	73,975
6. 1	Dol net	—	—	—	—	—	—	212,760	85,144	297,904
6. 2	Stake net	17,654	—	1,533	—	—	—	9,566	67,224	95,977
6. 3	Chinese dipnet	—	—	—	—	10,359	—	—	—	10,359
7.	Long lines	—	164,802	441,502	22,474	115,595	14,002	65,102	9,976	833,453
8.	Hand lines	—	335	—	—	—	1,938	4,375	—	6,848
9.	Traps	—	—	871	—	—	—	—	10,220	11,091
10.	Cast net	—	5,775	7,510	—	24,560	25,256	26,822	15,385	105,308
11.	Others	—	—	11,892	180	30,469	979	5,426	8,181	57,127

Centre which will function as a store house of different types of information vital for new projects on fisheries research and development and for the growth of the industry. This centre will collect and disseminate information such as results of exploratory surveys, location of new fishing grounds, abundance and movement of fish shoals and some environmental data useful for fishery operations.

Personnel associated with the above projects

S. K. Banerji, SFS., D. Chakraborty, JFS., C. R. Shanmughavelu, AFS., S. K. Dharmaraja, AFS., and many Senior Research Assistants, Research Assistants and other field staff.

FISHERY BIOLOGY

Summary of salient findings

The various projects under the Fishery Biology Division were grouped under Pelagic Fisheries, Demersal Fisheries, Crustacean Fisheries and Molluscan Fisheries. In pelagic fisheries, routine investigations on mackerel and oil sardine were carried out at some selected centres. These included catch trend, size composition, sex ratio, maturity, spawning behaviour and feeding habits. Growth studies based on an examination of scales were carried out on both mackerel and oil sardine. Fishery and biology of other important species under the groups, lesser sardines, anchovies, Bombay duck, ribbon fishes, cat-fishes, tunas and perches were carried out at centres where their occurrence was of some fishery importance. Investigations on the offshore fisheries were undertaken at Bombay, Karwar, Mangalore, Cochin, Neendakara, Tuticorin and Waltair with the help of Deep Sea Fishing Station. Data on catch and effort were processed according to different species.

In view of the importance of the Crustacean fisheries in the national economy, intensive studies were made on prawns, shrimps, lobsters and crabs. Species wise catch trends were investigated in prawns. The biology of various species of prawns, lobsters and other crustaceans were studied at Cochin, Mangalore, Madras, Mandapam and other places.

At Tuticorin, ecological surveys were carried out using underwater equipment at four selected stations for pearl oysters and chanks. The population of these commercially important molluscs was estimated. In other centres like Mandapam and Madras, the biology of certain important species of edible oysters and cephalopods were also studied.

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Researches in hand

PELAGIC FISHERIES

(a) Mackerel Investigations

(i) The Fishery

Landings of the Indian mackerel, *Rastrelliger kanagurta* Cuvier during the year have been the highest ever recorded in the country. This trend of increased landings has been reflected from the catches of important centres selected for biological studies of the mackerel along the west coast of India. The west coast gives about 98% of the mackerel landed in the country.

Shore-seines, boat-seines and gill nets are the chief gears operated for the mackerel fishery, while drift nets, cast nets, and hook and lines are also used to a limited extent. A month-wise break-up of the landings at some of the centres presented in table 13 clarifies seasonal intensity of the fishery along the south west coast.

TABLE XIII. *Month-wise landings of mackerel at different centres*

Month 1970	Landings in tonnes					
	Karwar	Mangalore-Ullal	Mangalore-Baikampady	Calicut	Cochin	Vizhinjam
January	6.797	13.922	6.761	93.460	0.657	
February	7.616	1.826	46.500	13.747	0.426	7.815
March	16.971	—	2.160	84.541	1.735	
April	10.948	—	0.679	25.185	—	36.371
May	0.753	—	—	2.325	5.322	
June	—	—	—	12.458	0.003	—
July	0.051	—	—	122.676	14.465	6.723
August	0 013	0.008	—	207.020	55.342	6.848
September	0.040	1.589	5.050	646.291	45.792	11.791
October	171.337	7.585	458.977	1299.235	213.867	531.123
November	835.083	0.960	294.666	602.598	190.999	23.130
December	592.515	12.733	73.144	919.224	228.024	0.411
Total	1642.124	38.623	887.937	4028.760	756.632	624.212

The bulk of the catches at these centres were landed during the second half of the year, with peak landings from October to December.

(ii) Size distribution in the catch

At Karwar, the fishery was predominantly based on the 170-190 mm modal group during the peak season (October-December), while 190-210 mm modal groups contributed to the fishery from January to May.

The peak fishery at Mangalore during October-December included larger fish of 205 mm modal size. In February at this centre, the modal size was 215 mm. The peak landings during October-December at Calicut was supported by 190-205 mm modal groups, but juvenile fish of dominant sizes of 110-145 mm also contributed to the fishery, from July to September. The fishery from January to April, however, was composed largely of 210-225 mm modal size groups. At Cochin during the October-December period, the 185-210 mm modal groups dominated the peak season.

At Vizhingam the peak fishery in October included fish of modal size 220mm. The drift net catches during October consisted of spawners of 245 mm modal length. At Mandapam (Gulf of Mannar) during the peak fishery season in December, the modal sizes included 200-215 and 235-245 mm. The mackerel fishery at the southern centres of the west coast were thus supported by comparatively larger sized fish than at Karwar. At Mandapam which was the only centre of observation on the east coast, a wider range in size throughout the year as well as during the peak season was noticeable. The occurrence of juvenile mackerel was noticed at various other centres. At Mangalore and Karwar juvenile mackerel of minimum sizes 110-150 mm appeared in September and October and at Calicut and Cochin 90-140 mm appeared from July and continued to be present till October. At Vizhingam small sized mackerel were recorded from April to November and at Mandapam also juvenile fish occurred from February to August. From these observations it is evident that juvenile mackerel are of common occurrence, at some centres along the Indian coast throughout the year.

(iii) Sex ratio and maturity studies

Sex ratio showed no consistent pattern during the year. At Karwar the sex ratio of mackerel was of equal proportion. Mangalore-Ullal catches in January showed a predominance of females. In September and December at this centre males were dominant except in the *odubala* (drift net) catches where the ratio showed a reverse trend. At Baikampady centre males dominated in April and females in September. Again males were dominant during the peak fishery at this centre in October and November. At Calicut, during the first half of the year (except June) males were dominant in the catches and during the latter half of the year when the ratio was reversed. Fairly equal numbers of males and females were encountered in the catches at Cochin except in May when males outnumbered the females. At Vizhingam females were dominant in the catches during the first half of the year except in the drift net catches of ripe fish where males were predominant

in April and May. The peak fishery of October at this centre was supported by predominantly male spawners. Sexes were distributed fairly in equal numbers during the peak fishery at Mandapam in December. Males were dominant at this centre during February, May, August, September and November.

Peak fishery was supported by immature fish upto stage III all along the west coast centres except Vizhinjam. At this centre peak landings in October by drift net consisted of spawners and they also contributed to a good fishery at this centre in May. The spawning ground has been reported at 40-50 m depths, 6 kilometres away from the shore. Small numbers of mature fish (IV-V) were encountered at Karwar, Baikampady, Calicut and Cochin from April to June. Spent specimens were seen in September at Mangalore and Calicut.

Occurrence of mature, ripe or spent fish was noticed at Mandapam on the east coast almost in all the months of the year. Very few adults were seen in July and August.

(iv) Growth studies from scale reading

Work on the scale reading was continued during the year, special emphasis being given to establish correlation between the maturity stages and the formation of the rings. The data collected during the year have shown that when the gonads reach ripening stage thin margins start appearing on the scales, these being the fore-runners of the actual rings which become clear as the scales grow. Only a few older specimens were available during the year, the majority in the commercial catches being less than two years old, and these did not show growth marks on the scales. The large numbers of small specimens examined have further confirmed the absence of the growth checks on the scales. These belonged to lower stages of gonad maturity.

Personnel associated with the above projects

G. Seshappa, FS., K. V. Narayana Rao, JFS., V. Balakrishnan, JFS., P. Vijayaraghavan, AFS., K. Rangarajan, AFS,, A. Noble, AFS., Senior Research Assistants, Research Assistants and others.

(b) Oil Sardine Investigations

(i) Fishery

There was year to year fluctuation in the total catch. The fishery in 1970 showed a marked improvement when as compared to that of 1969. Table 14 gives the estimated total landings of oil sardine at various centres where fishery biology work was also carried out.

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TABLE XIV. *Oil sardine landings at various centres (in tonnes)*

	1970	1969
Karwar	156.15	191.80
Mangalore-Ullal	149.70	37.01
Mangalore-Baikampadi	278.64	247.84
Calicut-Vellayil	8120.11*	9434.99
Cochin-Manassery	2705.43	1691.35

*Includes data from carrier boats also.

Calicut (Kozhikode), had the maximum landings which was followed by Cochin. While Mangalore and Cochin showed an increase in catches (33% and 40% respectively) as compared to 1969, Karwar and Calicut had a slight decline in their fishery. The bulk of the landings came in the second half of the year at Mangalore, Calicut and Cochin, and in the first half at Karwar. Table 15 shows the month-wise landings of oil sardine at the various centres. The peak fishery in Karwar was during January to April and the maximum catches were obtained by Rampan, with an average of 1120 kg per unit during the year. *Yendi*, purse-seine and drag net (*Combala*) were the other gears operated at the centre, purse-seine with an average catch of 1500 kg per unit. At Mangalore, *Rampani*, *Chalabale* and cast net were the chief gears used. *Chalabale* yielded larger catches at Ullal followed by cast net, *Rampani* also brought the maximum catch at Baikampady. At Calicut the fishery was good throughout the year except in March. The peak period of fishery was from August to November. *Pattenkolli* yielded the maximum catch with an average of 400 kg per unit.

TABLE XV. *Estimated month-wise landings of the oil sardine at various centres in 1970 (in tonnes)*

Month	Karwar	Mangalore		Calicut		Cochin
		Ullal	Baikampadi	Vellayil	Carrier boat	Manassery
January	61.00	24.84	59.12	396.73	324.00	63.41
February	52.00	10.59	0.90	435.01	309.06	217.40
March	13.55	26.14	—	26.05	8.38	171.20
April	15.50	29.44	8.62	562.73	152.70	121.45
May	—	1.60	—	321.37	11.28	8.55
June	—	—	—	383.36	1.68	7.34
July	—	—	—	491.18	3.78	74.15
August	0.10	0.14	3.80	1237.37	19.72	239.96
September	4.70	15.54	0.76	624.10	124.99	276.40
October	6.90	37.05	23.33	882.66	86.60	225.34
November	1.40	3.99	32.11	982.03	223.37	657.57
December	1.00	0.37	150.00	424.77	87.19	642.66
Total	156.15	149.70	278.64	6767.36	1352.75	2705.43

At Cochin, the peak periods of fishery were in March and November-December. *Thanguvala* yielded the bulk of the catches with an average of 250 kg per unit.

(ii) Size composition

At Karwar, the modal groups 95-180 mm were observed in the landings during the peak period of fishery from January to April. Zero-year class comprising modal group 115 mm - 135 mm was dominant. The modal group 170 mm of adults of 1-2 year old fish, which contributed to the fishery in January and February were, however, only second in importance to the 0-year fish. The latter were represented in two broods of different modal sizes, one growing rather slowly from 115 mm to 125 mm during January to April and the other more rapidly from 135 mm to 165 mm during February to April. During August to December the adult fish were represented by modal groups 160-180 mm. The juveniles from the 1970 brood entered the fishery in September. In general the fishery at Karwar was mostly dependent on the 0-year fish and the contribution by 1-2 year fish was of secondary importance.

At Mangalore (Ullal) during January to April the fishery was supported by adult fish of modal groups 170-175 mm and during the peak period in the second half of the year (Table 21) by modal groups 165-185 mm. 0-year fish were represented by modal groups 120 and 130 mm in January and 140 and 145 mm in March and their contribution to fishery was of secondary importance as compared to that of the adult fish. Juvenile recruits from the 1970 brood appeared in the catches of September in cast net and *Kooribala*. These had modal size groups 125 mm and 75 mm respectively.

The peak fishery in November-December at Baikampadi was supported by the adults of modal groups 160-185 mm. The 0-year fish with modal group 125 mm supported the fishery in January. Juvenile recruits from 1970 spawning entered in September with a modal size of 75 mm. In general fishery at Mangalore was dependent on adult fish (1-2 year olds).

At Calicut during the period January to June modal groups 115-120 mm (0-year) and 170-175 mm (1-2 year) were abundant and in the peak fishery during July to December modal groups 100-150 mm (0-year), 160 mm (1-year) and 180 mm (2-year) were predominant. The juveniles of 1970 brood entered the fishery in July with a modal size 100 mm.

At Cochin the peak periods of fishery during February-April and November-December were supported by 0-year fish of modal size 130 mm and 1-year fish of modal sizes 160-165 mm, respectively. Juvenile recruits from 1970 brood entered the fishery in August with a modal size 100 mm.

(iii) Sex ratio and maturity stages

At Karwar during January to April most of the fish were in stages I and II, and a few adults were seen in spent recovering stage (II b). Of the adults, spent fish dominated during August to October, with a small percentage of stage IV fish occurring during August and September. A few spent resting fish (IIb) were also seen during August and September and thus was the only stage observed among adults in November and December. Juveniles started appearing in catches in September at this centre and they were all indeterminates. Stage I fish were dominant during November-December period. In general the fishery at various centres largely included immature fish. In the first half of the year, there was no clear indication of one sex being predominant, but during August to December (except in November) females were more abundant.

At Mangalore stages I to III were observed from January to April. During August and September fish in advanced stages of maturity including spent fish were recorded. Indeterminates appeared at Ullal. During October to December immature fish were dominant. Spent fish were recorded in November in Baikampady. Females were more numerous in the catches of Mangalore.

At Calicut immature fish were dominant from January to April and a few spent fish with a resting stage were also recorded. From June to August fish in advanced stages of maturity were recorded (stage IV, V) along with spent fish. Spent and spent recovering fish were dominant during September to November. Indeterminates were abundant from July to November followed by stage I in December. No consistent pattern in the abundance dominance of one sex was observed.

At Cochin during January to May stages I and II were predominant, with a small percentage of indeterminate and spent recovering fish. In June, stage IV dominated but a few partially spent fish were also seen. In July stage IV and VII a were dominant while fish with a further advance in maturity were not seen in the catches. Spent fish continued to occur till October. In November and December, spent fish with a resting state were recorded. Females were slightly in greater number during the year except in April, September, October and December when males outnumbered the females.

From the data collected at the various centres, it is clear that during the year there were no record of stage VI fish. Partially spent fish started occurring from June at Cochin and Calicut and from August at Karwar and Mangalore but at the last two centres there was no sardine fishery from May to July. At these centres spent fish were recorded up to October-November. From November onwards these were replaced by the spent fish with recovering gonads (II b). The fresh recruitment of juveniles was evident in July at Calicut; in August at Cochin; and in September at the other centres.

(iv) Food and feeding

At Mangalore it was found that feeding was poor in January, but the feeding intensity increased until April and decreased gradually in the following months. In February, March and September copepods and other crustaceans formed the chief food. Diatoms were next in abundance in the gut. In April and October, diatoms belonging to the genus *Coscinodiscus* and *Pleurosigma* were dominant in the food. Dinoflagellates were seen frequently in the gut. In August, *Dinophysis* sp. formed the main food.

At Calicut from May to July, feeding was moderate among adults. Phytoplankton *(Coscinodiscus, Nitzchia, Dinophysis* and *Bacillariophyceae)* formed the chief food followed by zooplankton (Copepods and *Evadne)*. In August and September juveniles showed more active feeding than the adults. From October to December, diatoms *(Coscinodiscus* and *Biddulphia)* formed the major food item in all the samples examined.

(v) Age studies

At Cochin scales were examined regularly for the age determination of oil sardine. The number of rings occurring in the various size groups during the four quarters of the year are given in table 16.

TABLE XVI

Period	Size range of fish (mm)		
	1 ring	2 rings	3 rings
January–March	135–155	160–175	185
April–June	125–140	155–175	Very rare
July–September	135–150	155–170	175–190
October–December	160	165–180	185–195

The rings observed were distinct and they were assumed to be of annual nature. During June, most of the scales with two rings had their second ring near the margin.

(vi) Tagging

At Karwar, 862 oil sardine were tagged with loop tags and released off Tadri and the neighbouring fishing centres. Out of these only one fish released on 31-1-1970 was recovered at Kayal (near Kurta) on 22-2-1970, south of the place of release.

Personnel associated with the project

B. T. Antony Raja, JFS., V. Balan, JFS., M. H. Dhulked, AFS., Senior Research Assistants, Research Assistants and others.

(c) Lsseersardines investigations

(i) Fishery

Table 17 gives the landings of lesser sardines at various centres where biological studies during 1970, were carried out. The percentage composition of different species and their relative importance in the fishery have been shown in Table 18.

TABLE XVII. *Landings in tonnes of lesser sardines at various centres in 1970*

Centre	Landings	Species composition (% in brackets)
Karwar	0.19	*Sardinella fimbriata* (100)
Vizhinjam	194.73	*S. gibbosa* (62.27)
		S. dayi (32.20)
		S. sirm (5.24)
		S. fimbriata (0.29)
Tuticorin	288.00*	*S. sirm* (70.0)
		S. fimbriata (22.0)
		S. albella (8.0)
Mandapam	No data	*S. albella* (more common)
Madras	168.42	*S. fimbriata* (100)
Port Blair	—	*Harengula ovalis*

* Data for the second half of the year only.

(ii) Biology of lesser sardines

(1) Sardinella fimbriata : Investigations on this species were carried out at Madras, Tuticorin and Karwar.

At Madras, the peak period of fishery were supported by modal groups, 140 mm and 130 mm (spent fish) in January and February, and 125 mm (stage II fish) in September and October. In August the modal group recorded was 130-135 mm and the majority of fish were in stages III to V. Spent-recovering fish occurred in December. Females were found to be more dominant. Indeterminate fish were recorded in September. The food of the fish was mostly phytoplankton except during the last quarter when the fish were found to feed more on zooplankton.

At Tuticorin, the modal sizes varied between 120 and 135 mm from August to October when the fish were in stages IV to VI. During November and December, the fish were spent with modes at 130 and 135 mm. Most of the fish in these months had empty stomachs while a few had copepods as a dominant food item.

At Karwar, the catches were very poor and in October and November, indeterminate fish dominated, with modal sizes at 95 mm and 105 mm respectively. The spawning season of this species appeared to be during June to October. The growth was very rapid during the early stages till it attained 120 mm by about August-September.

(2) **Sardinella gibbosa:** Investigations were carried out at Vizhinjam and Mandapam. Table 18 summarizes the observations carried out in 1970 at Vizhinjam.

TABLE XVIII *Sardinella gibbosa : Biological data collected at Vizhinjam*

Month	Size range (mm) (modal sizes in parantheses)	Sex ratio % Male : Female	Maturity stages
March	51-65 (65*, 140) GN	52.4:47.6	Immature*
	61-100 (75, 90*) BS	40.9:59.1	do
April	96-165 (140*) GN	64.2:35.8	II-IV
May	160-180 (120, 140, 150* 170)	51.5:48.5 GN	II-IV
	136-165 (150)* BS	62.5:37.5	II-IV
June	136-175 (150*) GN	67:33	I-IV
	86-120 (100, 110)*	31:69	I-IV
August	120-139 (130, 170*)	66.7:33.3	I-IV
September	140-179 (155*, 165)	34.4:63.6	II-V, III*
October	110-175 (115, 145, 170*)	41.0:59.0	I-V
November	80-165 (100, 135*)	40:54.6	Indeterminate*

* Dominant, GN = Gill net, BS = Boat seine

At Mandapam the modal size remained more or less constant at 125 mm (range 105-145 mm) throughout the period from January to June. In the subsequent three months the fish were not available in the samples. During October to December, the modal groups were 120 mm, 115 mm and 125 mm respectively and they probably included freshly recruited juveniles. Nearly 33% of the fish examined were indeterminates while among the rest no significant dominance of either sex was noticed.

The above data suggests that the spawning season of the fish is long and probably extends from February to October. The entry of several groups of different modal sizes at Vizhinjam is probably an indication of a succession of spawning.

(3) **Sardinella albella:** At Mandapam the fishery was mainly supported by the modal group 110-125 mm. Females were generally more numerous. Indeterminates were seen in large numbers in the seine net. At Tuticorin the modal sizes were 130 mm in September and 135 mm in October. While in September fishes with advanced stages of maturity

(IV and V) were encountered, in October the fish were mostly in spent condition. Most of the fish with empty stomachs showed poor feeding.

(4) **Sardinella sirm:** Observations on this species were made at Vizhinjam and Tuticorin. The catches at Vizhinjam showed modal size at 70 mm in February, 95 and 120 mm in March, 100 and 185 mm in April, 130 mm in May and 180 mm in October. Two broods with different modal sizes seemed to support the fishery. Zooplankton formed 50% and diatoms about 35% of the food composition. At Tuticorin two modal sizes 170 mm and 190 mm were represented in the fishery in August. These seem to shift to 180 and 210 mm respectively in December.

(5) **Sardinella dayi:** This species formed a good fishery in July and December at Vizhinjam. The modal size in the fishery was 130 mm both in November and December (range 120-155 mm). The fish had the maturity stages III-VII, with stages IV and V as most dominant in both the months. Some spent-recovering fish were also recorded in December indicating that spawning probably occurred from July to December. The fish showed poor feeding, 50% of the fish had empty stomachs, 20% contained only small quantities of digested food and the rest had diatoms, copepods, fish eggs and fish scales.

(6) **Harengula ovalis (Herklotsichthys punctatus):** Studies on age, growth and length-weight relationship were carried out at Port Blair. The first ring on the scales appears when the fish reaches a range 85-98 mm, 2 rings at an average length of 110 mm and 3 rings when it attains 130 mm. The length frequency data showed modal groups at almost the same size range i. e. at 95 mm, 112 mm and 137 mm.

Personnel associated with the above projects

B. T. Antony Raja, JFS., K. Rangarajan, AFS., Syed Basheeruddin, AFS., P. Sam Bennet, AFS., R. Marichamy, R.A , and S. Lazarus, R.A.

(d) Investigations on other fishes

(i) Anchovy Fisheries

At Vizhinjam a total of 344.19 tonnes of *Stolephorus* spp. were landed contributing 7.6 % to the total fish landings of this centre. This is the highest annual landings recorded in 6 years. Of the annual *Stolephorus* catch 86.8 % was landed by boat seines, 2.1 % by shore seines and 11.1 % by gill nets (Netholi vala) with an average catch of 7.39 kg, 3.56 kg and 13.15 kg per unit respectively. *Stolephorus* sp. and *S. bataviensis* mainly supported the fishery forming 45.43 % and 42.06 % respectively of the total catch during the year at this centre. Of the other species, *S. andhraensis* occurred from August to December with better catches in September, and *S. indicus* from February to December, with good landings in May.

(IV and V) were encountered, in October the fish were mostly in spent condition. Most of the fish with empty stomachs showed poor feeding.

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(5) **Sardinella dayi:** This species formed a good fishery in July and December at Vizhinjam. The modal size in the fishery was 130 mm both in November and December (range 120-155 mm). The fish had the maturity stages III-VII, with stages IV and V as most dominant in both the months. Some spent-recovering fish were also recorded in December indicating that spawning probably occurred from July to December. The fish showed poor feeding, 50% of the fish had empty stomachs, 20% contained only small quantities of digested food and the rest had diatoms, copepods, fish eggs and fish scales.

(6) **Harengula ovalis (Herklotsichthys punctatus):** Studies on age, growth and length-weight relationship were carried out at Port Blair. The first ring on the scales appears when the fish reaches a range 85-98 mm, 2 rings at an average length of 110 mm and 3 rings when it attains 130 mm. The length frequency data showed modal groups at almost the same size range i. e. at 95 mm, 112 mm and 137 mm.

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B. T. Antony Raja, JFS., K. Rangarajan, AFS., Syed Basheeruddin, AFS., P. Sam Bennet, AFS., R. Marichamy, R.A , and S. Lazarus, R.A.

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At Waltair the fishery for *Stolephorus* was poor during 1970. Even during the peak period (May) only 1.49 tonnes were landed. Of the total landings, 65.4 % came from boat seines, 32.8 % from shore seines which were operated intermittently during the year, and the remaining 1.8 % from gill nets. Boat seine catches mainly contributed to the peak fishery *Stolephorus heterolobus* and *S. bataviensis* were the two species which largely contributed to the fishery.

Biology of anchovies (species-wise)

(1) Stolephorus sp. A

Investigations on this species were carried out at Vizhinjam. The size distribution in the catch varied from 25–99 mm and the modal group 70–75 mm mainly supported the fishery. The smaller modal size groups (35–45 mm) were present during April to July, and November to December. The size distribution pattern indicates that recruitment to the fishery by this species takes place at a smaller size and at least twice, or possibly thrice, a year.

Females in mature and partially spent stages were recorded almost throughout the year. Fishes with immature gonads (stages I and II) were most abundant from July to October. Spawning appears to take place in the inshore waters.

Feeding was moderate throughout. Copepods and young bivalves were the chief items of food. Copepods were common in June, whereas bivalves and *Lucifer* in July and polychaetes, *Acetes* and mysids in September. During these months this fish was landed in large quantities.

(2) S. bataviensis

Observations on this species were made at Vizhinjam and Waltair. At Vizhinjam the size of the fish ranged from 30-104 mm. Modal groups 70–75 mm was dominant in the fishery. Smaller modal group, 40–45 mm was also seen in May and June only. The recruitment to the fishery seems to occur twice a year.

Immature fish were common throughout the year, fish with mature gonads were seen in small numbers in June, July and December and partially spent fish were recorded in November and December. These observations suggest the possibility of two spawning seasons in a year, in June–July and in November–December. The lack of small size groups and of fish with advanced stages of maturity in the commercial catches indicate that the spawning of this species takes place outside the present fishing zone of five miles off the shore. Females dominated over males in many months. Indeterminates were common in May and June.

Feeding intensity was generally moderate and often poor. Copepods and young bivalves formed the chief items. Other items such as planktonic

crustaceans, polychaetes, fish eggs and larvae were found in good number in the stomachs during different months.

At Waltair two modal groups were represented in the fishery. Mostly immature fish contributed to the fishery and mature fish were observed in February. Sexes were almost equal numbers in June, September and November while the male predominated in February. Feeding was moderate. Dominant food items were copepods, larval molluscs, crab zoea, *Cypridina* sp., *Acetes* and amphipods.

(3) S. heterolobus

Investigations on this species were carried out at Waltair. The size of fish in the landings ranged from 35-89 mm and the modal group 50-75 mm contributed to the fishery. Immature fish were dominant throughout while mature fish were observed in February. Sex ratio was almost equal in February and in other months males were predominant. Feeding was high in February and June but low during May and November. Copepods, molluscan larvae, *Cypridina* sp. and brachyuran zoeae constituted the main food items.

(4) Thrissina baelama

Observation on various aspects of the biology of this species were made at Port Blair. A good fishery for this species existed during November-December period which coincided with the spawning season of the fish. The data collected from March 1968 to February 1970 on the maturity and spawning of this species indicated that the fish matures at an average length of 117 mm and spawns twice in a year. Mature and spent specimens were collected in appreciable numbers during July-August and November-January which coincided with the two monsoons. Studies on the sex ratio indicated that the females after attaining maturity migrate to coastal waters.

Personnel associated with the project

G. Luther, AFS., V. Ramamohana Rao, AFS., and A. Marichamy, RA.

(ii) Bombay duck (Harpodon nehereus) Fisheries

Investigations on the biology and fishery of Bombay duck on the west coast of India was commenced from October 1970 and covered 5 centres, namely, Dabhol, Jangira-Murud, Versova, Dahanu and Jafrabad. Biological data were also collected from Versova during January-May 1970. The analysis of the catch composition at all the five centres for the period October-December showed that the adult fish of size over 210 mm were abundant during the month of December. Juveniles of the size ranging from 15-210 mm occurred in October and November.

Length frequency distribution of the catches showed that the modal groups of 195 and 210 mm contributed mainly to the fishery at Versova from January-May. During the period October-December, observations made at all the centres indicated that the fishery was mainly supported by the juvenile fish of the size groups 90 mm, 150 mm and 165 mm. During December when the percentage of adults was greater, the modal groups 255 mm and 270 mm were predominant.

During the first half year period, mature and spent females were recorded. During October-December stages I to III were predominant. A few fish in stage V was also recorded at Versova in November and December. No consistent pattern in the sex ratio was observed. Studies on the feeding habit showed that the food of the species comprised mainly of fishes *(Harpodon*, Sciaenids, *Bregmaceros*, *Coilia*, *Pellona)*, penaeid prawns and *Acetes indicus*.

Personnel associated with the project

S. V. Bapat, JFS. and A. Kurian, RA.

(iii) Flat fish fisheries

(I) The fishery of the Malabar sole

Studies on this fishery were continued both at Calicut and Mangalore during 1970. The estimated landings of the Malabar sole, *Cynoglossus semifasciatus* showed a decline over the landings of the previous year, particularly at Mangalore.

At Calicut most of the sole landings during the year were from the mechanised boat units. The Institute also conducted some sampling from 6 m and 12 m depths off West Hill.

(Ia) Size composition in the catches

At Calicut from the samples obtained from the 6 m area, the modal size group fluctuated between 6 and 10 cm during the first quarter; in the 12 m region there were two clear modes in January from 6 to 11 cm for the smaller sizes and between 12 to 14 cm for the larger sizes. The larger juveniles dominated the inshore catches during the entire period, the size range in April being 6 to 11.8 cm. In the first week of May the range was from 5 to 11.7 cm. Repeated occurrence of the small juveniles indicated their continued recruitment during the period, though not with the same intensity throughout. Samples from the mechanised boats during the first quarter had the modes at 13 and 14 cm groups, but in April at 9 cm. In the first postmonsoon sample on 25-9-1970 the total length ranged from 9.5 to 15.8 cm, the mode being at 11 cm. Seven specimens examined on 24-9-1970 fell between 11-15 cm groups. On 29-9-1970 the range was from 10-15.9 cm with the highest frequency again at 11 cm. In October the range noticed was from 9-16 cm with modes between 11 to 14 cm

groups. The same range was noticed in the samples of November, the mode being 13 cm group. Smaller sizes of the 0-year class occurred in the commercial catches after the third week of December. Three age-groups as determined from the examination of scales viz., 0. 1 and 2 year class were common. The 2-year class however was not being abundant in the samples. The 0-year class was more frequent in the departmental collections during December; and ranged from 2 to 9.9 cm with mode between 4 to 7 cm group. Examination of the scales showed that the commercial landings were dominated by the 1-year class.

At Mangalore the size composition of the fish from the trawl catches ranged from 100-154 mm in January, 95-159 mm in February, 120-164 mm in March and 80-140 mm in April; the corresponding modes were at 120, 135 and 85 mm groups respectively. The samples obtained from Baikampady during September ranged from 95-149 mm with mode at 110 mm. The samples from the trawl landings during the last quarter of the year had the modes at 115 and 120 mm, the length range being 100-164 mm.

(Ib) Maturity trends

At Calicut the larger juveniles which dominated the catches during the first quarter of the year were in earlier stages of maturity (upto stage II only), while the smaller juveniles of about 5 cm were usually indeterminates. Stage III appeared in March and April. The larger specimens from the commercial landings had the gonads in advanced stages from IV to VII in the first quarter, rarely ripe as well as spent individuals. Such advanced stages were rarely seen in April. When the fishery again started after the rainy season the gonads were in advanced stages, mostly stage IV and further advanced stages appeared subsequently in the last quarter of the year. Along with the occurrence of indeterminates during December some large sized fish of the 9 cm group were also seen.

At Mangalore the maturity trends indicated that the fish were in stages I-III (predominant) from January to April. Advanced stages of maturity (III-V) were noticed from September to December.

(Ic) Feeding habits

Studies at Mangalore showed that during the first half year period the food largely consisted of polychaet remains, copepods and diatoms (species of *Thalassiothrix*, *Pleurosigma* and *Fragilaria)*. From September to December the important items of food were fish remains, polychaet remains, copepods and diatoms *Thalassiothrix*, *Pleurosigma*, *Coscinodiscus*, *Nitzschia* and *Fragilaria)*.

(Id) Other species of flatfishes

The landings of *Cynoglossus dubius* from mechanised boats at Calicut during the year were estimated as 11.64 tonnes. Wide fluctuations

in the size composition of the species during the different months of the year were also observed. Indeterminate and immature fish were more common in the samples during the first half of the year and fishes with advanced stages of maturity occurred during the next half of the year. Other species of *Cynoglossus* which occurred in this area as stray catches include *C. bilineatus, C. lida, C. puncticeps* and *C. macrolepidotus.* Of these species *C. bilineatus* was relatively more common in the samples than the other species and some biological studies on the same were also carried out during the year.

Personnel associated with the project

G. Seshappa, FS and A.C.C. Victor, RA.

(iv) Catfish fisheries

At Waltair offshore catches of the catfish, *Tachysurus thalassinus* trawled by the Government of India vessels, M.V. Champa and M.T. Ashok were examined. About 23,399 kg of *T. thalassinus* were landed during the year from an effort of 943.51 hours. The catch rate was 24.8 kg per hour of trawling. Best catch rate was noticed during February (43 kg/hour) for M. T. Ashok. *T. thalassinus* formed 12 % of all the fish caught by the two vessels during the first half year and 6.4 % in the second half year.

It was observed that young fish upto stage II maturity formed the bulk of the catch. From March to May fishes in advanced stages of maturity were also caught. Crabs, *Squilla*, prawns and other crustaceans, fish and cephalopods formed the food of *T. thalassinus.*

Sex ratio of Males: Females in the catches varied from 8 : 1 in August to 1 : 1 in January and February.

Personnel associated with the project

B. Krishnamoorthi, JFS, A. S. Kaikini, AFS, and P. Mojumder, AFS.

(v) Eel fisheries

Studies were carried out at Bombay on the biology of the eel, *Muraenesox talabonoides* (Bleeker) commonly known as *wam*, landed by the offshore fishing vessels. The dominant size groups which contributed to the fishery during the first half of the year were 138-150 cm and from July to September the size groups, 123-135 cm and 136-148 cm predominated. Fishes in the ripe and running conditions were seen from April to June.

Personnel associated with the project

M. K. George, RA.

(vi) Lactarius fisheries

The fishery for this species at Madras (Royapuram and Thiruvanmiyur) started only in September, slightly later than the previous year. Stray catches were observed during January and May at Royapuram. The fishes were mainly landed from bag nets *(Thuri valai)* and occasionally from the shore seines.

During the year specimens of *Lactarius lactarius* was available in the commercial catches only during the months of January, May, September-November. The size composition in the catches showed that the modal groups of 100, 120 and 140 mm mainly contributed to the fishery. The length weight relationship of this species was calculated as :

$$W=0.00004916 \ L^{2.9772}$$

Fishes examined during January were all immature. The few mature specimens were recorded in May, while in September all the fishes were in maturing condition. Anchovies and polynemids formed the favourite food of this fish.

Personnel associated with the project

Syed Basheerudin, AFS and C. R. Shanmugavelu, AFS.

(vii) Pomfret fisheries

Pomfret fishing, (*Pampus argenteus*) by the gill nets commenced at Veraval in September after the south-west monsoon. About 70 boats operated during this month and they yielded on an average catch of 500kg per boat. In October 100 boats operated and although there was a fall in the catches during the first fortnight, the catches improved to 100 kg per boat. The fishery was fairly good during November and December.

The dominant size groups that contributed to the fishery were 246, 271, 280, 286 and 320 mm. Samples obtained from 'Dol' net catches at Navabander consisted of small fishes in the size range of 46-100 mm with the dominant size group of 60-70 mm.

Personnel associated with the project

Kuber Vidyasagar, SRA.

(viii) Leiognathid fisheries

Investigations on the fishery of silver bellies at Waltair and Madras and also on the biology of the two common silver bellies, *Leiognathus bindus* and *Secutor insidiator* (the former at Waltair and the latter at Madras) were

continued during the year. At Mandapam, studies on the fishery of silver bellies (*Leiognathus* spp.) and silver biddies (*Gerres* spp.) and also on the biology of *Gerres filamentosus* were commenced. In recent years, silver bellies and silver biddies have attained considerable commercial importance as they form a substantial part of the trawl catches and studies on their fishery and the biology of the important species is being pursued.

(1) Fishery at Waltair

A steep fall in the catch rates of silver bellies was noticed this year as compared to that of the previous year. Table 19 gives the data of the trawlers and shore seines, conducted by the Government of India.

TABLE XIX

	1969	1970		1969	1970
M.T. Ashok			*Boat seines*		
C	3401.90	772.80	C	5426.00	3114.50
E	331.68	569.75	U	4635.00	2819.00
cph	10.30	1.40	c/u	1.20	1.10
M.V. Champa			*Shore seines*		
C	4482.30	311.70	C	4321.00	426.00
E	598.00	373.76	U	929.00	281.00
cph	7.50	0.80	c/u	4.70	1.50

C = Catch; E = Effort; cph = Catch per hour; and c/u = catch per unit

With boat seines there was a decrease in the catches in 1970 as compared to that of 1969. The monthly catch rates of *M.T. Ashok* ranged from 0.1 to 3.6 kg per hour, the highest was in August. *M.V. Champa* recorded a peak catch rate of 16.0 kg per hour in June, but in the other months the catch rates were very poor and ranged from 0.2 to 1.4 kg per hour. Except in May when the catch per unit was 4.03 kg the catch rates of the boat seines in other months were very small. By shore seines, high catches were obtained in January (12.0 kg/unit) and April (8.9 kg/unit). *Leiognathus bindus* ranked first in abundance followed by *Secutor insidiator*, *Leiognathus leuciscus*, *L. splendens*, *Gazza minuta* and *Secutor ruconius* in the order of abundance. *L. equulus*, *L. dussumieri* and *L. blochi* were also caught in small quantities.

(2) Biology of Leiognathus bindus

The progression of modes in the length frequency distribution showed a growth of 5 to 10 mm per month. The occurrence of juveniles (30-40) mm in December and the occurrence of females in stage IV for prolonged period indicate that the spawning in this species may extend from October to

March. The eggs appear to be shed in batches and a number of broods enter the fishery. Copepods and polychaetes form the main items of food of this fish.

(3) **Fishery at Mandapam**

The catch details of silver bellies and silver biddies obtained by the trawlers at Mandapam are given in table 20.

TABLE XX. *Estimated landings (kg) of silver bellies at Mandapam*

Month 1970	Total catch	Catch of silver bellies	Catch of silver biddies	Catch per boat	
				All fish	Silver bellies
		PALK BAY			
May	1022065	981396	381	2156	1070
June	938358	872563	2061	1158	1077
July	1977314	1875249	1819	1626	1542
August	1392129	1294127	681	1210	1125
September	369653	339659	371	832	765
October	108165	82669	359	329	251
November	71146	34303	709	213	102
December	112487	62108	1326	219	121

Trawling in the Palk Bay continued from May to November, 1970. Silver bellies constituted more than 90% of the total catch. Their maximum landings (ranging from 872.56 tonnes to 1875.25 tonnes) were from May to August, during which period the catch per boat (CPUE) exceeded one tonne, the highest being in May with a figure of 2070 kg per boat. The fishery declined considerably from September to November in the Palk Bay, partly because of rough weather prevailing during the monsoon and partly because of the trawlers going for prawn fishing during the night. In November-December, trawling was carried out in the Gulf of Mannar, but as compared to the Palk Bay the silver belly fishery was poor, the catches in November and December were 34.30 tonnes and 62.11 tonnes respectively. The estimated landings of the silver bellies by trawlers at Rameswaram going for night fishing in the Palk Bay ranged from 14.15 tonnes (in December) to 160.29 tonnes (in September). The landings of silver bellies were generally higher at Mandapam than at Rameswaram. This is because more boats operated from Mandapam. At both the places silver biddies constituted a small percentage of the total catch.

The catch of silver bellies obtained from Palk Bay and Gulf of Mannar varied in their species composition. In the Palk Bay, *Leiognathus*

jonesi was more abundant than the other species of silver bellies, followed by *L. brevirostris.* In the Gulf of Mannar on the other hand *L. dussumieri* formed the most abundant species followed by *L. jonesi, Secutor ruconius, Leiognathus brevirostris. L. bindus, L. lineolatus, L. berbis* and *Gazza minuta* also at times formed a sizeable part of the catches.

(4) Biology of Gerres filamentosus

Gerres filamentosus of the length range 85 to 160 mm with males at 105 to 145 mm were obtained at Mandapam. From the Palk Bay the size ranged from 90 to 150 mm during May to November with mode at 105 to 130 mm. A growth rate of 4 to 5 mm per month for fish measuring 105 mm and above can be assertained from the progression of modes on the length frequency distribution. The sex ratio showed almost equal proportions of both sexes. Studies on the maturity stages showed that the spawning season of this fish lasts from October to December, when specimens in stage IV and above are of common occurrence.

Personnel associated with the project

G. Venkataraman, JFS., K. Venkatasubba Rao, AFS., and J. C. Gnanamuthu, SRA.

(ix) Ribbon fish fisheries

Investigations on the ribbon fishes were carried out at Kakinada, Madras and Tuticorin. At Kakinada three centres were selected for biological studies. These were Uppada, Dummulapeta and Kakinada Fishing Harbour. At Madras samples were collected from Triplicane and Royapuram landings centres. The landings of ribbon fishes at the centres in Kakinada and Madras were generally greater during the second half of the year except at Dummulapeta where the peak landings occurred in the month of April. At Tuticorin investigations on *Eupleurogrammus intermedius* were carried out only during the first half year. The following species were studied :

(1) Trichiurus lepturus

At Kakinada the sizes of *T. lepturus* ranged from 105 to 854 mm during the year with the modal groups 200 and 500 mm largely supporting the fishery. At Madras similar modal groups largely contributed to the fishery. At Tuticorin this species had a size range 195 to 670 mm with only one mode at 440–469 mm. Heavy catches at Madras during November had the modes at 700 and 800 mm.

Immature and spent fish occurred together in the catches throughout the year at Kakinada along with fishes in other stages of maturity. Mature fish in stage V were recorded during March and April. It is already known that this species has a fast growth and prolonged spawning

season. At Madras, most of the fish examined were immature and a few were in maturing condition during October. At Tuticorin, no specimens with advanced maturity stage was recorded during the first half year. At Madras the feeding of the fish was fairly high during the second half of the year. Anchovies and squids were the common food items during August. Prawns, were the dominant food in September and October. *Sardinella fimbriata* also formed an item of food in October.

(2) Eupleurogrammus intermedius

Investigations on this species were carried out at Tuticorin only during January–June. In the shore seine catches the sizes ranged from 200-450 mm with a dominant mode at 320 mm. In the gill net catches the sizes ranged from 343–482 mm with the mode at 380 mm. Most of the fishes examined were in stages I-III. Feeding intensity was high from April to June.

(3) Lepturacanthus savala

At Tuticorin, this species had a size range of 340-540 mm with a modal group at 430-439 mm. The fishes were generally immature.

Personnel associated with the project

P. T. Meenakshisundaram, AFS., J. C. Gnanamuthu, SRA., K. A. Narasimham, SRA., and others.

(x) Tuna fisheries (At Vizhinjam)

About 675 tonnes of tuna were landed during the year at Vizhinjam. The catches were mainly from drift nets and hooks and lines. Among the species of tuna landed, *Euthynnus affinis* contributed to the bulk of the fishery. Other species that commonly occurred were *Auxis thazard*, *Auxis thynnoides* and *Sarda orientalis*. During the year the peak period of occurrence of the tunas was from March to May. Moderate catches were obtained during October-December.

(1) Euthynnus affinis

The size ranges of *Euthynnus affinis* obtained from boat seine, hook and lines and drift nets were 260–679 mm, 260–659 mm and 220–819 mm respectively. The size group 280–299 mm dominated the boat seine catches in September, while in hooks and lines the size groups 280–299 mm, 380–399 mm, 600–619 mm and 368–379 mm were dominant from September–December. However, in drift net catches, the size groups 340-359 mm became abundant in November and December. Males were more numerous and most of the specimens examined were in the maturity stages I, II and III from September to November. However, a few specimens in stage IV were also recorded once in December. Feeding was moderate in September and October and poor in November and December. The species fed chiefly on

fish *(Stolephorus* spp., *Sardinella* spp., *Nemipterus japonicus, Rastrelliger kanagurta, Dussumieria* spp., and *Caranx malabaricus)* and small quantities of *Metapenaeus* spp., and *Parapenaeopsis stylifera* were also recorded from the stomachs.

(2) **Auxis thazard**

Auxis thazard obtained from drift nets were 280–499 mm in length with dominant size groups at 300–319 mm and 320–339 mm during November and December respectively. The ratio of males to females in November and December were 40:17 and 36:29 respectively. Stages I and II were dominant in the month of November, while stage III was abundant in December. However, a few specimens with fully mature stages (IV and V) were also recorded in the catches towards the end of December. A few stomachs were found to contain crustacean remains (*Metapenaeus dobsoni, Parapenaeopsis* spp., and *Penaeus* sp.). A small quantity of larval and juvenile *Stolephorus* sp. and *Arius* spp., were also present in the stomachs.

At Minicoy, the length of oceanic skipjack, *Katsuwonus pelamis* studied ranged from 390 to 730 mm and in the samples males were dominant. Spent fishes were seen in April and May. Stomach analysis showed that fish, crustaceans and cephalopods formed the bulk of the food, while stomatopods, mysids and megalopa constituted the other items.

Personnel associated with the projects

M. D. K. Kuthalingam, AFS., M. S. Rajagopalan, AFS., and K. K. Appukuttan, RA.

(xi) Biology of other species

At Bombay *Polynemus indicus* which occurred in trawl catches had females in advanced stages of maturity (stage IV or spent) during the first half of the year. *Polynemus microstoma* was the most important polynemid fish at Mandapam and this species occurred in the size range 91 to 150 mm with a mode at 116–120 mm. The food of this species consisted of megalopa larvae, *Acetes, Lepidomysis xenops,* amphipods and smaller fishes.

Lutianus kasmira studied at Port Blair was found to spawn only once during the year and the spawning season was long and extended from November to March. Its minimum size at first maturity is about 170 mm. The fecundity varied from 42000 to 333000 ova. The mature ovaries contained two groups of ova. The second group of ova ranged from 0.25 to 0.65 mm in diameter. High feeding intensity was recorded during March–April and August–November. Teleost fishes, (chiefly clupeids), prawns and invertebrate larvae constitute the chief items of the diet of this species. There appeared to be no marked change in the diet of young or adult fish.

Studies on *Pomadasys hasta* were carried out at Bombay and Waltair. At Bombay the important size groups which contributed to the fishery during the year were 16, 40, 51 and 55 cm. From the observation on the maturity stages of this fish during the year it was inferred that the species spawns twice during the year.

Investigations on carangids were carried out at Waltair and Vizhinjam. At Waltair the size group of *Carangoides malabaricus* ranged from 142-202 mm in the trawl catches from January to April. Modal sizes were at 167 mm in January, 152-162 mm in February, 152-167 mm in March and 162-172 mm in April. Small fishes in the size range 52-112 mm occurred in the catches during May. From July to December, 117-167 mm, 132-167 mm, 142-172 mm, 147-177 mm, 150-172 mm and 152 mm were the predominant modal groups. At Vizhinjam this species was caught mostly by hook and line and a small quantity by boat seines. Maximum catch was recorded during September. Larger fish with modal groups of 130, 150, 160 and 180 mm occurred in the hook and line catch and smaller groups of 80 to 140 mm dominated the boat seine landings. The predominant food items observed during the period of observation were fishes belonging to the genera *Stolephorus*, *Leiognathus*, *Saurida*, *Caranx* and Sciaenids. Juvenile prawns, amphipods, *Acetes*, pteropods, copepods, isopods and *Lucifer*, were also present in the stomach. Other food items included *Thenus* and polychaetes. Although there was no regular pattern in the intensity of feeding, the catches from hooks and line showed a larger percentage of fish with empty stomachs.

Investigations on *Megalaspis cordyla* were also carried out at Vizhinjam. About 10042 kgs. of this species were landed from July to December. The maximum catch was during November. The predominant size groups which were 110, 140, 150, 180, 280 and 290 mm. The sex ratio varied considerably during the period and the maturity stages of females varied from I-IV.

Studies on important sciaenid fishes were carried out at Veraval, Bombay, Calicut, Mandapam, Madras and Waltair. At Veraval sciaenids, especially *Otolithus ruber* and *Johnius dussumieri* were the major components of trawl catches. *J. dussumieri* was the dominant species from January to March and after the monsoon, young fishes of the species *O. ruber* appeared from March-May. Growth of the species was studied from the modes in the length frequency distribution. Growth of about 5 cm in 3 months was deduced for *J. dussumieri*.

The fishery for *Sciaenoides brunneus* at Bombay was mainly supported by the O-year class from the inshore catches and II-year class from the offshore catches. The dominant size groups during the year were 45.5 cm for January to May, 17.5 cm in June, 24.5 cm in July, 32.5 cm in September

and 39.5 cm in November and December. Prawns formed the major food item of this species.

The biology of *Pennahia aneus (Pseudosciaena aneus)* was studied at Mandapam. The size of this fish in the catches ranged from 72–207 mm and a growth rate of about 5 cm per month was observed. Fishes in the size range 160–172 mm with ripe ovaries were seen during February and March. Size at first maturity was found to be 145 mm. Fecundity ranged from 8000 to 24000. The main food items of this species were *Engraulis commersoni*, *Acetes indicus*, *Lucifer* spp. and *Parapenaeopsis* sp. Investigations on this species were carried out at Madras also.

Pseudosciaena sina with a size range 145-206 mm occurred at Madras during the second quarter of the year. Females of this species in spent or spent recovering condition were also seen during this period. Prawns and anchovies formed an important food item. In the inshore catches *P. vogleri* occurred throughout the year. Adults of the size range 115–180 mm and juveniles of the size range 29–52 mm were present in the samples.

Personnel associated with the project

T. Tholasilingam, FS., V. Sadasivan, JFS, P. V. Kagwade, AFS, S. J. Rajan, AFS., K. Rangarajan, AFS., T. Appa Rao, SRA., R. S. Lalmohan, SRA., S. Reuban, SRA., and Research Assistants and other staff.

B. OFFSHORE FISHERIES INVESTIGATIONS

At Bombay

A. Government of India fishing vessels

(a) **Trawling:** Five vessels, viz., M. T. Kalyani IV (300 H. P.), M. T. Kalyani V (300 H. P.), M. V. Meenakhojini (200 H. P.), M. V. Meenaprayas (200 H. P.) and M. T. Matsya Vigyani (578 H. P.) conducted trawl fishing. The total fishing effort utilized were 814.00 hrs at a depth range of 7-74 m which yeilded a total catch of 144,927 kg of fish and prawns, with an average catch rate of 178.00 kg/hr. Fishing operations were poor in the second half of the year. Prawns formed only 0.33% of the total landings and 19.97% of the catch comprised of rays which dominated the commercial fishes landed. Table 21 gives the composition of trawl landings.

(b) **Purse seining:** Table 22 gives the details of purse seine operations by M. V. Meenakhojini. The purse seine was operated off Goa. In all 34 hauls were made which gave a total catch of 77736 kg of which, the Indian mackerel alone constituted 97.18%.

B. New India Fisheries vessels

(a) **Bull-trawling:** The vessels Akashimaru 23 and 25 of the New

and 39.5 cm in November and December. Prawns formed the major food item of this species.

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B. OFFSHORE FISHERIES INVESTIGATIONS

At Bombay

A. Government of India fishing vessels

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B. New India Fisheries vessels

(a) **Bull-trawling:** The vessels Akashimaru 23 and 25 of the New

India Fisheries conducted bull-trawling at a depth range 22-60 m and made 1112 hauls. The total fishing effort was 1370.40 hrs which gave 671650 kg of fish with a catch rate of 490.11 kg/hr. Prawns formed only 0.79% of the total catch. 'Dhoma' (small sciaenids) dominated the catch forming 30.26% of the landing. The catch and catch per hour during the first half were markedly higher than those of the second half of the year. Table 23 gives the data of bull-trawling operations.

(b) **Shrimp trawling:** The vessels Akashimaru 23 and 25, Sudha Nos. I to VIII and the vessel 'Konchu' conducted shrimp trawling operations. During the second half of the year only Akashimaru 23 and 25 were operated. The vessels altogether made 2791 hauls at the depth range of 6–45 m, expending 3491.35 hrs of fishing effort and landed 611280 kg of fish with an overall catch rate of 175.08 kg/hr. Prawns constituted 82.18% of the total catch (Table 24).

At Karwar

The area trawled off Karwar was about 280 sq. km. Of this, 120 sq. km was fished intensively from January to May. In all 354 mechanised fishing vessels (24-84 H. P.) operated trawl nets and landed 739478 kg of fish at 88.5 kg/haul. During the preceding year 179 vessels (10-120 H. P.) landed 1425432 kg at 148.4 kg/haul. 50% was obtained by 30-36/37 H. P. vessels. Nearly 72% of the total catch was landed from January to April (Table 25).

TABLE XXI. *Composition of trawl landings by Government of India fishing vessels of Bombay base during the year 1970*

	January-June '70	July-December '70	Total	%
Effort (hrs)	800.59	13.50	814.09	
Depth (metres)		12.31		
Catch details *				
Ghol	8304	10	8314	5.74
	(10.37)	(0.74)	(10.21)	
Koth	1685	180	1865	1.29
	(2.10)	(13.33)	(2.29)	
Dhoma	19382	250	19632	13.55
	(24.21)	(18.52)	(24.12)	
Dara	787	—	787	0.54
	(0.98)			
Karkara	2843	15	2858	1.97
	(3.33)	(1.11)	(3.51)	
Wam	19069	—	19069	13.16
	(23.82)		(23.82)	

Table XXI *(Contd.)*

	January-June '70	July-December '70	Total	%
Catfish	25818	70	25888	17.86
	(32.25)	(5.19)	(31.80)	
Prawns	464	10	474	0.33
	(0.58)	(0.74)	(0.58)	
Rays	27920	1025	28945	19.97
	(34.87)	(75.93)	(35.56)	
Sharks & Skates	13265	185	13450	9.28
	(16.57)	(13.70)	(16.52)	
Miscellaneous fishes	23280	365	23645	16.32
	(29.08)	(27.04)	(29.04)	
Total	142817	2110	144927	
	(178.39)	(150.30)	(178.02)	

*Catch and (Catch per hour) are given in kgs.
Ghol = *Pseudosciaena diacanthus;* Koth = *Otolithoides brunneus;*
Dhoma = Small sciaenids; Dara = *Polydactylus indicus;*
Karkara = *Pomadasys hasta;* Wam = *Muraenesox talabanoides*

TABLE XXII. *Particulars of Purse seine operations by Government of India Vessel M. V. Meenakhojini from Bombay base during the year 1970*

	January - June '70	July - December '70	Total	%
Areas fished	15-73 3E, 4E, 3F	15-73 1F, 2F, 3E, 4E, 3D, 4D		
Depth (metres)	7-12	9-14	7-14	
Fishing effort (hrs)	21.74	27.71	49.45	
No. of hauls	16	18	34	
Catch details*				
Sardines	625	25	650	0.84
	(28.74)	(12.50)	(13.14)	
Mackerel	26502	49044	75546	97.18
Miscellaneous fishes	—	1540	1540	1.98
Total	27127	50609	77736	
	(1247.80)	(1826.38)	(1572.01)	

* Catch and (Catch per hour) are given in kg.

TABLE XXIII. *Catch particulars of Bull-trawling operations by the New India Fisheries vessels Akashimaru 23 and 25 (from Bombay base) during the year 1970*

	January - June '70	July - December '70	Total	%
No. of hauls	549	563	1112	
Depth range (Metres)	22-56	25-60	22-60	
Fishing effort (in hours)	650.05	720.35	1370.40	
Catch details *				
Ghol	32390 (49.83)	7254 (10.07)	39644 (28.93)	5.90
Koth	1190 (1.83)	849 (1.18)	2039 (1.49)	0.30
Doma	134892 (207.51)	68336 (94.86)	203228 (148.30)	
Dara	3591 (5.52)	72 (0.10)	3663 (2.67)	0.55
Karkara	47664 (73.32)	836 (0.16)	48500 (35.39)	7.22
Wam	21798 (33.53)	35284 (48.98)	57082 (41.65)	8.50
Catfish	27396 (42.14)	9872 (13.70)	37268 (27.19)	5.55
Kati	20466 (31.48)	1116 (1.55)	21582 (15.75)	3.21
Pomfrets	7398 (11.38)	720 (1.00)	8118 (5.92)	1.21
Prawns	2610 (4.01)	2668 (3.70)	5278 (3.85)	0.79
Rays	38736 (59.59)	26637 (36.98)	65373 (47.70)	9.73
Sharks & Skates	65440	9484	74924	11.16
Miscellaneous fishes	98731 (151.88)	6220 (8.63)	104951 (76.58)	15.63
Total	502302 (772.71)	169348 (235.05)	671650 (490.11)	

* Catch and (Catch per hour) are given in kg.

TABLE XXIV. *Particulars of Shrimp trawling operations by the New India Fisheries Vessels Akashimaru 23 & 25, Sudha No. I to VIII and 'Konchu' during 1970 (Bombay Base)*

	January-June '70	July-December '70	Total	%
No. of hauls	2228	563	2791	
Depth range (Metres)	14-36	6-45	6-45	
Fishing effort (Hours)	2787.19	704.16	3491.35	
Catch details *				
Ghol	328 (0.12)	—	328 (0.09)	0.05
Dhoma	27018 (9.69)	3000 (4.26)	30018 (8.60)	4.91
Kati	1566 (0.56)	— —	1566	0.26
Pomfrets	90 (0.03)	478 (0.67)	568 (0.16)	0.09
Pervi	—	1800 (2.55)	1800 (0.52)	0.29
Rays	1600 (0.57)	—	1600 (0.046)	0.26
Sharks & Skates	7980 (2.86)	18550 (26.34)	26530 (7.60)	4.34
Miscellaneous fishes	32538 (11.67)	13974 (19.81)	46512 (13.32)	7.61
Total fish	71120 (25.52)	37802 (53.68)	108922 (31.20)	17.81
Prawns	428526	73832	502358	82.18
Total	499646 (179.27)	111634 (158.53)	611280 (175.08)	

* Catch and (Catch per hour) in kg.

TABLE XXV

Species	Total catch (kg)	Months of occurrence (%)	Period of abundance
Opisthopterus tardoore	72253	January-April & December (65%)	January, April & December
Leiognathids	120690	March, May & December (80%)	March & May
Sciaenids	112786	January, March & May (85%)	March & May
Prawns	202021	January-April & December	January and February
Lactarius lactarius	231728	—	—

At Mangalore

(a) Trawling: Mechanised fishing vessels, operated by the trainees and ex-trainees at the Mangalore centre and by the ex-trainees alone at Malpe, Mulki and Ganguli, formed the source of the Mangalore offshore data. Trawl net was the main gear operated. At the Mangalore training centre, 54 gill net operations were made. *M. dobsoni*, *P. indicus*, *P. stylifera*, *M. affinis* etc. were the major species of prawns landed. Fish catches were mainly composed of *Cynoglossus*, *Leiognathus*, *Caranx*, *Sciaenids*, *Opisthopterus*, *Trichiurus*, *Saurida and Lactarius lactarius* (Table 26).

TABLE XXVI

Centre	No. of operations	Total catch kg	Prawns kg	Fish kg	% of prawn
Mangalore	22928	1980880	1062058	918822	53.6
Mulki	1647	195707	73645	122062	37.63
Malpe	17636	3427583	1323308	2104275	38.6
Ganguli	9930	2374012	241047	2132965	10.15

(b) Gill net operations: The Mangalore training centre boats carried out 48 operations of gill nets which gave 5346 kg of fish consisting of catfishes, tunas, elasmobranchs, seer fish and mackerel.

At Cochin

(a) Indo-Norwegian Project

In all, 13 vessels including 3 larger vessels, M. V. Klaus Sunnana (220 H. P.), M. V. Velameen (480 H. P.) and M. V. Tuna (480 H. P.), seven medium vessels M-2, M-3, M-11, M-13, M-14 (48 H. P.), M. V. Kalava (120 H. P.), M. V. Karwar No. 1 (90 H. P.) and INP 167 (24 H. P.) participated in the fishing operations.

i. Operations by large vessels (120-480 H. P.)

Trawling: The depth of fishing operations was from 21-823 m. The different types of trawl nets employed by these vessels included 150' mexican trawl, F-2 fish trawl, F-3 fish trawl, F-4 fish trawl, F-5 fish trawl, Japanese fish trawl, 450 fish trawl, F-4/W. O. bobbin trawl etc. A total quantity of 218436 kg of deep sea fishes, lobsters, prawns and crabs etc. were landed by the exploratory fishing operations. Details of group-wise catches are given in table 27.

TABLE XXVII

	Catch and (catch/hr) in kg	
	1969	1970
Effort (hrs)	788.86	875.22
Depth range (m)	9-457	21-283
Total catch	249704.5 (316.56)	218436.0 (249.57)
Prawns	19187.5 (24.32)	19441 (22.21)
Fish	147824.5 (187.40)	125301 (143.16)
Lobster	65462.5 (82.98)	61531 (70.30)
Crabs	17230 (21.84)	12163 (13.89)
% of prawns	7.68	8.9

These vessels while operating in the shallower regions landed quality fishes of commercial importance such as elasmobranchs, perches, tunas and carangids resulting in an average catch rate of 249.5 kg/hr as against 316.56 kg/hr during the previous year.

ii. Purse seine operations by larger vessels

Purse seine operations were carried out by some of the larger vessels from January to May. An effort of 74.25 hrs was put in off Cannanore, Tellicherry, Calicut, Ponnani and Azhikode yielding 13712 kg of fish consisting of *Euthynnus affinis*, *Caranx* sp. and *Chorenemus* sp. at a catch rate of 184.67 kg/hr.

iii. Operation of medium sized vessels (24-90 H. P.)

Trawling: The medium sized vessels carried out commercial shrimp trawling at a depth range 5–48 m in the grounds off Cochin. The average catch rate was 52.16 kg/hr which was about the same as that of the previous year (51.45 kg/hr). The percentage of prawns in the total landings was 46.25 as against 44.79 in 1969. Details are given in table 28.

TABLE XXVIII

	Catch and (catch/hr) in kg	
	1969	1970
Effort (hrs)	5170.42	3444.24
Depth range (m)	4–40	5–48
Total catch	266920.25	179658
	(51.45)	(52.16)
Prawns	119162.75	83094
	(23.04)	(24.12)
Fish	146866.5	96536
	(28.4)	(28.02)
% of prawns	44.79	46.25

Purse seining: Some of the medium sized vessels conducted purse seine operations off Cochin in 8–15 m depth and landed large quantities of oil sardine and mackerel. The total catch amounted to 179589 kg for a total effort of 242 hrs.

Hand line operations: M. V. Kalava (120 H. P.) was engaged in "Kalava" (*Epinephelus* spp.) fishing using hand lines, in rocky grounds off Calicut, Ponnani, Chetwai, Azhikode, Cochin, Alleppey and Quilon at depths ranging from 84-106 m. During the year, 197.25 hrs of fishing landed 10380 kg of perches.

(b) Government of India fishing vessels

Two medium sized vessels M. L. Durga and M. L. Flying fish (56 H. P.) conducted shrimp trawling operations in the grounds off Cochin

at depths ranging from 5-73 m. The vessels stopped fishing during July and August due to rough weather conditions. The average catch rate during the year was 65.14 kg/hr. The catch rate of prawns was 19.11 kg/hr. Miscellaneous fishes were found to constitute 63.83% of the total landings. The other major groups represented in the landings were prawns, elasmobranchs, catfishes, *Nemipterus japonicus* and *Lactarius lactarius*. These formed 29.33%, 3.06%, 1.13%, 2.59% and 0.21% respectively of the total catch.

(c) Cochin Company

Shrimp trawlers numbering 3-5 belonging to Cochin Company (43-63 H. P.) operated off Cochin and Alleppey with Cochin as the base. The vessels stopped fishing in June. A total catch of 40140 kg, with catch rates of prawns and fishes as 20.25 and 12.48 kg/hr respectively were obtained. Nearly 61.87% of the total landings were composed of prawns.

At Vizhinjam

Small mechanised boats at Neendakara (with 8-17 H. P.) conducted daily trawling and drift net operations. The total catch from trawling was estimated as 14930 tonnes which gave a catch per unit effort of 261 kg. The total landings from drift nets were 964 tonnes with a catch per unit effort of 150 kg. Prawns formed the bulk of the trawl catches. The fish component was made up of *Nemipterus sp.*, *Saurida* spp. and sciaenids. Elasmobranchs, catfishes and seerfishes dominated the drift net catches.

At Tuticorin

The Government of India vessels, MFV Meenabharathi, MFV Jheenga and MFV Meenaprayas conducted exploratory fishing at a depth range of 5-40 m. The fish landed by these vessels was 93333.5 kg for a total effort of 454.7 trawling hours at the rate of 205.3 kg/hr. Details of species-wise catch are given in table 29.

TABLE XXIX

	January - June '70	July - December '70	Total	%
Effort (hrs)	355.59	99.1	454.7	
Depth range (metres)	10-38	5-40	5-40	
Catch details *				
Elasmobranchs	12421 (33.41)	2506 (25.29)	14927 (32.83)	15.99
Sciaenids	10440 (28.08)	4242 (42.81)	14682 (32.29)	15.73

Table XXIX *(Contd.)*

	January - June '70	July - December '70	Total	%
Leiognathids	24457 (65.79)	5366 (54.15)	29823 (65.59)	31.95
Pomadasys sp.	3552 (9.55)	810 (8.17)	4362 (9.59)	4.67
Arius sp.	1944 (5.23)	367 (3.7)	2311 (5.08)	2.48
Ephippus orbis	3258 (8.76)	657 (6.63)	3915 (8.61)	4.19
Polynemus sp.	665 (1.79)	98 (0.99)	763 (1.68)	0.81
Drepane punctata	129 (0.35)	167 (1.69)	296 (0.65)	0.31
Upeneus sp.	1023 (2.75)	479 (4.83)	1502 (3.30)	1.61
Saurida sp.	851 (2.29)	483 (4.87)	1334 (2.93)	1.43
Nemipterus sp.	988 (2.66)	259 (2.61)	1247 (2.74)	1.34
Lactarius lactarius	159 (0.43)	—	159 (0.35)	0.17
Prawns	43.5 (0.12)	24 (0.24)	67.5 (0.15)	0.07
Others	11695 (31.46)	6250 (63.07)	17946 (39.47)	19.23
Total	71625.5 (192.67)	21708 (219.05)	93333.5 (205.26)	

* Catch and (catch/hr) in kg

At Visakhapatnam

The fishing vessels of the Government of India and of the Andhra Fishermen Co-operative Society carried out trawling operations during the year off Visakhapatnam. The vessels, M. T. Ashok and M. V. Champa fished at 18-59 m depths throughout the year and brought a total catch of 72299.3 kg after expending a total effort of 570 hours. Details of the catch obtained from these vessels are given in table 30.

TABLE XXX

Fish	Catch in kg	
	G. I.*	A. F. C. S.†
Sharks and skates	6424.00	2085.00
Rays	4250.50	610.00
Catfish	23399.50	6538.00
Prawns	3457.80	10752.75
Miscellaneous (small)	32286.00	37194.00
Miscellaneous (big)	2481.50	2858.50
Total	72299.30	60038.25

* G. I. = Government of India vessels.
† A. F. C. S. = Andhra Fishermen Co-operative Society vessels.

Personnel associated with the project

T. Tholasilingam, FS., S. V. Bapat, JFS., B. Krishnamoorthi, JFS., M. V. Pai, JFS., M. D. K. Kuthalingam, AFS., P. V. Kagwade, AFS., D. M. Punwani, AFS., K. Venkatasubba Rao, AFS., M. G. Dayanandan, AFS., V. Ramamohan Rao, AFS., and number of Senior Research Assistants, Research Assistants and other staff.

CRUSTACEAN FISHERIES

1. STOCK ASSESSMENT OF PRAWNS

The total landings of marine crustaceans amounted to 125148 tonnes during the year. This showed an increase of 12.5% over the previous year. The major constituents of the landings were penaeid prawns (70.3%), non-penaeid prawns (21.0%) and other crustaceans (7.9%). While the landings of the penaeid prawns and other crustaceans showed an increase of 22.9% and 75.6% respectively, that of the non-penaeid prawns registered a decrease of 22.8% over the previous year.

The statewise break-up of the landing figure is given in Table 31. An increase in penaeid prawn landings was noticed in four states namely Andhra, Mysore, Maharashtra and Gujarat, but this was most pronounced in Maharashtra where the increase was of the order of 88%. In all the other states the landings showed a slight decrease. The most significant feature in the landings of non-penaeid prawns was a decrease of about 36% in Maharashtra. In all the other states, the landings of this category of prawns

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CRUSTACEAN FISHERIES

1. Stock assessment of prawns

The total landings of marine crustaceans amounted to 125148 tonnes during the year. This showed an increase of 12.5% over the previous year. The major constituents of the landings were penaeid prawns (70.3%), non-penaeid prawns (21.0%) and other crustaceans (7.9%). While the landings of the penaeid prawns and other crustaceans showed an increase of 22.9% and 75.6% respectively, that of the non-penaeid prawns registered a decrease of 22.8% over the previous year.

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showed an improvement. Maharashtra was again responsible for the increase in the landings of other crustaceans. On the whole, the crustacean landings showed a significant increase during the year.

The details of prawn fishery as observed at the different observation centres are summarised in table 32. On the west coast, offshore prawn fishery by the mechanised trawlers was active practically throughout the year, excepting the monsoon period. The highest prawn landing was recorded at Cochin but the maximum catch per unit effort was obtained at Bombay. In the offshore catches, *Metapenaeus affinis* predominated at all the centres between Veraval and Karwar, *Parapenaeopsis stylifera* between Mangalore and Calicut and *Metapenaeus dobsoni* at Cochin. On the east coast, *Penaeus indicus* and *Penaeus semisulcatus* were the predominant species.

Data obtained from a special sampling scheme carried out from Cochin showed an improvement in prawn catches. An estimated catch of 2253 tonnes of prawns were landed this year as against 1064 tonnes from the same scheme in 1969. This increase was reflected in the catch / effort which in 1970 was 31.28 kg/hr as against 16.36 kg/hr in 1969.

The trawlers of the New India Fisheries Company Limited operating in waters far away from Cochin landed 1119 tonnes of prawns during the year. Nearly 50% of this catch was of *M. affinis*, while the remaining portion was constituted equally by *P. indicus* and *M. dobsoni* The vessels of the Deep Sea Fishing Station and the Indo-Norwegian Project together landed 257.7 tonnes of prawns consisting mostly of *M. dobsoni* and *P. stylifera*.

On the west coast, at Veraval and Bombay, the inshore fishery was active in all months except during the monsoon (as was the case with offshore fishery at these centres). While at the southern centres the inshore fishery was active during the monsoon months when the offshore fishery had stopped. Large quantities of shrimps were landed from the inshore waters at Bombay and the catch was mainly composed of non-penaeid prawns. At other centres, penaeid prawns formed the major portion of the landings.

An unusual bumper catch of prawns amounting to 45 tonnes per day was reported from Pallithode-Manassery area in the 3rd week of June. This was part of the mud bank fishery prevailing at that time at the distance of 50 miles from the coast-line at Azhikode and Nattika. From these centres also very high catches were reported. Large sized *P. indicus* constituted the bulk of the catches.

Estuarine prawn fishery in Aghanashini Creek (Karwar) was of moderate intensity during the year and an estimated catch of 6.5 tonnes consisting of juveniles of *M. monoceros, M. dobsoni* and *P. merguiensis* was landed. In the experimental fishing carried out in the estuaries near

Mangalore, *M. dobsoni* predominated the catches throughout the year. From the Korapuzha estuary, near Calicut, *M. monoceros* and *M. dobsoni* together gave rise to about 80% of the prawn landings, estimated at 56.7 tonnes. Of this, about 50 tonnes were landed in the first half of the year. From Cochin backwaters (Ernakulam District) an estimated quantity of 1564 tonnes of juvenile prawns was landed by stake nets, while the catches from the paddy fields adjoining these backwaters amounted to 3698 tonnes. The stake net fishery of the backwaters was active throughout the year and the prawn fishery of paddy fields extended from October to May. *M. dobsoni* (44.7%), *M. monoceros* (23.1%), *M. affinis* (13.6%), *P. indicus* (11.8%) and *P. semisulcatus* (6.8%) were the prawns obtained from the backwaters. The quantity of prawns landed from the backwaters by other gears such as cast nets and dip nets was not available.

The estuarine prawn fishery of the Pulicat lake (Madras) was active throughout the year but relatively higher catches were obtained in the last quarter of the year. The estimated catch of prawns from this lake was 373 tonnes. Juveniles of *P. indicus, M. monoceros, M. dobsoni* and *P. semisulcatus* were the species that contributed to the fishery. A catch of 268 tonnes of juvenile prawns was obtained from the estuarine regions of B. V. Palam and Yanam (Kakinada). As at Pulicat lake, the fishery was more active during the last quarter of the year and it was supported by *M. monoceros, P. indicus, M. brevicornis, P. monodon, M. dobsoni, M. affinis* and *P. merguiensis.*

TABLE XXXI. *Statewise landings of marine prawns*

States	Penaeid prawn		Non-penaeid prawn		Other crustacean	
	1970*	1969	1970*	1969	1970*	1969
West Bengal & Orissa	2986	5638	22	—	3	—
Andhra	4995	4307	1886	1757	114	114
Tamil Nadu	4721	5526	540	287	4250	4789
Pondicherry	447	614	—	—	92	156
Kerala	37993	34334	14	34	351	435
Mysore	6760	3980	1	—	34	26
Maharashtra	27407	14545	22820	31235	4903	144
Gujarat	2653	2622	946	651	—	1
Goa	1000	559	—	—	—	5
Andamans	10	8	—	—	—	—
Laccadives	—	—	—	—	—	—
Total	88972	72133	26229	33964	9947	5670

* Provisional figures.

TABLE XXXII. *Particulars regarding the prawn fishery at different observation centres during the year 1970*

	Veraval	Bombay	Karwar	Mangalore	Calicut	Cochin	Colachel	Mandapam	Madras	Kakinada
Offshore prawn Catch in tonnes	555.40	428.50	195.00	1062.05	1280.00	3626.70	—	180.60	266.20	403.00
Catch/effort (kg/hr.)	20.64	153.75	—	46.16	142.23	31.28@	—	—	—	—
Important species*	1,6,11,12	1,3,7	1,2,6	1,2,3,5,6	1,2,5,6	1,2,5,6	—	9	3,4,5	1,2,3,4,5,8
Peak fishing season**	1,11,12	1,2,5	1,2,3,12	1,3,9,10	1-4	4-6,10-12	—	1,4,5	1-5,10,11	—
Inshore prawn catch tonnes	73.00	2407.60	41.00	13.32	354.00	80.20	37.70	—	—	14.00
Catch/effort (kg/hr. per boat unit)	—	—	—	12.533	—	255.5	—	—	—	—
Important species*	6,10,11,12	1,6,13,14,15	1,6,7	2,5	1,2,5,6	2,5	5	—	—	2,4
Peak fishing seasons**	3,10,11	1-5,10-12	7-9	7-9	7-10	6-9	7-9	—	—	—
Estuarine prawn catch tonnes	—	—	6.50	—	51.00	1564 from open estuary 3689 tonnes from paddy fields	—	—	372.90	268.00
Catch/effort	—	—	—	—	—	—	—	—	—	—
Important species*	—	—	2,3,7	—	2,3,5	1,2,3,5	—	—	2,3,5,9	2,3,4,5
Peak fishing season**	—	—	1,2,10,12	—	2-5	2-10	—	—	10-12	—

* Species numbered:

1. *Metapenaeus affinis*
2. *Metapenaeus dobsoni*
3. *Metapenaeus monoceros*
4. *Metapenaeus brevicornis*
5. *Penaeus indicus*
6. *Parapenaeopsis stylifera*
7. *Penaeus merguiensis*
8. *Penaeus monodon*
9. *Penaeus semisulcatus*
10. *Penaeus sculptilis*
11. *Hippolysmata ensirostris*
12. *Palaemon styliferus*
13. *Palaemon tenuipes*
14. *Acetes indicus*
15. *Solenocera indica*

** Months of the year:

1. January
2. February
3. March
4. April
5. May
6. June
7. July
8. August
9. September
10. October
11. November
12. December

@ Data from the sampling scheme for mechanized fishing vessels only

2. Biology and fishery of prawns

(i) Prawns of the genus Penaeus

(a) Penaeus indicus

Being a large sized species, this prawn is the most valuable for export from India. Although the species is widely distributed on both the coasts of India, its fishery is of a diffused and sporadic nature. On the west coast, the species did not contribute much to the commercial fishery at the observation centres which were Veraval, Bombay and Karwar. But in Mangalore *P. indicus* accounted for 34.2 tonnes forming 3.2% of the prawn catches from the offshore regions. In the inshore region, although the species was scarce but it formed a considerable portion of the estuarine catches as evidenced by the experimental catches at Kasargode, Bengre and Mulki estuaries. In these estuaries the fishery was most active in the first half of the year when its size groups predominantly remained 21-50 mm. In the second half of the year, bigger prawns of size group 46-55 mm constituted the modes at Bengre and Kasargode, whereas, at Mulki smaller individuals (36-40 mm) were the most common. In the inshore fishery, *P. indicus* appeared in substantial quantities in late September. In the offshore fishery the species was obtained from January to May and November to December with modes at 116-120 mm for males and 131-140 mm for females.

About 61 tonnes of this species were landed at Calicut. Of this the inshore and offshore catches were 30 and 22 tonnes respectively, while the estuarine catch amounted to 9 tonnes landed during the first half of the year. Size groups 106-120 mm dominated the estuarine fishery from January to March and thereafter the size group 96-100 mm became abundant.

From the Cochin area 1552 tonnes of *P. indicus* were landed and most of this catch (985 tonnes) came from the paddy fields. Size frequency studies of the offshore catches indicated that the smaller sized mode observed at 126-130 mm in January gradually progressed to 171-175 mm in December.

The landings by the New India Fisheries Company gave about 280 tonnes of *P. indicus* and *P. merguiensis*, the former being more abundant. Most of this catch came from the waters off Quilon-Alleppy in June, July and August and from the Tuticorin waters during September and October. The catches off Quilon-Alleppy had the mode for *P. indicus* at 150-160 mm for both the sexes, while off Tuticorin it was at 166-170 mm for males and at 181-185 mm for females.

The inshore fishery for *P. indicus* was of a sporadic nature. In the third week of June, an unusually heavy catch of this species was reported from the mud-bank areas. This unusual fishery which lasted for a week between Alleppey and Nattika was estimated to yield about 1000 tonnes. The modal size was 151-155 mm for males and 156-160 mm for females.

The regular inshore fishery of Manassery had the size range 71-195 mm with modes at 146-150 mm for males and 161-165 mm for females.

From the estuarine catches *P. indicus* came from the open estuary and from the paddy fields adjoining the backwaters. In the backwaters the species was caught almost throughout the year in stake nets and cast nets. The mean size (combined) showed an increasing trend from 62 mm in April to 100 mm in September.

The monsoon fishery of prawns in the Kanyakumari District was totally supported by the large sized *P. indicus*. An estimated catch of 38 tonnes of this species was landed at three observation centres of this district (Enayam, Manakkudy and Colachel) during July, August and September. The catches had a modal size at 171-175 mm for males and 175-180 mm for females. Small quantities of juvenile *P. indicus* were fished from Manakkudy estuary almost throughout the year.

In the prawn catches landed at Madras, *P. indicus* constituted about 65%. The offshore catches landed at Royapuram consisted exclusively of *P. indicus* in January, April, May, June, September and December. In other months it was absent. During the first half of the year the species had a modal size at 111-130 mm, but in September only large sized prawns with modal size 186-190 mm were obtained.

The catches from Pulicat lake largely included this species. In February and August the catch was exclusively of this species with a size range 65-135 mm. The modal size of the juvenile prawns varied from month to month.

About 38 tonnes of *P. indicus* was landed from the estuaries of Kakinada (B.V. Palem and Yanam). Although the catch from both these centres consisted of juveniles, that from B.V. Palem was relatively smaller in size (50-90 mm), while from Yanam it ranged from 70-100 mm.

(b) Penaeus merguiensis

This species formed a large part of the catches of the New India Fisheries Co. Ltd. At Karwar the species was found in the inshore catches during July to September and in the estuarine catches from January to April. The absence of this species in the offshore catches during the year is particularly noteworthy. The catch amounted to approximately 4 tonnes, of which over 3 tonnes were obtained from the inshore waters. The modal sizes for females in the catches during July was 141-145 mm and in August it was 156-160 mm. For males there were two modal sizes in July at 131-135 mm and 141-145 mm but in August there was only one single mode at 146-150 mm. Early maturing and mature prawns were noticed during these months. From the estuaries juveniles of the species were obtained and their size ranged from 51-130 mm.

The trawlers of New India Fisheries Co. Ltd. working from Cochin at 20-35 m depth landed large quantities of *P. merguiensis*. Similarly in the waters of Goa and Ratnagiri the quantities landed had modal sizes larger than 150 mm.

(c) Penaeus semisulcatus

Substantial catches of this species were obtained from Mandapam. A total of 180.6 tonnes was landed by the offshore fishing vessels. The species occurred throughout the year although the landings from June to September were poor. The size distribution of the species in different months indicates that the recruitment of the smaller prawns to the fishery takes place in May. Thereafter, the size of the prawns increases every month. Females with advanced stages of maturity were found practically throughout the year, but peak maturity seems to occur from May to September.

(ii) Prawns of the genus Metapenaeus

(a) Metapenaeus dobsoni

About 70 tonnes of this species were landed at Karwar which is the northern limit of its occurrence. Nearly 97 % of this was caught by the mechanised boats. The inshore catches by the shore-seine were very poor. About 1.6 tonnes came from the Aghanashini estuaries. In the early part of the year the modal size of the species was at 78-80 mm in males and 91-95 mm in females, which gradually shifted to 96-100 mm and 106-110 mm respectively towards the end of the year. Almost all stages of maturity were found in females throughout the year, but a predominance of mature prawns was evident in November and December when about 77 % of prawns were gravid. The estuarine catch contained juvenile stages with a modal size at 41-45 mm.

At Mangalore, 693 tonnes of *M. dobsoni* were landed. This formed about 64.4 % of the total prawn landings from this centre. Of this, about 680 tonnes were landed by the mechanised fishing vessels and the rest by the indigenous gears. In the pre-monsoon fishery, the modal size of the species in the offshore catches was 76-85 mm for males and 91-105 mm for females. In the post monsoon fishery, larger prawns with modes at 101-105 mm for males and 111-120 mm for females were obtained up to November but in December smaller modes (65-70 mm male and 86-90 mm female) representing new recruits appeared in the fishery in addition to the disappearing larger modes. In the inshore waters the fishery by the indigenous boats was active in August and September and the species was represented by the larger sized maturing prawns. In the experimental catches made from the estuarine centres at *Mulki*, Bengre and Kasargode, this species was predominant in November and December and was represented by the juveniles below 50 mm.

Of the 729 tonnes of *M. dobsoni* landed at Calicut during the year, 408 tonnes were from the offshore areas and the rest were from the boat-seines. From January to April the trawl landings of this species largely constituted 2 size groups, one at 85–85 mm, in January and the other at 71–75 mm which appeared in February. The former shifted to 86–90 mm in February and then disappeared but the latter continued to dominate the catches in April. The boat-seine fishery of July to October and the trawl fishery of November-December were constituted chiefly by the size groups 86-105 mm and 96–110 mm respectively. Spent females were found mostly in July-August and November–December. *M. dobsoni* formed 44.37% of the prawn catches obtained from Korapuzha estuary. Relatively better catches were obtained during the pre-monsoon period.

At Cochin, *M. dobsoni* formed 58.3 % of the total catches of prawns and was the mainstay of the fishery from the waters offshore, inshore and estuary. In the offshore fishery, the species was predominant in the first half of the year. The size distribution of the species in the offshore fishery was of unimodal nature in the pre-monsoon months, (the modes being relatively smaller) while in the post-monsoon fishery it was characterised by a bimodal distribution. The recruitment of the smaller prawns into the fishery appears to take place in all the months of the year except May and June.

The inshore fishery at Cochin was restricted to the monsoon months when large sized prawns dominated the catches. This confirms the earlier observation that the species moves nearer to the shore during this period.

In the backwaters of Cochin, *M. dobsoni* was the predominant species in the stake net catches. The fishery was supported by the juvenile prawns of the size range 16–100 mm. The mean size of the species noticed at 54 mm in Junuary decreased gradually to 46 mm in April. During the monsoon months, however, the mean size was relatively larger (62 mm).

M. dobsoni was poorly represented in the catches of the east coast. Of the 639 tonnes of prawns landed at Madras, *M. dobsoni* formed only 8.4 %. The species appeared occasionally in the catches of the mechanised fishing vessels at Royapuram and in the estuarine catches from the Pulicat lake. At Royapuram the modal size of the species was about 81 mm in January, March and August, while in July it was at 66-70 mm. Mostly juveniles formed the catches from the Pulicat lake. At Kakinada landings of this species were negligeable.

(b) Metapenaeus affinis

The species formed a large proportion of the trawl landings at Veraval and constituted over 50 % of the 555.4 tonnes of prawns. The fishery was active only in the first and last quarters of the year. The modal size of the species was uniform throughout the year, although slightly larger

prawns (121-130 mm) were obtained in the first quarter of the year. In November and December more mature specimens were found in the catches.

In the offshore catches of prawns landed by the trawlers of the New India Fisheries Co. Ltd., Bombay, *M. affinis* was the most dominant species. At Versova and Sasoon Dock (Bombay) 196.2 tonnes of *M. affinis* were landed. The highest catches of the species were in April and October. The dominant length group was 121-125 mm in March and 116-120 mm in April. In September and October the modal size groups were found at 101-105 mm and 106-110 mm respectively. Juveniles also appeared in October along with the adults. Immature females occurred throught the year except in March and April.

At Karwar, the total catch of *M. affinis* was slightly less than that of the previous year from the offshore regions, 100.5 tonnes of this species were landed of which only 4 tonnes came from the inshore region. This species was not represented in the estuarine catches. The fishery was generally good in the first and last quarters of the year. In January, 3 modal sizes were noticed for females at 76-80mm, 86-90mm and 96-100mm, while for males there was only a single mode at 86-90mm. These size groups showed some increase in subsequent months and in April both the sexes had two modal sizes. Females had modes at 106-110 mm and 121-125 mm and males at 101-105 mm and 111-115 mm. In the post-monsoon fishery, the modes for females were noticed at 121-125 mm and 131-140 mm and for males at 121-125 mm. In the fishery of indigenous boats, which was active only in August and September, the species had the modal size at 96-105 mm for females and 101-105 mm for males. Most of the females caught in November and December were mature.

At Mangalore, a sizeable catch of this species (82.1 tonnes) was obtained from the offshore areas. Almost the entire catch was landed during the first half of the year, especially in March, April and May. The predominant size group for males was at 111-115 mm and for females it varied from 111-115 mm and from 136-140 mm. During the period of peak fishery, about 30 % of the females were mature. In the experimental fishing carried out in the estuarine regions, the juveniles of the species were rather scarce. At Calicut 100.6 tonnes of *M. affinis* were landed and of this 99.4 tonnes came from the catches of mechanised boats and the rest from the indigenous fishing boats operating in August. The species was not represented in the estuarine catches. In the offshore catches the modal size of the species was at 131-135 mm in January. This mode disappeared in May. A second mode was seen at 116-120 mm in February which continued to occur till May. In November and December the principal mode was at 126-130 mm. Spent females occurred in large numbers in January and May. In the inshore fishery of August, *M. affinis* was represented by 101-105 mm size group.

At Cochin, the catch of *M. affinis* was 761.4 tonnes (8.5 % of total prawn catch), most of which came from the offshore areas. The inshore catch of the species was insignificant, while the estuarine catches amounted to 41.3 tonnes. The smaller sizes that entered the fishery of the offshore waters in February-March continued to occur in subsequent months. The principal mode was seen at 121-125 mm towards the end of the year. In the estuarine fishery at Cochin, the mean size of the species (52-55 mm) remained unchanged practically throughout the year. In June, however, new recruitment seemed to occur as the mean size was reduced. In the inshore fishery the species occurred only in January when a small quantity (519 kg) was caught in the gill nets.

In the trawlers of the New India Fisheries operating in waters far away from Cochin, this species formed about 50 % of the total prawns landed. One noteworthy feature observed in the size distribution of this species in these catches was that the prawns obtained from 30-40 m depth off Ratnagiri and Goa were larger (120-130 mm) than those obtained from 25-40 m depth off Alleppey and Quilon.

(c) Metapenaeus monoceros

This species was not represented in the prawn catches at Veraval and Bombay. At Karwar it was obtained only from the estuaries. An estimated quantity of 4.1 tonnes was landed from Aghnashini estuary. The species occurred in all the months except May and September. The entire catch was of juvenile prawns and their size varied between 51-55 mm and 66-70 mm in all the months indicating their continuous recruitment in the fishery. The species made its appearance in the offshore catches of Calicut only in April. From the Korapuzha estuary (Calicut) 22.2 tonnes of *M. monoceros*, forming 39.1 % of the entire catches from this estuary, were landed during the year. Small sized prawns (with mode at 61-70 mm) recorded in the early part of the year, formed the mainstay of the fishery here. In the second half of the year, although the fishery was relatively poor, the prawns were generally larger (modal size 81-85 mm).

At Cochin 369 tonnes of *M. monoceros* was landed from the offshore regions and the estuaries. The estuaries provided the bulk of the catch, especially from April to July. The highest mean size of 88 mm was noticed in August while the lowest size of 48 mm was seen in February. Excepting February, in all the months the average size of the species remained at about 60 mm.

From the east coast, this species was landed in fairly large quantities (23 tonnes) at Royapuram (Madras) by the indigenous (non-mechanised) boats. The size range of the species in these catches was between 66 mm and 115 mm. In the catch from the Pulicat lake, which amounted to 58.1 tonnes, this species appeared off and on in large quantities. Their size in the catch ranged from 36-40 mm to 106-110 mm but most of them were between 66 and 85 mm.

From the estuarine regions at Kakinada 159.3 tonnes of *M. monoceros.* were landed. The stake net fishery at B. V. Palam was poor as it landed only 47 tonnes of this species as compared to 188 tonnes in 1969. From July to September prawns of the size range 45-65 mm dominated the catches of B. V. Palam, while in the other months 30-55 mm size groups were predominant. At Yanam, however, the size groups were slightly larger (50-80 mm).

(d) Metapenaeus brevicornis

This species formed a good fishery only at Kakinada. Landings were of the order of 40.5 tonnes. Of this, 28 tonnes (70 %) came from the trawlers and the rest from the estuaries. The species was mainly fished from shallow regions, at depths not exceeding 30 m. The peak fishing season was in September and December, during which period the catch/ effort of the species in the trawl catches exceeded 1 kg/hr. In the inshore waters this species was scarce, while it was fairly abundant in the estuarine catches. In the inshore and offshore catches the size frequency of the species showed almost the same pattern. Peak spawning activity of the species was noticed from September to January.

(iii) Prawns of the genus Parapenaeopsis

(a) Parapenaeopsis stylifera

The species was landed in considerable quantities at Veraval where it formed as much as 45 % of the total prawn landings. A major portion of the catch came from the offshore regions where the size mode was noticed at 91-95 mm in January which progressed to 111-115 mm in March. Smaller prawns of 76-80 mm mode constituted the post-monsoon fishery. In the inshore catches of Navabandar which was active only during the last quarter of the year the smaller prawns (36-50 mm) entered the fishery in December.

In the prawn catches of the 'Dol' net at Bombay *P. stylifera* amounted to 253 tonnes forming 6.5 % of the prawns at Versova and 16.2 % at Sassoon Dock. Most of the landings took place in the last quarter of the year. The dominant size groups at Sassoon Dock were 86-90 mm in January and 91-95 mm in March. During the monsoon months (July and August) slightly smaller sized modes at 71-75 mm and 76-80 mm were seen at this centre and in October and November still smaller sized groups between 50 and 70 mm, were landed. At Versova, on the other hand, prawns larger than 65 mm were present and the dominant mode was at 86-90 mm which remained unchanged from October to December. Juveniles were completely absent in the fishery at both these centres. In the post-monsoon months mature and spent prawns were common in the catches.

As compared to the previous year, Karwar had an unusually high catch of this species in 1970. Of the 53 tonnes landed, about 60 % was

from the inshore waters in September. The principal size mode was 86-90 mm for females and 76-85 mm for males. In February and March most of the females were in maturing condition. Offshore catches were landed mostly in January and March and their size modes were at 81-85 mm and 96-100 mm for females and 76-86 mm for males.

At Mangalore 260 tonnes of *P. stylifera* were landed. Most of this catch was by the mechanised boats. The modal sizes of the males were 76–80 mm, and 86–90 mm and of females 91-95 mm and 106–110. Smaller specimens were caught in December. *P. stylifera* was caught almost exclusively by trawling at Calicut and its total catch was 746 tonnes. Of this only 2 tonnes came from the boat-seines operating in the inshore waters. Adult prawns of 75-90 mm constituted the bulk of the catch. Maturing stages were present in all the months.

At Cochin the entire catch of *P. stylifera*, amounting to 1019 tonnes, was landed by the mechanised vessels mostly in the last quarter of the year. The size frequency distribution showed that small sized prawns enter the fishery in January-February. The modes were generally distributed between 72-75 mm and 101-105 mm.

(b) Parapenaeopsis hardwickii

This species forms an important fishery only at Bombay and Kakinada. At the former centre, 43 tonnes were landed and the bulk of the catch came from Versova. In the first quarter of the year the juveniles (26–40 mm) entered the fishery. In the post-monsoon period, larger specimens with a modal size 86-95 mm supported the fishery. The peak breeding season for the species was from December to May. At Kakinada 9.2 tonnes of *P. hardwickii* were landed by the mechanised vessels.

(iv) Biology and Fishery of Solenocera indica

Commercial fishery of this species was only in Bombay and Kakinada centres. In Bombay, 13.8 tonnes were landed by 'Dol' net mostly at Versova. The fishery for this species came to an end before monsoon. The species exhibited wide variations in the pre-monsoon fishery, males were of a larger size (56-65 mm mode) but in the post-monsoon period their size was small, only 36–40 mm. In females also a similar trend was noticed. From January to May the females were of varying sizes ranging from 73 mm to 103 mm but in October and November the size became uniform at 51-53 mm. Different maturity stages were recorded in practically all the months suggesting a continuous breeding habit for the species.

In Kakinada, 8.4 tonnes of this species were landed by the mechanised boats from the offshore areas. May and June appeared to be good fishing months at this centre.

(v) Life history of penaeid prawns

The life history studies of the five commercial penaeid prawns, viz., *Metapenaeus dobsoni*, *M. monoceros*, *M. affinis*, *Penaeus indicus* and *Parapenaeopsis stylifera* were continued in the laboratory. Earlier studies on the rearing of penaeid larvae upto a known stage were supplemented by a detailed examination of the preserved specimens obtained from the plankton. This enabled the protozoeal stages of *P. indicus*, *M. dobsoni* and *P. stylifera* and the mysis and post-larval stages of all the five penaeid prawns to be distinguished and identified.

Growth factor (ratio between size at a particular stage and size at the previous stage) at different stages was almost constant for each species and was found to be less than 2, except for the protozoea I of *P. stylifera* and *M. dobsoni*. During the transformation of the last nauplius to protozoea I, maximum growth factor and percentage increase in size were noticed. During the early stages, the postlarvae of *P. stylifera* and *M. monoceros* moulted once in every 2 to 3 days but as the larvae grew moulting took place once in every 3 to 4 days. The rearing experiments showed an average growth rate of 0.453 mm per day in the case of post-larval stages (4 mm to 17.6 mm) of *P. stylifera* and 0.321 mm per day with those of *M. monoceros* (3.45 mm to 18.0 mm).

From 80 tow-net samples collected from the inshore waters of Cochin in 1970, 807 penaeid larvae were obtained. The percentage of different species were *M. dobsoni* (82.7 %), *M. monoceros* (9.0 %), *M. affinis* (2.6 %), *P. indicus* (4.2 %) and *Parapenaeopsis stylifera* (1.4 %).

Eggs and nauplii of *M. dobsoni* and *P. stylifera* were seen in November. The larvae of the former species occurred throughout the year except in July, August and October. They were abundant in January March and April and were scarce in the second half of the year. The larval stage of *M. monoceros* appeared in small numbers from April-June and in September and those of *M. affinis* in January, April and December. In other months they were completely absent. Larvae of *Parapenaeopsis stylifera* and *Penaeus indicus* were not common in the inshore waters and were seen only occasionally from February–March. In the second half of the year they were completely absent.

Analysis of the plankton samples collected from the backwaters showed that the post-larvae were exceptionally abundant in January and moderately abundant in February. In the subsequent months they showed a declining trend. From July to October their presence was negligible but they reappeared in November in very small quantities. *Metapenaeus dobsoni* was represented in plankton abundantly throughout the year. Among the other species, the post-larvae of *Penaeus indicus* and *M. affinis* occurred in small numbers from March to May and November to December. The larvae of *P. semisulcatus* and *M. monoceros* were very few and were seen

only in May, November and December. The scarcity of larval and post-larval forms in November–December period was very conspicuous.

A comparison of the distribution pattern and abundance of larvae of prawns during the year with those of the previous year showed several variations from the general pattern. The rate of occurrence of prawn larvae and post-larvae in the inshore plankton was about 10.0 per haul during 1970 as against 270.4 during 1969. Similarly in the backwaters, the rate of occurrence was 33.0 per haul as against 45.2 per haul in the previous year. This obvious recuritment of the larvae and post-larvae to the inshore regions and backwaters could have been due to various reasons such as the decrease in breeding activity, poor larval survival and other natural causes. Whatever may be the reason, this apparent reduction in recruitment may affect the prawn fishery of the next year.

(vi) Migration of larval and juvenile penaeid prawns in Cochin backwaters

This assesment was made by the following two methods. (1) making observations on the juvenile prawns from the stake net catches during high tide (immigration) and low tide (emigration) and (2) making collections from the bottom by specially designed try net.

The rate of immigration of the various species of juvenile prawns as reflected in the experimental stake net catches during high tide was as follows: Intensive emigration of *M. dobsoni*, the principal species, was observed from January to May and again in November-December; that of *P. indicus* from April to September, and *M. affinis* and *M. monoceros* during the monsoon months (July-August). Emigration of these species was continuous throughout the year. From the try net catches also, a similar trend was noticed. Although the pattern of size distribution and the quantity of prawns immigrating and emigrating were generally similar to those of the previous year, the number of small juveniles observed during the second half of the year was considerably low. The poor abundance of larvae of prawns in the inshore and backwater plankton probably leads to a low recruitment of the juveniles. Analysis of the backwater catches showed a strong lunar periodicity. High catches were obtained during the dark phase of the moon, especially in November.

(vii) Prawns of the genus Acetes

Acetes indicus forms a commercial fishery only at Bombay. During the year, 1241 tonnes of the species were landed at the two observation centres at Bombay (Versova and Sassoon Docks). With the exception of monsoon months the species occurred in the fishery throughout the year but exceptionally high catches were obtained during the last quarter of the year. The size ranged from 15 to 36 mm. In the size frequency distribution certain special characteristics were noticed. The males were generally smaller and their maximum size observed was only 26 mm. Females had a size of 36 mm. The bulk of the catch consisted of females above 25 mm.

All stages of maturity were present in the catches. In March and April, mature and spent females occurred in large numbers. From August onwards, the bulk of the catch was composed of immature prawns.

(viii) Non-penaeid prawns

(a) Hippolysmata ensirostris

At Veraval this species was landed in small quantities. In the offshore catches, it occurred only in September. In the inshore catches, 29.8 tonnes were landed and most of it came in the last quarter of the year. A single mode which was seen at 46–50 mm in October and November shifted to 66–70 mm in December. In the offshore catches, a well defined mode occurred at 51–55.

At the two observation centres at Bombay, 33.5 tonnes of this species were landed. The catches were heavy in January at Versova, and in August and September at the Sassoon Dock. The size which predominated in the catches was 66-70 mm. In July, August and September, berried females were recorded.

(b) Palaemon *tenuipes*

This species has a commercial importance only at Bombay where 427.5 tonnes were landed in 1970 at the two observation centres. The species was predominant in the catches of the 'Dol' net from January to May. The smaller sized prawns enter the fishery in January-March and thereafter the size becomes gradually larger.

(ix) Prawns of the genus Macrobrachium

(a) Macrobrachium rosenbergii

As in the previous year, the fishery for this species in the Pampa River system was a total failure. Stray specimens including berried females were occasionally obtained from the backwaters near Cochin in the post monsoon months. A few attempts were made to rear the larval forms in the laboratory with little success.

(b) Macrobrachium idella

Laboratory experiments were conducted to study the breeding of the species and attempts were made to rear the larvae. The berried specimens readily spawned in the laboratory. The interval between spawning and hatching of eggs was found to be 19-20 days. After hatching the females spawned again within 5 days if a male was nearby. The hatched larvae were reared in the laboratory upto various stages. The experiments are still in progress.

(x) Prawns of the deep-sea

Three vessels namely 'Klaus Sunnana', 'Velameen' and 'Tuna' were engaged in deep-water explorations along the southwest and southeast coasts. The combined trawling operations of the three vessels extended from Mangalore to Cape Comorin along the southwest coast and from Cape Comorin to Mandapam along the southeast coast recorded a total catch of 10 tonnes of deep-sea prawns. The prawns obtained from 274 m depth were the smaller species *Metapenaeopsis andamanensis*, *M. varunae* and *Penaeopsis rectacuta*. Sometimes these were mixed with medium sizd pandalid prawns such as *Heterocarpus wood-masoni* and *Parapandalus spinipes*. The catches from the deeper grounds, between 256-421 m depth, especially off Alleppey and Quilon were contributed by *H. wood-masoni*, (51.8 %), *H. gibbosus* (24.0 %), *P. spinipes* (9.3 %), *Plesionika martia* (7.2%), *Aristeus semidentatus* (5.3%), *Aristaeomorpha wood-masoni* (1.2%) and *M. andamanensis* (1.2%). There were not much differences in the species composition of the catches from the east and west coasts, except that the species, *H. wood-masoni* was only recorded between Cochin and Trivandrum. The size distribution, sex ratio and percentage of ovigerous females of pandalids, were almost similar to those recorded during the previous year.

Personnel associated with the above mentioned projects

K. H. Mohamed, FS., S. Ramamoorthy, JFS., M. S. Muthu, AFS., Mydeen Kunju. AFS., K. Radhakrishna, AFS., P. Vedavyasa Rao., AFS., V. M. Deshmukh, AFS. and number of Senior Research Assistants, Research Assistants and other field staff.

3. Paddy field prawn culture

Vypeen Island in Kerala supports a very lucrative culture fishery for prawns. Prawns are cultivated in the paddy fields and impounded backwaters near Cochin. During the year, about 870 tonnes of juvenile prawns were landed from these sources. Fishing operations in the paddy fields are seasonal and are restricted to eight months, from October-May. However fishing lasts throughout the year in the perennial backwaters. At the observation centre in Edavanakad, the highest yield was observed in February and the lowest in September. *M. dobsoni* (71.1%), *P. indicus* (26.7%) and *M. monoceros* (2.2%) were the species contributing to the fishery. Average monthly size of *P. indicus* remained between 130 mm and 145 mm in all the months except in July when it became smaller. In *M. monoceros* the maximum size was 98 mm in April and the minimum size was 55 mm in August. The size of *M. dobsoni* showed a steady increase from 43 mm in April to 70 mm in December.

Personnel associated with the above mentioned project

K. Y. Telang, SRA., and K. V. George, RA.

4. Fishery and biology of spiny lobsters

A. Panulirus homarus

Lobster fishery investigations at Kanyakumari district were continued during the year. A total catch from 3 observation centres amounted to 80690 specimens of *Panulirus homarus*. The catch was generally poor in comparison to that of the previous year. The sizes predominant in the catches were 151–170 mm for males and 181–200 mm for females. Berried females were also obtained in all the months when the fishery was active.

In December, a few experiments on the spawning behaviour and larval development of the spiny lobster, *Panulirus homarus*, were conducted at Muttom and the following observations were made:

(a) Lobsters obtained from traps were generally in a better condition for rearing purposes than those obtained from the gill nets.

(b) The larvae on hatching were in naupliosoma stage which lasted for a short period. The presence of this controversial stage is thus confirmed. This stage is also obtained from the plankton of the area.

(c) Hatching generally takes place early morning. The larvae which are hatched are carried forward by the current generated by the movement of the pleopods of the females and they emerge from the region of the antennal peduncles. These larvae remain inactive and settle to the bottom of the tank. They show twitching moments and within a short time transform themselves into the first phyllosoma.

(d) When reared in filtered sea water and fed with freshly hatched *Artemia* nauplii, the larvae remained active and swam about for 7–8 days at temperature ranging from 22.0°C to 27.0°C. After this period, they became inactive and settled to the bottom where they lie on their backs.

(e) The maximum period for which the larvae were kept alive was 13 days and during this period no moulting took place.

(f) The larvae seemed more active and healthy when the temperature of water was maintained between 22.0°C and 25.0°C.

B. Puerulus sewelli

The deep sea spiny lobster, *Puerulus sewelli*, was fished by the exploratory vessels of the Indo-Norwegian project and the Central Institute of Fisheries Operatives. During the year, 61 tonnes of this species were landed in 353 hauls spending 448 hours of actual trawling along the continental shelf of the southwest and southeast coasts of India. Along the westcoast

they were fished from the well-known grounds off Cochin and Quilon at depths ranging from 183-295 m.

The most important development that took place during the year in respect of this new fishery was the discovery of 3 new potentially rich beds off Mandapam, off Tuticorin and off the west coast of Ceylon. Off Mandapam, the lobster grounds are characterised by muddy bottom and are located about 17 miles south, between Lat. 8°56′ & 8°59′N and Long. 79°12′ & 79°14′E at depths 235-260m. Off the west coast of Ceylon these are situated between Lat. 8°44′ & 8°45′N and Long. 79°33′E at almost the same depths. The bottom of these grounds are sandy with pieces of broken shells of gastropods and echinoderms. Off Tuticorin, the grounds are located at 180-230 m depth and have muddy bottoms.

The size of the lobsters caught ranged from 66 mm to 203 mm. There was little difference in the size range in different localities. The principal modes in females were observed between 151-155 mm and 171-175 mm and in males between 136-140 mm and 161-165 mm. On 23-4-1970, an exclusive catch of juvenile lobsters measuring between 68 mm and 96 mm was obtained from Lat. 8°46.5′N and Long. 78°44′E at a depth of 360 m.

In most of the months, females dominated the catches. In January and February almost 80 % of the females were berried and the berries were in advanced stages of development. This confirms the earlier observations that this lobster breeds intensively during these months. As the fishing season advanced, the percentage of berried females decreased gradually.

During one of the cruises of R. V. 'VARUNA' in January 1970, it was possible to get hatched phyllosoma larvae from the eggs of berried females. The larvae were reared in the laboratory for 10 days but no moulting took place during this period.

Personnel associated with the above mentioned project

K. H. Mohamed, FS., P. Vedavyasa Rao, AFS., and C. Suseelan, RA.

5. FISHERY AND BIOLOGY OF THE COMMERCIALLY IMPORTANT CRABS

A. **Scylla serrata**

The estimated catch of this species from two observation centres (Yetimoga and B. V. Palam) at Kakinada amounted to 18.4 tonnes. The gears used for capture of the species were the crab nets at Yetimoga and bait lines at B. V. Palam. The major portion of the catch came in the first half of the year. Generally large crabs (160-210 mm carapace width) were caught by the crab nets and smaller sizes (70-100 mm) in the bait lines.

At Cochin the species occurred throughout the year. The size range of the specimens examined from the Thevara market was 36 to 175 mm in

males and 56 to 141 mm in females. Berried females were found in December. Examination of the gut contents of the species showed that small crabs and prawns were the principal food of the species. There was no significant difference in the food of adults and juveniles.

B. Portunus pelagicus

The species was caught in considerable quantities at Yetimoga (Kakinada) in Crab nets. Estimated catch at this centre was 87 tonnes. Crabs of 120-170 mm carapace width dominated the catches. Berried females were observed in all the months indicating that the species spawned throughout the year.

At Cochin the species formed about 60% of the departmental try net catches taken from the estuaries. The smaller crabs enter the fishery in January when the modal size is 30 mm. Thereafter, regular growth takes place and the species continues to occur in the fishery until the beginning of monsoon. It reappears in December when the salinity of the backwater increases.

Personnel associated with the above mentioned project

G. Sudhakara Rao, SRA., and M. Kathirvel, RA.

MOLLUSCAN FISHERIES

1. Ecology of the Chank and Pearl Oyster Grounds

This scheme was started in 1969 in collaboration with the State Fisheries Department, Government of Tamil Nadu. It was approved for a period of 5 years and involves direct observations on the chank and pearl oyster grounds with the aid of aqua-lung.

The survey is aimed at obtaining a detailed picture of four selected areas between 8°35'N and 8°55'N, where chank and pearl oyster grounds occur. Table 33 gives the details of the areas surveyed.

Table XXXIII

	Inshore		*Offshore*	
	Rocky	Sandy	Rocky	Sandy
1. Vaipar area	1A	1a	1B	1b
2. Tuticorin area	2A	2a	2B	2b
3. Pinnakayal area	3A	3a	3B	3b
4. Tiruchendur area	4A	4a	4B	4b

During the year, 20 sea trips were made to study (a) the population of pearl oysters in the inshore rocky grounds off Vaipar and Tuticorin and offshore rocky grounds off Tuticorin, (b) to study the population of chanks

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in the inshore sandy grounds of Vaipar and the offshore grounds off Tuticorin, and (c) to conduct observations on the habitat of the oysters and chanks. During the year, observations were restricted to the first two areas from January to May. Non-availability of the launch, spells of rough weather and shortage of spares for the SCUBA equipment curtailed the programme during the second half of the year.

The sampling methods included underwater observations on animal life in an area of 25 sq. metres and the collection of animals from 1 sq. metre. For estimating the population of chanks a wider area was taken into consideration and the drift method of counting was adopted.

A. Quantitative assessment of the fauna and flora of the inshore area

Zone 1. Off Vaipar–Station 1A

The bottom was of laminated dead coral flats with innumerable ledges and crevices harbouring a variety of fish fauna. Sand of coarse grain 2–6 mm in thickness was found covering most of the rocky cores. Clarity of water in the area where depths were less than 13 metres, was poor. The fauna of the locality was very characteristic. It was either sedentary or attached firmly to the substratum. The sponge fauna was luxuriant and was dominated by the species *Siphonochalina communis.* The solitary coral *Heterocyathus* sp., occurred abundantly. Live corals such as the species of *Turbinaria, Coelaria, Goniastreaea* were found in the area which were very flat. The gorgonid, *Juncella juncea* was also abundant. The density of the coelenterates, *Lyptocarpus, Sertularia* and *Thuirea* were widespread.

The fish fauna was diverse and varied from small sized species to medium sized rocky perches. The species which were very abundant in this area belonged to the genera *Upeneus, Upeneoides, Balistis, Scolopsis, Enneacentrus, Lethrinus, Lutjanus, Holocentrus, Siganus, Pomacanthodes Chaetodon, Heniochus, Pterois, Gaterin* and *Epinephelus.*

Zone 2. Off Tuticorin–Station 2 A

The bottom of the inshore area in this zone was rocky. It was covered with sand. Coral debris and stones with pits and crevices were sporadically present. The sponge fauna was poor. The fish population was characterised mostly by *Balistis* spp., *Scolopsis* spp., *Lutjanus lineolatus* and *L. marginatus.* The dense growth of the seaweeds, *Sargassum* and *Padina* present at this station was unlike that of the Station 1 A.

B. Fauna and flora of the offshore rocky area

Zone 1. Off Vaipar–Station 1 B

The area could not be covered adequately as water clarity was poor on the days when underwater observations were made.

Zone 2. Off Tuticorin-Station 2 B

This area had a substratum of either large brown calcrete rocks or was covered with conglomeration of corals, *Poralithon* and dead shells. The thickness of sand over the flat rocky bottom was large. However, wherever the rocky cores were not covered with sand, a variety of fauna and flora was found. The predominant species of sponges, about 12 or more were also found to occur sporadically. The echinoderm population was well represented by *Pentaceros lincki, Linkia laevigata* and *Holothuria edulis.*

Pearl oyster population in zone 1 & 2

From the earlier surveys conducted in 1969, it was found that the pearl oyster settlement takes both in zone 1 and 2. The spats observed at that time ranged from 25 - 30 mm at stations 1A and 2A. At stations 1B and 2B spats of 15 - 20 mm were noticed. In 1970 further observations in zones 1 and 2 and Stations 1A and 1B and 2A and 2B showed that the oyster population was thriving although they were adversely affected by the enormous growth of *Modiolus* sp. over the oyster beds. The minimum size of the oyster was 35 mm and they had grown upto 55 mm at stations 1A and 2A. The growth of the size group, 25 - 30 mm noticed in November - December 1969 was upto 55 mm within six months. The oysters at stations 1B and 2B showed an increase in length from 35 mm to 45 mm.

The population however, in these areas was not dense. Each square metre of rocky bottom at 1A and 2A was found to contain about 53 live oysters in 1969. In 1970, the average number per square metre became 17. At stations 1B and 2B, the count were about 2 oysters per sq. metre.

If the existing population of oysters continue to survive, a good spat fall is expected during June - July 1971. Because of the sparse population of oysters no successful pearl fishery can be expected for the next two or three years.

Estimation of chank population

Only one trip was possible to each of the stations 1a, 2a and 2b. The total area at the three station was 1500 sq. m and the chanks present were counted within a span of 15 metres rope held end to end at the bottom and gradually drifting it to 100 metres from north to south. The stations 1a and 2b were richer than that of 2a. A total number of 70 chanks were counted at 2b and 41 chanks at station 1a, while hardly 7 were counted at station 2a.

Chanks with diameter 55 - 65 mm constituted 50% of the catches, chanks larger than 95 mm diameter were rare. At station 2b, size group, 75 - 85 mm were common. Evidently the commercial fishing in this area needs to be encouraged.

2. Biology of the Edible oyster, *Crassostrea madrasensis* (Preston)

Some aspects of the biology, reproduction, growth, percentage edibility and epifauna and epiflora of the oyster, *Crassostrea madrasensis* (Preston) of Athankarai estuary, near Mandapam Camp, were studied.

Reproduction

There are two periods of gametogenetic activity in the oysters during the year. These are from August to September and from March to April. A high percentage, very often 100% of the oysters taken at random were found to be mature at different time of the year excepting June, July and August when the gonads of the oysters were in a spent phase or no gametogenetic activity was seen. The presence of a large percentage of sexually mature oysters is apparently due to the fact that the estuary was connected with the sea throughout the year. Spawning took place in February – March and November – December. The water temperature in February and March over the oyster beds was 27.8°C and the salinity 17.99 – 19.06‰ Small percentage of hermaphrodite oysters was observed in February – April, June, September and November.

Growth

The growth of the oysters was studied by collecting data on the growth of oysters of several beds near the mouth of the estuary in successive months and analysing the data by size frequency method. The growth rate as derived from the average size at the end of July, August, September, October, November and December was 3.2, 2.5, 1.7, 2.8 and 3.5 mm in the respective months. The growth rate was poor from August to October and relatively fast in July, November and December.

Percentage edibility

The percentage edibility of oysters reached maximum thrice during the year, January, April and August – October when the meat of the oysters was heavy and in good condition due to the accumulation of reserve substances in the body. There is a fall in the condition of meat in March, June – July and December following spawning. The meat of oysters collected in successive months was dried at 100°C, the water and solid content determined and the meat was preserved after homogenizing, for the estimation of lipid, protein and carbohydrates contents.

Epifauna and epiflora of the edible oyster

The polychaete *Polydora* sp. is a serious pest of the oysters as it bores and burrows in groups in the shells of oysters damaging the shells very badly. These polychaetes were rare in July, October and December but common in June, August, September and November. A few specimens of *Marphysa* were also recored in September and December. The barnacle, *Balanus amphitrite communis* was rarely present from January to July but

was common from August - December. Amphipods were abundant in February and May, but common in March and rare or absent in other months. Isopods were common in January, moderately common from February - July and rare during the rest of the year. The presence of *Marphysa*, barnacles, amphipods and isopods does not appear to cause any noticeable harm to the oysters. Large numbers of the mussel, *Modiola undulata* live attached to the shells of the oysters throughout the year. They are harmful to the oysters as their spats settle on submerged structures in large numbers thus giving competition and reducing the oyster spat settlement. The red algae *Polysiphonia* was found to form a thick covering over the oysters in some months, while *Enteromorpha* sp. and Myxophyceae were not so common. The planktonic diatom *Coscinodiscus*, *Chaetoceros* and *Pleurosigma* were also recorded on the shells of the oysters.

3. Biology of *Turbo intercostalis* Menke

A total number of 192 specimens were collected from Mandapam Camp, (Gulf of Mannar) during the year. Gonad samples of 59 animals, with the shell length ranging from 16 mm to 50 mm, were taken for analysis. Specimens were marked and released for studying the growth and their movements. This species exhibits sexual dimorphism.

4. Biology of Cephalopods

During the year regular samples of *Sepia aculeata* and *Loligo indica* were obtained from the commercial catches of Palk Bay and at Rameswaram. *Loligo duvaucelii* was available only from April to June. *S. aculeata* formed a substantial portion of the catches. Specimens with a size range 22 mm - 159 mm (dorsal mantle length) were recorded. From June to December the size range was 19 - 155 mm with 85 - 90 mm size group dominating. The details of length weight relationship, thickness of the mantle and the shell, weight of the liver and shell and the size of the nidamental glands in *S. aculeata* were as follows:

Sex	Mantle length	Body wt. gms.	Cuttlebone wt. gms.	Liver gms.	Nidamental glands. mm.
Male	50-97	17.8- 91.9	0.9- 2.7	0.7-2.5	—
Male	48-87	18.5- 77.0	1.8- 5.3	0.6-2.5	—
Female	51-156	21.6-509.1	1.3- 1.9	0.6-3.0	10-44
Female	60-122	28.4-212.1	2.5-12.0	0.8-7.7	3.3-8.0

S. aculeata usually feed on small fishes, crustaceans and polychaetes. Under captivity they preferred to eat live fishes and prawns. Life history studies on *Sepiella inermis* have also been undertaken and the live and narcotized eggs and embryos have been figured. Observations on the preserved larvae of *Octopus dollfusi* were also made. The following species

of cephalopods have been identified from the commercial catches of Palk Bay and Gulf of Mannar. *Sepia aculeata, S. pharoanis, S. thrustoni, S. brevimans, S. trygonina, S. winckworthi, Sepiella inermis* and *S. ornata* among cuttlefish; *Loligo duvaucelii, Loliolus investigatoris, Euprymna stenodactyla, Doryteuthis pickfordi, Abralia andamanica* among squids; *Octopus dollfusi, O. globossus, Cistopus indicus, Beryya kerelensis* among octopi.

Personnel associated with the above projects

K. Nagappan Nayar, JFS., S. Mahadevan, AFS., K. Satyanarayana Rao, AFS., E. G. Silas, SFS., K. S. Sundaram, R. A., R. Sarvesan, R. A.

Researches contemplated

During 1971, detailed investigations on the fishery and biology of commercially important species of fishes, crustaceans and molluscs will be continued. New projects undertaken during the year include (1) fishery of elasmobranchs, (2) ecology of green and brown mussels, (3) fishes of Andaman Islands, (4) reproductive physiology of some important species and (5) marine and estuarine fish farming.

MARINE BIOLOGY AND OCEANOGRAPHY

Summary of salient findings

A steady progress was maintained during the year in all the 30 Research Projects undertaken by this Division. Under the project, 'Studies on phytoplankton productivity', the total net Organic production for the Indian ocean as a whole was computed. The contribution of the shelf waters of the west coast of India was estimated in terms of carbon as 46×10^6 tonnes. The estimates of primary productivity and the yield from fisheries in selected regions of the Indian ocean showed that at the present rate of exploitation the potential yield of fish would be 11–12 million tonnes and in the shelf waters of India it is estimated as 2–3 million tonnes.

As the phytoplankton show considerable variations in the different marine environment, detailed studies on the systematics and quantitative abundance of various phytoplankters were made on the samples collected from inshore, offshore and brackish waters. The benthic microflora were also studied.

For a proper understanding of the fluctuations of the major commercial fisheries, the characteristics and seasonal abundance of zooplankton were studied from different centres like Bombay, Mangalore, Calicut, Madras and Port Blair.

From the zooplankton collections, the larvae of the Indian mackerel have been identified from several stations in the area 8°50'N to 10°40'N and 75°45'E to 76°16'E and in some regions, the abundance of these larvae were

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as great as 427 to 730 per 1000 m^3. (IOS, vertical tow). Larvae of such important species that of sardines, tunas and frigate mackerels were also identified.

Detailed studies on the systematics and ecology of important zooplankton groups like, copepods, euphausiids, chaetognaths, siphonophores and pelagic tunicates were carried out with special reference to the distribution of some important genera and species.

Studies on the economically important sea weed resources have been accelerated considerably. Growth and reproduction of several algae were studied at Mandapam. The ecology of sponges and holothurians were also carried out at Mandapam.

At Cochin detailed studies were undertaken on the spawning, maturity and the related aspects of some important pelagic and bathy-pelagic fishes such as tunas, deepwater trichiuroid fishes, bramble shark, etc.

Hydrographic data collected during the previous years were subjected to detailed analysis and many interesting features were noted in the Laccadives and Maldives region and along the west coast of India. The circulation pattern in the northern Indian Ocean was also studied in detail. In addition to these, some basic hydrographic and meteorological data were collected at Bombay, Karwar, Mangalore, Calicut, Cochin, Madras, Waltair and Port Blair for a better understanding of the meteorological factors which influence the fisheries.

Researches in hand

1. STUDIES ON PHYTOPLANKTON PRODUCTIVITY

A. Primary Productivity along the west coast of India

During the first quarter of 1970 primary production rates were estimated using ^{14}C technique at 10 stations between latitudes 8°48'N and 10°11'N and 72°E and 76°E longitudes. The values ranged from 0.1 to 0.3 gC/m^2 day. These values were lower than those observed during the south west monsoon period (average 2.0 gC/m^2/day) in earlier cruises.

The total net production for the Indian Ocean (20°E to 120°E and north of 40°S) comprising about 51 million square kilometres was computed as 3.9×10^9 tonnes of carbon. This value was obtained from the data collected so far by this Institute and those available from the IIOE Reports. Of this, the total shelf areas of the Indian Ocean (ca. 3.1 million square kilometres) alone accounts for 560×10^6 tonnes of carbon or approximately 14% of the total. The contribution of the shelf waters of the west coast of India is of the order of 46×10^6 tonnes of carbon. The rate of production is higher within the 50 metre depth contour and decreases further offshore. The estimates of primary productivity, region-wise for the Indian Ocean when compared with the available data on exploratory fishing showed that

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the potential yield at the present level of exploitation of the Indian Ocean is 10–11 million tonnes. A report on the productivity of the Indian Seas with special reference to the fishery resources is under preparation.

B. Standing crop of phytoplankton by pigment analysis

Chlorophyll *a*, *b*, *c* and carotenoids of *Tetraselmis gracilis* were estimated using a spectrophotometer. Culture of the species having a concentration of 10,000 cells per cc gave a value of 0.78/μg/m3 chlorophyll *a*. 0.29μg/m^3 chlorophyll *b*. 0.17 μg/m^3 chlorophll *c* and 0.03/μg/m^3 carotenoids per litre.

A review of the work on the distribution of chlorophyll '*a*' in the Indian Ocean was completed. Distribution charts of this pigment for the entire Indian Ocean and vertical profiles for certain stations in the Arabian Sea have been prepared. Average value of chlorophyll *a* in the Indian Ocean was found to be 14.81 mg/m^2. On the west coast of India it was 25.41 mg/m^2 and 8.24 mg/m^2 on the east coast. The highest value of 47.17 mg/m^2 was obtained for the area between 20°N and 25°N and longitudes 60°E and 65°E. The lowest value of chlorophyll *a*. namely 2.20 mg/m^2 was found between latitudes 25°S and 30°S and longitudes 75°E and 80°E.

C. Culturing phytoplankton organisms

Tetraselmis gracilis, *Chlorella* and species of *Dicrateria* and *Sceletonema costatum* and *Pleurosigma* were grown in culture media having different salinities to study the influence of the latter on the organisms. *Tetraselmis gracilis* when grown in low salinity medium had a prolonged non-motile stage. A few more phytoplankton organisms are being cultured for the study of isolated environmental factors on their growth.

D. Photosynthesis and respiration in some phytoplankton cultures

A comparison of productivity values by concurrent oxygen and ^{14}C experiments was made using cultures of *Tetraselmis gracilis* (5 experiments) and *Chlorella* (1 experiment). Values obtained by ^{14}C method were found to be lower by 20 - 60% than those obtained by the oxygen method. The importance of extra-cellular products and some such factors such as the influence of copper irons and the effect of different values of photosynthetic quotients, which could bring out disparity in the rates of primary production are under investigation.

Personnel associated with the projects

P. V. Ramachandran Nair, JFS., and K. J. Joseph, RA.

E. Characteristics of phytoplankton in offshore and oceanic waters

Studies on the qualitative and quantitative aspects of phytoplankton in the offshore and oceanic waters of the west coast of India and the

Laccadive Sea in the region of 7°-10°N and 74°-77°E. have been continued. The samples for the study were obtained during the cruises of *R. V. Varuna* (Cr. No. V52-V61) using half metre nets of No. 21 bolting nylon during the period May to September 1964.

Diatoms were found to be more abundant in the samples than the dinoflagellates. Among the dinoflagellates, *Ceratium, Peridinium, Dinophysis* and *Ornithocercus* were the most dominant organisms. Eighty species of planktonic diatoms were identified, of which 9 species have been recorded for the first time from our waters. They are *Asterolampra marylandica* Ehrenberg, *A. marylandica* var. *major* Peragallo, *Asteromhalus arachne* Ralfs, *A. heptactis* Ralfs, *Actinocyclus ralfsii* Smith, *Coscinodiscus reniformis* Rattray, *Hemidiscus cuneiformis* Wallich, *H. cuneiformis* var. *ventricosa* Hustedt, *Clossleriella radiata* Shutt. A bloom of the diatom *Streptotheca indica* Karsten was observed in July. Besides, auxospore formation in *Biddulphia mobiliensis* and *Ditylum brightwellii* were seen in the samples during May and July.

The displacement volumes of the samples of the cruise V37 to V51 were taken. These cruises were undertaken along the west coast of India between 7°-16°N and 70°-77°E from September 1963 to April 1964. The total number of samples for the study were as follows:

Qualitative studies of Phytoplankton

Cr. No.	*No. of sampls*	*Area covered*	*Month*
V52	21	07°-10°N 75°-77°E	May 1964
V53	19	08°-11°N 75°-77°E	,,
V57	18	08°-12°N 74°-77°E	July
V58	21	08°-12°N 74°-76°E	,,
V59	37	07°-10°N 75°-77°E	August
V60	10	09°-10°N 75°-76°E	,,
V61	55	07°-10°N 74°-77°E	September

F. Phytoplankton of the inshore waters

At Calicut seasonal changes in the displacement volume, dry weight and other properties of phytoplankton at the surface were as follows:

Month	*Displ. volume (ml)*	*Dry weight (gm)*	*Total cell counts x 1000*
January	13.0	1.55	1087
February	11.5	2.405	1352
March	8.2	1.95	603
April	49.0	2.08	1057
May	25.0	1.25	1949
September	7.3	0.51	190
October	7.15	1.495	99
November	29.0	2.535	599
December	12.8	1.535	378

Samples could not be obtained during June, July, August and part of September, due to inclement weather.

G. Phytoplankton of brackish waters

During the year, 58 plankton samples were collected from the surface waters at two fixed stations near the Cochin Harbour. The area had an abundance of diatoms during the period July–September. During October–December, dinoflagellates, especially *Peridinium*, were predominant. Species of some rare organisms such as *Campylodiscus*, *Surirella* and *Amphiprora* were also observed in the backwater samples.

Personnel associated with the project

R. Subrahmanyan, FS., V. S. Krishnamurty Chennubhotla, AFS., and C. P. Gopinathan, RA.

2. Studies on zooplankton

All along the west and east coasts of India, an intensive fishing activity is carried out within the inshore region, upto a depth of 10 fathoms.

The largest share of the annual marine fish landings of the country comes from this region. Therefore, the studies on the inshore zooplankton have become indispensable for a proper understanding of the fluctuations in the fisheries at different places. The investigations carried out at some of the important centres are as follows:-

Bombay

The data on zooplankton collected from the inshore fishing areas, off Bombay, over a period of three years (January 1966 to May 1968) were processed. The results showed that the zooplankton biomass had two peaks - one in March-April and the other in October-November. A detailed study of the copepods showed that the relative abundance of this group coincided with the peaks in biomass. Of the total number of about 50 species of copepods identified, 27 were of common occurrence. Of these, *Eucalanus crassus*, *Acrocalanus gibber*, *A. gracilis*, *Temora turbinata*, *Acartia spinicauda*, *Oithona plumifera* and *Corycaeus catus* were predominant and were present throughout the year. Some species such as *Euchaeta marina* and *Centropages tenuiremis* showed their occurrence in some seasons. The copepods were very abundant when the temperature and salinity in the surface waters were high.

During this year, plankton and hydrographic data were collected at two stations, viz., the light ship and Versova creak, from October to December. The surface temperature declined from 29.2°C in October to 23.2°C in December. Plankton displacement volumes were minimum for these stations during November. The relevant data are given below:

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	October	*November*	*December*
Surface temperature °C	29.2	27.1	23.2
Dissolved oxygen ml/l	3.05	3.12	3.02
Displacement volume of plankton for 15 minutes horizontal surface haul (ml)	3.1	1.0	4.0

Copepods were the most important constituent in the plankton. Other components were chaetognaths, decapod larvae, siphonophores and coelenterates. Fish eggs and larvae were most common in November.

Mangalore

Routine samples could not be obtained from July to September due to inclement weather. Information available for the last quarter of the year, as given below, showed that plankton displacement volumes were highest at the two stations during November.

	Displacement volume in ml		
	October	November	December
4 fathom zone	20.5	23.0	11.7
8 fathom zone	30.5	50.3	23.0

Copepods were predominant and the common species were those of the genera *Acartia*, *Paracalanus* and *Temora*. The cladocerans ranked second in abundance.

Calicut

The zooplankton displacement volumes were poor during the first half of the year with an average of only 12.4 ml for the period. From June to September, plankton collections could not be made due to inclement weather. From October to December, the displacement volumes were high with a peak in November. The relevant quantitative data are presented in the accompanying table 34.

TABLE XXXIV. *Calicut: Zooplankton biomass from surface hauls*

Month	Displacement Volume (ml)	Dry weight (mg)	Total Numerical counts x 100
January	25.1	3325	203
February	7.8	1678	34
March	6.0	1238	145
April	13.4	2730	193
May	9.5	1800	103
October	25.3	2660	231
November	52.2	9680	1440
December	29.8	3120	344

Throughout the period of observations, copepods were predominant in the samples. It was observed during the previous years that in the order of abundance, the cladocerans usually ranked second, but during the first half of 1970 their numbers were considerably low. However, during October-December they started occurring in large numbers, with *Penilia avirostris* predominating. In December, *Evadne tergistina* were more abundant than *P. avirostris*. Swarming of pelagic tunicates and radiolarians were observed during October. Other important constituents of the zooplankton were appendicularians, fish eggs and larvae, decapod larvae, larvae of polychaetes, molluscan veligers, pteropods, medusae and siphonophores.

Among the copepods, *Temora turbinata*, as usual, was numerically most abundant. Other members which occurred in good numbers were the species of *Centropages* (mainly *C. tenuiremis*), *Acrocalanus*, *Eucalanus*, *Canthocalanus*, *Labidocera*, *Undinula*, *Pseudodiaptomus*, *Oithona*, *Microsetella* and *Euterpina*.

Madras

Monthly mean displacement volumes showed two peaks, one in May and the second in August. Different types of plankton nets and two different types of hauls were employed for sampling. Low values were observed during February and December. Mean monthly values of the plankton displacement volumes using oblique hauls of organdie net are given below:

Displacement	Jan	Feb	Mar	Apr	May	June
volume (ml)	6.69	4.86	6.16	14.32	18.22	13.5
,,	July	Aug	Sept	Oct	Nov	Dec
	8.4	22.3	7.9	11.4	13.7	7.1

The salient features of the zooplankton were as follows: In February, swarming of pelagic tunicates viz., *Thalia democratica* and *Doliolum* spp., and a bloom of phytoplankton were observed. Swarms of *Pleurobrachia* were noticed in May and June; *Lucifer* spp., and copepods were found in abundance in April and May.

During the second half of the year, phytoplankton organisms were markedly abundant during October-December. Among the zooplankters, chaetognaths, *Evadne*, *Acartia*, pelagic tunicates and siphonophores were predominant.

Port Blair

Observations reported for the period July-December indicated that the mean displacement volumes had a peak in August with low values during July and September.

Copepods were abundant during August and occasionally in September-November. The important planktonic copepods were species of *Pontella, Oithona, Pseudodiaptomus, Sapphirina, Corycaeus, Labidocera, Anamalocera*, and *Heterorhabdus*.

Phytoplankton consisted largely of *Melosira, Coscinodiscus, Rhizosolenia, Thalassiosira, Biddulphia, Bacteriastrum* and *Pyrocystis* from July to September.

Monthly mean displacement volume of plankton

Month	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Displacement volume (ml)	21	52	21	31	27	31

Personnel associated with the projects

K. N. Krishnakartha, AFS., K. Rangarajan, AFS., N. S. Radhakrishnan, AFS., V. Kunjukrishna Pillai, SRA., K. G. Girijavallabhan, SRA., and others.

3. INVESTIGATIONS ON SPECIFIC PROBLEMS RELATED TO ZOOPLANKTON

A. Zooplankton biomass from the west coast of India and Laccadive sea

Plankton distribution atlases are being prepared from the data relating to 1674 plankton samples collected using the Indian Ocean Standard Net (IOSN) during the cruises of *R. V. Varuna* from May 1963 to April 1969.

Personnel associated with the project

E. G. Silas, SFS.

B. Fish eggs and larvae from the south west coast of India and the Laccadive Sea

The major objectives of the investigations on fish eggs and larvae from the collections of *R. V. Varuna* are :

i. To estimate the total abundance of fish eggs and larvae in time and space and also in relation to the hydrological conditions and the biomass of zooplankton in the area.

ii. To identify the fish eggs and larvae for the purpose of life-history studies.

iii. To investigate the abundance of fish eggs and larvae of important species in space and time for recruitment studies.

During the year the findings on the above three aspects were as follows :

Copepods were abundant during August and occasionally in September-November. The important planktonic copepods were species of *Pontella*, *Oithona*, *Pseudodiaptomus*, *Sapphirina*, *Corycaeus*, *Labidocera*, *Anamalocera*, and *Heterorhabdus*.

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i. To estimate the total abundance of fish eggs and larvae in time and space and also in relation to the hydrological conditions and the biomass of zooplankton in the area.

ii. To identify the fish eggs and larvae for the purpose of life-history studies.

iii. To investigate the abundance of fish eggs and larvae of important species in space and time for recruitment studies.

During the year the findings on the above three aspects were as follows:

(a) Occurrence of larvae of Indian mackerel, *Rastrelliger kanagurta* in the plankton.

Larvae of the Indian mackerel have been identified from several stations in the area 8°50'N to 10°40'N and 75°45'E to 76°16'E, chiefly between depth contours 50 m and 90 m. In some areas, especially around 09°30'N and 76°10'E, night collections have shown a large abundance of mackerel larvae in the month of May with counts up to 730/1000 m^3 (Indian Ocean standard net vertical tows). In order to obtain confirmatory evidence of the spawning periods and the spawning areas of the Indian mackerel and other pelagic species, a survey of fish eggs and larvae was conducted in January 1970, but this had to be abandoned in March 1970 after 6 short cruises as the research vessel *Varuna* could not be made available. The subsorting of the mackerel larvae from the cruises conducted between 1964 and 1969 has been completed and the data are being processed for the presentation of a synoptic picture of their occurrence and the areas of their abundance, and for the study of their life-history stages.

(b) Occurrences of larvae of *Sardinella* in the plankton.

Larvae which appears to be that of the Indian oil sardine, *Sardinella longiceps* have been identified from the plankton collections made during June-July, from the area 09°30'N to 10°00'N and 75°59'E to 76°08'E, between the depth contours 20 m and 60 m. Heavy concentrations of this type of larvae occurred in day hauls, estimated at about 1218 larvae/1000m^3 (IOSN vertical tows). Correct identification of the larvae of different species of *Sardinella* will help in the studies on recruitment.

(c) Larvae of tunas.

Larvae of the following species of tunas have been identified from the plankton collections of *R. V. Varuna*. Skipjack, *Katsuwonus pelamis* from several stations in the Laccadive Sea and off the continental shelf, Frigate mackerels, *Auxis thazard* and *A. rochei*. Two types of larvae of *Auxis* seem to be present in the collections and in view of some confusions existing in the identification of the larvae of these two species, attempts are being made to clarify the point so as to enable a precise estimation of the species-wise abundance of the young fish. Larvae of coastal species of tunas such as *Euthynnus affinis* and *Sarda orientalis* have also been identified. Tuna were found to spawn largely from November to May.

(d) Other species.

Eggs and larvae of other species of fishes are also being subsorted and identified for working out the life-history; for locating the spawning grounds and for deducting the spawning seasons of commercially important species. It is also important to know the eggs and larvae of the species which form the food of tunas.

Personnel associated with the project

E. G. Silas, SFS and others.

A detailed study has been completed on the life-history and seasonat abundance of the epi-and mesopelagic gonostomatid fish *Vinciguerria nimbaria* (Jordan and Williams). This species is important as it is abundant in the Arabian Sea and forms an important source of food for tunas. Il also froms an important constituent of the upper deep scattering layer.

Personnel aesociated with the project

E. G. Silas, SFS., and K. C. George, AFS.

C. **Studies on the biology of Euphausiacea**

The euphausiids form an important source of food for pelagic fishes such as tunas. During the year, work has been in progress on the following aspects:

(a) Larval development.

Post-naupliar developmental stages of the two species of euphausiids, *Euphausia diomedeae* Ortmann and *E. distinguenda* Hansen, which are the most abundant species in the tropical Indian Ocean have been worked out completely from the material collected off the south west coast of India and the Laccadive Sea. Three calyptopis stages and six furcilia stages were identified in each of the two species. Some of the developmental stages of other species of euphausiids as shown in the table below have also been identified. (Table 35)

TABLE XXXV. *Occurrence of euphausiids in the standard collections from the continental shelf waters between Cochin and Karwar*

Species	No. of stations at which the species occurred	Larval stages						
		Calyptopis I	II	III	Furcilia (stages)	Juv.	M	F
Thysanopoda monacantha	5				4	x		
T. tricuspidata	7	x		x	9			
Euphausia diomedeae	13	x		x	6	x		
E. tenera	6				5	x	x	
E. distinguenda	22		x	x	5	x	x	
Pseudeuphausia latifrons	52	x	x	x	12	x	x	x
Nematoscelis gracilis	25		x	x	5	x	x	x
Stylocheiron carinatum	37		x	x	8	x	x	x
S. affine	17		x	x	8	x	x	x
S. suhmii	3				5	x	x	
S. microphthalma	3					x		x
S. abbreviatum	1							x

Juv=Juvenile; M=Males; F=Females

During the year, 103 plankton samples collected from the shelf waters, between Cochin and Karwar, have been examined for euphausiids. Of these, only 67 samples contained this group. It was observed that as a rule, euphausiids were absent in samples taken at depths less than 20 metres. Moreover, their occurrence was more in the samples collected at night than during the day.

Personnel associated with the project

K. J. Mathew, RA.

D. Ecology of Chaetognatha

Chaetognaths form an important constituent of zooplankton and as the identification of different species is an essential prerequisite for any ecological investigation, a guide for the identification of the different species from the Indian Ocean has been prepared. This includes an illustrated key for the identification of 33 species of chaetognaths from the Indian Ocean belonging to 5 genera namely, 1) *Sagitta* Quoy and Gaimard (1827), 2) *Pterosagiita* Costa (1869), 3) *Krohnitta* Ritter-Zahony (1910), 4) *Eukrohnia* Ritter-Zahony (1909) and 5) *Spadella* Langerhans (1880).

For species identification, attention has been drawn to the dependable characters and to different maturity stages. Of special interest is the record of 2 species of *Sagitta*, namely *S. macrocephala* Fowler (1905) and *S. maxima* (Conant, 1896) from 09°57'N 75°27'E, off Cochin. *S. maxima* was earlier known from only south of 30°S. There is only one earlier record of *S. macrocephala* from the Indian ocean (Chagos Archipelago).

Quantitative abundance of chaetognaths was studied during the year from 100 samples and the following species were recorded: *Sagitta bedoti*, *S. species*, *S. ferox*, *S. hexaptera*, *S. hispida*, *S. inflata*, *S. pacifica*, *S. pulchra*, *S. regularis*, *S. robusta*, *Pterosagitta draco*, *Krohnitta pacifica* and *K. subtilis*. The study also showed that most of the meso and bathyplanktonic species (*S. decipiens*, *S. lyra*, *S. macrocephala*, *S. maxima*, *E. fowleri*, *E. minuta*) were absent in the collections. The species such as *S. inflata*, *S. bedoti* and *S. ferox* were abundant and occurred throughout the year.

Personnel associated with the project

M. Srinivasan, RA.

E. Taxonomy and Ecology of Siphonophora

During the year, 37 species of siphonophores occurring commonly in the plankton were identified from the collections.

Further investigations on the distribution, biology and ecology of this group are in progress.

Personnel associated with the project

K. Rengarajan, RA.

F. Studies on the ecology of pelagic copepods

(a) Calanoida

During the year, weekly collections of plankton were made along with hydrographic data. In all, 74 plankton samples were collected from the inshore and brackish waters of Cochin. Copepod material from the samples was sorted and studied.

Studies on the Candaciid copepods of the *VARUNA* collections were continued. Candaciids sorted out from 227 *VARUNA* stations were identified. Descriptions and illustrations of the copepodid stages of *Labidocera pectinata* Thompson and Scott were completed. It was found that the segmentation and setation of the maxillipeds were particularly useful for distinguishing the different stages. An account dealing with the developmental stages and phenotypic variations of *Labidocera pectinata* has been prepared.

A revision of the family Pseudodiaptomidae has been carried out and the descriptions and illustrations of 13 species of *Pseudodiaptomus* have been completed. A new record of *P. marinus* Sato and also of the hitherto unknown male of *P. burckhardti* Sewell collected from Andaman Sea have been made.

A revision of the family Tortanidae (Calanoid copepoda) has been undertaken during the year.

Personnel associated with the project

P. Parameswaran Pillai, RA.

(b) Cyclopoida

Based on 142 plankton samples collected during the cruises of R. V. *Varuna* along the west coast of India and the Laccadive Sea, taxonomic studies were carried out and the materials belong to 8 genera were sorted out.

A detailed taxonomic study of the species belonging to the genus *Sapphirina* which is in progress has enabled the identification of 18 species. The identification of other genera of cyclopoid copepods is also in progress.

Personnel associated with the project

P. K. Martin Thompson, RS.

G. Ostracods of the Indian Seas

Based on 99 plankton samples collected during the cruises of R. V. *Varuna* 25 species of ostracods belonging to 5 genera have been identified. Of these *Conchoecia concentrica* Muller and *C. porrecta* Claus are new records from the Indian Seas.

Personnel associated with the project

C. M. James, RS.

H. Ecology of planktonic gastropods

Studies on pteropods and heteropods of the *VARUNA* collections were continued. The examination of the sorted samples showed the presence of over 15 species of thecosomatous and one gymnosomatous pteropod, besides 5 species of heteropods.

An examination of the collections from some more stations is in progress and the pattern of their distribution in relation to the hydrographic conditions is under study.

Personnel associated with the project

C. Mukundan, AFS.

I. Pelagic Tunicata of the Indian Seas

The salps, doliolids and pyrosomes occurring in the plankton of the west coast of India and the Laccadive Seas have been studied in detail during the year. Nearly 325 plankton samples obtained during the cruises of *R. V. Varuna* from 70°E to 78°E to 14°N of the quarter were studied. 19 species of salps, 13 species of doliolids and 3 species of pyrosomida have been identified and their quantitative abundance in the plankton is being studied.

The different developmental and growth stages of zooid clumps and solitary zooids for many species of salps; the tailed larva, oozooid, trophozoid and phorozooid of *D. denticulatum* and *D. gegenbauri* and ascidiozooids of Pyrosomida have also been identified.

Personnel associated with the project

P. Dhandapani, SRA.

J. Plankton Collections

Plankton collections kept in store were properly maintained and wherever necessary relabelling of the samples was done. The accession register was kept up to date. During the year, 7 short cruises were undertaken by *R. V. Varuna* the details of which are given below:

Cr. No.	*No. of zooplankton samples*	*No. of phytoplankton samples*
V135	21	4
V136	4	4
V137	10	10
V138	19	-
V139	4	-
V140	15	15
V141	1	-
Total	55	33

General sorting was completed for 24 samples. Fish eggs and larvae were sorted out from 229 samples and Cephalopods from 189 samples. The sorted materials were sent to research scholars and interested ataff working in different sub-stations:

1. 43025 specimens of decapod larvae from 259 samples were sorted out and sent to Shri K. H. Mohamed, Crustacean Fishery Section, CMFRI, Sub-station, Cochin.

2. 182 specimens of Leptocephali were sorted and sent to Dr. R.V. Nair, CMFRI, Mandapam Camp.

3. 2658 specimens of Mysidaceae from 170 stations were sorted and sent to Shri R. Soundararajan, Research Scholar, CMFRI, Mandapam Camp.

4. 18505 specimens of medusae from 252 stations were sorted and sent to Shri Thampi Cherian, Research Scholar, CMFRI, Mandapam Camp.

5. Fish larvae from 358 stations collected during 1963 were sent to Vizhinjam Sub-station, for the study of Dr. S. Jones, Emeritus Scientist, ICAR.

6. Heteropoda from 209 stations, pteropoda from 255 stations and gastropoda from 190 stations were sorted out and sent to Shri C. Mukundan, Assistant Fishery Scientist, CMFRI, Mandapam Camp.

A. Miscellaneous Studies

A. Ecology of epiphytic and benthic diatoms

Studies on the taxonomy and ecology of the epiphytic and benthic diatoms were continued during the year. Samples were obtained from the east coast of India in 1969, mainly from the Palk Bay and Mandapam-Rameswaram area. In addition to 36 species of diatoms identified already, 9 more species, associated with the algae, *Cladophora* and *Gracilaria* were also identified. These were: *Climacosphenia moniligera* Ehrenberg, *Climacosphenia elongata* Baily, *Licmophora abbreviata* Agardh, *Cocconsis littoralis* Subrahmanyan, *Gramatophora marina* Kutz., *G. oceanica* Grun., *Rhabdanema mirificum* Smith, and *Synedra undulata* Bailey.

Personnel associated with the project

C. P. Gopinathan, RA.

B. Ecology of Polychaetes

During the year, studies on the taxonomy, biology and distribution of polychaetes were in progress. New records of *Sabellaria alveolata* (L.), *S. floridensis* Hartman, *S. rupicaproides* Augener and *Phragmatopoma* sp.

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from the Indian region was made. The euryhaline habit of *S. cementarium* Moore, was established by its collection from the backwaters of Cochin and Mangalore. The bathymetric distribution and the habits of various genera of the family Sabellaridae were also noted.

The role of Sabellariids in the benthic animal communities was studied by selecting two groups of organisms as basis units viz. *Sabellaria floridensis* Hartman and *Hyatella cribriformis* (Hyatt), *S. pectinata* Fauvel and *Montipora informis* Bernard as associates and also on growth pattern of *Porites solida* (Forskal) in response to external stimuli, under laboratory conditions. The study showed a synchronisation in the growth of diffcrent sedentary invertebrates in a particular environment. It was also seen that the presence of sabellariids which are capable of utilizing inorganic material for building their tubes, stabilize the substratum of sand, mud and silt and thus influence the settlement of other benthic animals.

The polychaetes, *Gattyana deludena* Fauvel was found to be a regular commensal on the hermit crabs namely *Diogenes diogenes*, and *D. custos*.

Investigations on polychaetes, which bore the molluscan shells, corals and calcareous substrata, were made. The majority of boring polychaetes belong to the family Eunicidae, Spionidae, Chloraemidae and Sabellidae. Among the spionids, *Polydora* forms the dominant species which bores inside the shells of the oyster, *Crassostrea* and the chank *Xancus* and other gastropods. *Sabello porifera* Grube was observed to destroy massive corals by boring deep into them.

A noteworthy observation was that in all such cases where the boring action of *Polydora* was dominant in the molluscan shells, the boring sponges were almost absent and vice versa.

Personnel associated with the project

G. P. Kumaraswamy Achari, SRA.

C. Seaweeds of the Palk Bay and the Gulf of Mannar

Studies were continued on the growth and reproductive behaviour of different algae at 4 stations around Mandapam. Although the seasonal rhythm observed in the growth of different algae were similar, certain variations in the maximum growth and regeneration periods were seen during the year. Monthly variations in the growth of *Sargassum wightii*, *Turbinaria conoides*, *T. cronota*, *Ulva lactuca*, *Gracilaria corticata*, *G. lichenoides*, *G. follifera* and *Gelidiella acerosa* recorded during the year were similar to those observed during the previous year. However, some year to year variations were noticed in *Enteromorpha compressa*, *Chaetomorpha antennina* and *Gracilaria verucosa*.

Data on the fruiting periods or on the relative abundance of vegetative sexual or asexual plants were collected on some agar-agar and

algin yielding seaweeds, like *Sargassum wightii, Turbinaria conoides, T. ornata, Gracilaria corticata, G. foliifera,* and *G. lichenoides.* In general two types of fruiting behaviour were observed in the brown and red algae. In *S. wightii, T. conoides, and G. verucosa* fruiting period was confined to certain months of the year, whereas in *G. corticata, G. lichenoides, G. folifera* and *T. ornata* reproductive processes occurred throughout the year.

D. Studies on Agar and Algin yielding seaweeds

During the year, sample surveys were conducted in some selected areas near Mandapam, Pudumadam and Rameswaram. The mean density of *Gracilaria corticata, G. crassa* and *Sargassum wightii* occurring in the near shore areas was estimated by taking quadrat samples during the period of their maximum growth. During the first half-year, about 646 sq. m covered with *G. corticata* at Pudumadam and 14148 sq.m covered with *Gracilaria crassa* at Rameswaram and Mandapam (Palk Bay side) were surveyed.

To study the effects of harvesting on the density of crop, experiments were conducted with *G. corticata* from June 1970 onwards. The alga growing in $0.5m^2$ area was harvested at two month intervals and their dry weights were determined. These are given in the following table:

Month	June	August	October	December
Fresh weight (gm)	1225	1705	1585	910
Dry weight (gm)	153	229	207	—

Initial weight of the crop in the area was 1225 gm and within two months fully grown plants were seen in the harvested area. The density of the crop increased during the subsequent two harvests and only in the month of December low biomass was obtained.

Personnel associated with the project

M. Umamaheswara Rao, AFS.

E. Foraminifera of Mandapam Area

To study the taxonomy, abundance and distribution of foraminifers, which form an important item of food of fishes, prawns and holothurians, the gut contents of *Penaeus semisulcatus* were examined regularly from January to June and nine more species of Foraminifera were identified of which *Globigerina bulloides, Bolivina variabilis* and *Quinqueloculina oblonga* occurred in large numbers.

Personnel associated with the project

K. M. S. Ameer Hamsa, RA.

F. Ecology of sponges

Ecological studies on the sponge, *Spongia officinalis* Linnaeus showed that the larvae of this species are usually released from January to March in

the Rameswaram area. Studies on the boring sponges were also continued during the year. About hundred shells of different species of molluscs infested with sponges were examined. These were collected from the Palk Bay, Gulf of Mannar and also from the Chank Industries, Kilakarai. It was observed that the boring sponges mainly attack the sacred chank, *Xancus pyrum* among the molluscan fauna. The infestation by *Cliona celata* Grant and *C. vastifica* Hancock were more widespread in pearl and chank beds than those by *C. carpenteri* Hancock and *C. orientalis* / Thiele, which infest other shells belonging to the genera such as *Murex, Turbo, Trochus, Hemifusus* and *Lambis.*

Deep sea sponges collected from the depths of 200 to 260 m by the vessel "Klaus Sunnana" were analysed and were found to include 9 species including 3 new species and 2 new records.

A monograph on "Sponges of the Indian Seas" is in preparation.

Personnel associated with the project

P. A. Thomas, SRA.

G. Ecology of Holothurians

A general survey was undertaken on the occurrence and abundance of the different species of holothurians near Mandapam. Twenty two species were found to occur in the Gulf of Mannar and Palk Bay. Of these, *Stichopus chloronotus, S. variegatus, Holothuria edulis, H. mobei, H. cinerascens, H. atra, H. spinifera, H. pardalis, H. scabra, H. hilla, H. argus* and *H. leucospilota* were found to be of economic importance. At present only *H. scabra* and *H. spinifera* are used for Beche-de-mer industry at Mandapam.

The holothurian fauna was richer in the Palk Bay than in the Gulf of Mannar. At Tirupalakudi (Palk Bay) 30,000 holothurians were collected daily during the peak season.

Biology and fishery of the commercially important species, *Holothuria scabra* were studied during the year and the following results were obtained. The individual specimens in the commercial catches weighed between 190 to 270 g. Their gut largely contained sand and mud. The gonad index showed that most of the specimens were in spent condition. Males and females were occurring almost in the ratio 2:1.

The fishing season for this species commences in February and lasts till October with the peak period between April to August. Holothurians are also collected in large numbers by fishing trawlers.

Personnel associated with the project

D. B, James, SRA.

H. Ecology of pelagic and bathypelagic fishes

To study the spawning, maturity and other related features, ova diameter frequencies from the available material belonging to four species of tunas were examined. In addition to the measurements and counts taken from 15 ovaries of the two species of *Auxis*, 12 ovaries of *Euthynnus affinis* and 4 ovaries of *Sarda orientalis* were examined during the year. Some of the ovaries are being re-examined for the differences in ova within each ovary.

Investigations on the biology of *Chascanopsetta lugubris* Alcock (Family Bothidae) was continued. Sex composition in the catches was examined and this was found to be males 52% and females 48%. Ovaries were examined for fecundity counts and the number of ova per fish was about the same as observed during the preceding year (100,520 to 542,915).

Studies on deep water Trichiuroid fish, *Lepidopus caudatus* were taken up and fecundity estimates showed that the total number of ova varied from 3456 to 22482. Specimens of *Lepturacanthus savala* from deep water catches were also examined for fecundity which was found to range from 1925 to 10865.

Mature ovaries of *Emmelichthys nitidus*, one of the important species found along the shelf edge were also examined for fecundity which was found to vary from 45,000 to 80,000. Investigations on other species are also in progress.

Taxonomic studies on deep water fishes has been found necessary for the correct identification of species and their larvae. Morphometric data and meristic counts have been collected for the different species.

Detailed studies have been completed on the bramble shark, *Echinorhinus brucus* (Bonnaterre) and the chimaeroid, *Neoharriotta pinnata* (Schnackenbeck), both occurring along the upper continental slope.

Personnel associated with the project

E. G. Silas, SFS., M. S. Rajagopalan AFS., V. Kunjukrishna Pillai, SRA., A. Regunathan, RA., G. S. D. Selvaraj, RA., and M. Rajagopalan, RA.

I. Environmental studies of Vembanad Lake

Hydrological surveys of this lake and connected estuarine areas were possible during five months in this year. During each survey 28 stations were worked between Azhikode and Alleppey. Phytoplankton samples were also collected regularly during the surveys and C^{14} experiments were carried out at selected stations. The data are being analysed. During the surveys, samples of prawns were collected by using cast nets, and they were analysed for different biological features.

Personnel associated with the project

G. Subba Raju, AFS., K. V. George, RA., K. J. Joseph, RA.

5. Oceanographic Investigations

A. Hydrographic studies

Data collected during seven cruises in the past by R. V. *Varuna* in the Arabian Sea were examined. In all, 378 samples for salinity and 319 samples for dissolved oxygen taken from 71 hydrographic stations were analysed. Temperature was also determined at standard depths of all these stations.

The hydrological data of the Maldive region (O° to 8° N and 71°E to 80°E) collected during the period September to October 1962 were analysed. It was observed that a well developed thermocline with an upslope towards the north was present. Below 500 m depth the distribution of temperature at all the stations was alike. A well developed salinity maximum was observed in the northern part of all the sections above the thermocline. Towards the equator this salinity zone was not conspicuous. Dissolved oxygen in the vertical profile showed a deficit zone between 300 and 500 m. An increase in the oxygen was observed below 1250 m and values as high as 3.5 ml/L occurred at 3000 m and below. Sigma-T values for nearly 1000 stations were computed and temperature and salinity corrections for these stations were made.

The hydrographic features of the Laccadive region for the monsoon period of 1957 have been studied. The charts showing the distribution of various hydrographic properties are under preparation and a comparison of the hydrographic features of the Laccadive area with those of the coastal region will be made. The data on temperature, salinity, dissolved oxygen content and sigma-T of about 1023 stations for the period of six years have been averaged in relation to area, depth and seasons.

Along the Maharashtra coast, a weak gradient in temperature, north of 17°N, was seen from the winter data of 1964. The thermocline was found at a shallower depths during this season. A steady increase in salinity was observed northwards, the maximum being off Bombay. At 50 m, a weak southward drift was noticed. Dissolved oxygen content was uniform at surface and at 20 m, but at 50 m depth, gradients in oxygen were noticed. A sharp decrease in dissolved oxygen occurred above the thermocline and thus an oxygen minimum layer became conspicuous in all the sections. The total phosphorus content was low in the regions between 15°N and 18°N, but values further north and south of these latitudes became somewhat high. The distribution of oxygen and total phosphorus showed a reverse trend.

Horizontal and vertical distributions of hydrographic properties namely temperature, salinity, oxygen content, sigma-T, reactive phosphate,

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Personnel associated with the project

E. G. Silas, SFS., M. S. Rajagopalan AFS., V. Kunjukrishna Pillai, SRA., A. Regunathan, RA., G. S. D. Selvaraj, RA., and M. Rajagopalan, RA.

I. Environmental studies of Vembanad Lake

Hydrological surveys of this lake and connected estuarine areas were possible during five months in this year. During each survey 28 stations were worked between Azhikode and Alleppey. Phytoplankton samples were also collected regularly during the surveys and C^{14} experiments were carried out at selected stations. The data are being analysed. During the surveys, samples of prawns were collected by using cast nets, and they were analysed for different biological features.

total phosphorus, nitrite-N, nitrate-N, and reactive silicate related to the Angria Bank have also been mapped out.

The nutrient data of the west coast, from Calicut to Karwar have also been processed and their charts are under preparation.

B. Studies on Upwelling

To study the upwelling phenomena, the data collected during the cruises of R. V. *Varuna* from Cape Comorin to Karwar during the monsoon season of 1962 were processed. The distribution of various properties such as temperature, salinity, density and dissolved oxygen in vertical and horizontal planes have been studied. A bathymetric chart representing the slope of the bottom convection layer has also been prepared. It was found that in the region, between Cape Comorin and Cochin, typical monsoon conditions had not fully developed when the curise was undertaken. A strong southward drift (especially in the region Calicut to Karwar) was conspicuous in the upper layers. A northward counterflow was found at deeper layers around the lower limits of the thermocline, but the flow was relatively weak and discontinuous. The coastal upwelling was noticed in the region Cochin to Karwar. The evidence for this was derived from the low temperature (22°C to 23°C) and low dissolved oxygen values (less than 0.5 ml/L) prevalent in this area. These features were more marked in areas off Mangalore and Karwar.

C. Studies on Currents

Direct observations on currents were made using a current meter from the research vessel anchored for 36 hours off Cochin at a station having a depth of 150 m. This investigation was carried out in January 1970 and showed that the sub-surface currents were stronger and more variable than those at the surface. The current speeds were around 2 cm/sec at 20 m depth, 6 cm/sec at 60 m depth and about 12 cm/sec at 100 m depth. A semidiurnal oscillation in the direction of currents with a general flow northward was noticed.

The IIOE data collected during the cruises of R. V. *Varuna* in the Maldive were examined for the study of currents in that region. Indirect methods such as dynamic depth anomalies, the slope of isentropic surface were also used for the study of current during the latter half of the monsoon season (September).

The drift currents off the west coast of India during the winter season were examined for a number of years in relation to barometric pressure differences along the coastline. The long-term changes of the wind drift seem to be related to the long-term changes in the oil sardine landings. The data indicate that the north-east monsoon which helps in developing the force of the northerly drifts in the waters off the coast, appears to be favourable for the fishery.

Maps representing the distribution of salinity, dissolved oxygen (oxyty) and depth on three surfaces of uniform density: sigma-T 24.0, 25.0 and 26.0 g/l are under preparation. Some possible inferences drawn are as follows:

(a) Presence of the Equatorial Undercurrent is manifested by high salinity, high oxyty and also with ridge structure on the depth distribution along the equator.

(b) A strong evidence seems to suggest that the incursion of low salinity water from the Pacific Ocean through the Banda and Timor Seas occurs into the Indian Ocean. This is indicated by a tongue of low salinity water extending upto 50°E.

(c) The rapid decrease of oxyty towads the north and the existence of low oxyty water in the Arabian Sea and the Bay of Bengal is a prominant feature.

(d) The effect of relatively heavier Red Sea and the Persian Gulf waters have not been noticed probably because these waters can exist only at higher isopycnic surface.

D. **Observations on basic hydrological and meteorological conditions at different centres**

Routine hydrological and meteorological data from the inshore waters were collected regularly at centres like Bombay, Karwar, Mangalore Calicut, Madras, Waltair and Port Blair.

Bombay

Hydrological data collected over a period of 3 years from January 1966 to May 1968 from the inshore fishing areas off Bombay were analysed during 1970 and the following noteworthy features were observed.

The sea surface temperature was bimodal with two maxima - one in May (average 30°C) and the other in October (average 29°C). The minimum temperature recorded was usually in January (average 24.2°C). The surface salinity values were high in May (average 36.2°/$_{oo}$) and low in November (average 33.7°/$_{oo}$).

Karwar

A total of 210 sea water samples were analysed during the year from the Karwar Bay, Devgad and Chendia for temperature, pH, salinity, dissolved oxygen, inorganic phosphorus, nitrite-nitrogen and silicates.

Mangalore

Sea water samples were collected at two stations from 8 and 16 metres off Ullal during the periods January to May and October to December. The environmental features analysed were temperature, pH, salinity, oxygen, silicates and phosphates.

Calicut

During the year, water samples were collected regularly at 3 stations from 6, 12 and 20 m depths. The samples were analysed for pH, oxygen, salinity, inorganic and total phosphate, nitrites and nitrates and silicates. Atmospheric and surface temperature were noted at the time of collection. Due to unfavourable weather conditions no collections could be made from June to August. The salient features observed during the year can be hardly summarised as follows :

Temperatures were found to decrease from shallow to deeper stations in all the months. An increase in pH was observed at all the depths from September to November. At 20 m station, the surface pH was high in December (8.45). The surface oxygen did not show large fluctuations at the three stations, whereas in the bottom samples, an increase was noticed from September to December (e. g. at 20 m station). The surface salinity values generally showed an increase from shallow to deeper waters. But during October at the station which had a depth of 20 metres, surface salinity was relatively low (32.79°/$_{oo}$). The bottom salinity showed a reverse trend during November. The values of nutrients such as total phosphorus, nitrites, nitrates and silicates from surface samples were observed to increase gradually from 6 to 20 m stations. Little differences were, however, obtained during December. But the values of the bottom samples were found to decrease from shallow to deep stations. Usually the values for the bottom samples were greater than those at the surface for salinity and nutrients.

Madras

Hydrological data collected from fixed stations off the Madras coast from January to June revealed the following features. Salinity values increased steadily from January to April and declined thereafter. The oxygen content did not show wide fluctuations. The values of nutrients such as inorganic phosphates, nitrites, nitrates and silicates showed no marked variations. The pH was maintained without much change.

Waltair

During the year 44 sea water samples (22 surface and 22 bottom) were analysed at stations having a depth of 56 m.

Port Blair

Sea water samples were collected from two stations were analysed. (Marine Bay and South Point), from July-December, 1970.

Personnel associated with the projects

A. V. S. Murty, FS., G. S. Sharma, JFS., C. P. Ramamirtham, AFS., D. Sadananda Rao, AFS., G. Subba Raju, AFS., N. S. Radhakrishnan, AFS., K. Rangarajan, AFS., and Senior Research Assistants and Research Assistants.

Researches contemplated

During subsequent years, the different fields of investigation handled previously will be revised in accordance with the objectives of the Institute, recently redrawn. A number of projects will have to be re-oriented or grouped in conformity with the main objectives.

Studies on plankton productivity will be carried out from a number of centres both on the east coast and west coast to obtain a better assessment of the resources at the primary and secondary levels. The important role played by the phytoplankton and zooplankton organisms in the marine food chain will be investigated to have a better knowledge of the production processes and the efficiency of food conversion in the sea.

A greater emphasis would be laid on the location of spawning grounds of important species of fish and also on the studies of fish eggs and larvae.

The productivity of benthos and the significance of the mud bank formation along the Kerala coast will also be investigated.

In view of the growing awareness to the problem of marine pollution as a result of the growth of population and industry, application of pesticides and fungicides and other forms of interference with the natural environment, a new project will be initiated to study the deleterious effects of pollution on the marine fauna and flora.

Another new project entitled "A survey of economic seaweed resources of Tamil Nadu coast" will be undertaken.

SUMMARY OF THE REPORT

In 1970, the total marine fish production in India, for the first time, crossed one million tonnes. The provisional estimate of total fish landing was about 1.1 million tonnes. The total input of fishing effort which gave rise to this figure was 179 million man-hours. The fishing effort showed an increase of 2 million man-hours during 1970. The catch per unit effort also increased from 4.9 kg to 5.73 kg.

The mackerel fishery was exceptionally good during the year and reached an all time record figure of 147 thousand tonnes. The oil sardine fishery was also very successful (226 thousand tonnes) and so was the case with prawn fishery (114 thousand tonnes.)

Fishery biology studies during the year were continued on pelagic and demersal fishes, and on crustaceans and molluscs. The main size groups which were predominant in the fishery were established in all the major and minor fisheries and the spawning seasons and migratory behaviour of all fishes constituting a fishery were studied in detail. Considerable emphasis was given during the year on prawns and shrimps and the biology of various commercially important species of prawns was intensively studied.

Researches contemplated

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Environmental studies on coastal and offshore waters were continued with a view to establish their influence of physical, chemical and biological factors on fish populations. The abundance of organisms which formed the chief food of pelagic stocks were enumerated throughout the year from the plankton. In the shelf waters of the west coast of India, studies on primary production were continued and the total production which the shelf waters sustain was estimated.

From the zooplankton collections, fish eggs and larvae were sorted out and their distribution in different parts of the sea was studied. The larvae of the Indian mackerel were identified and these were found to be extremely abundant in certain parts of the coastal waters.

Economically important seaweeds of the Tamil Nadu coasts were surveyed this year and work was initiated on the growth and reproduction of some seaweeds.

PERSONNEL

Appointments

The following appointments to the posts equivalent to gazetted status were made during the year.

1. Dr. S. Z. Qasim — as Director from 7-12-1970
2. Dr. R. V. Nair — as Director in Charge from 27-2-1970
   — as Senior Fishery Scientist from 10-7-1970
   — as Deputy Director from 7-12-1970
3. Shri. S. K. Banerji — as Senior Fishery Scientist
4. Dr. E. G. Silas — as Senior Fishery Scientist
5. Dr. A. V. S. Murty — as Fishery Scientist
6. Dr. B. T. Antony Raja — as Junior Fishery Scientist
7. Shri K. Venkatanarayana Rao — as Junior Fishery Scientist
8. Shri. M. Vijaya Gupta — as Assistant Fishery Scientist
9. Shri. K. A. Narasimham — as Assistant Fishery Scientist
10. Dr. (Miss) M. Dharmamba — as Assistant Fishery Scientist
11. Shri. P. Mojumder — as Assistant Fishery Scientist

Retirements

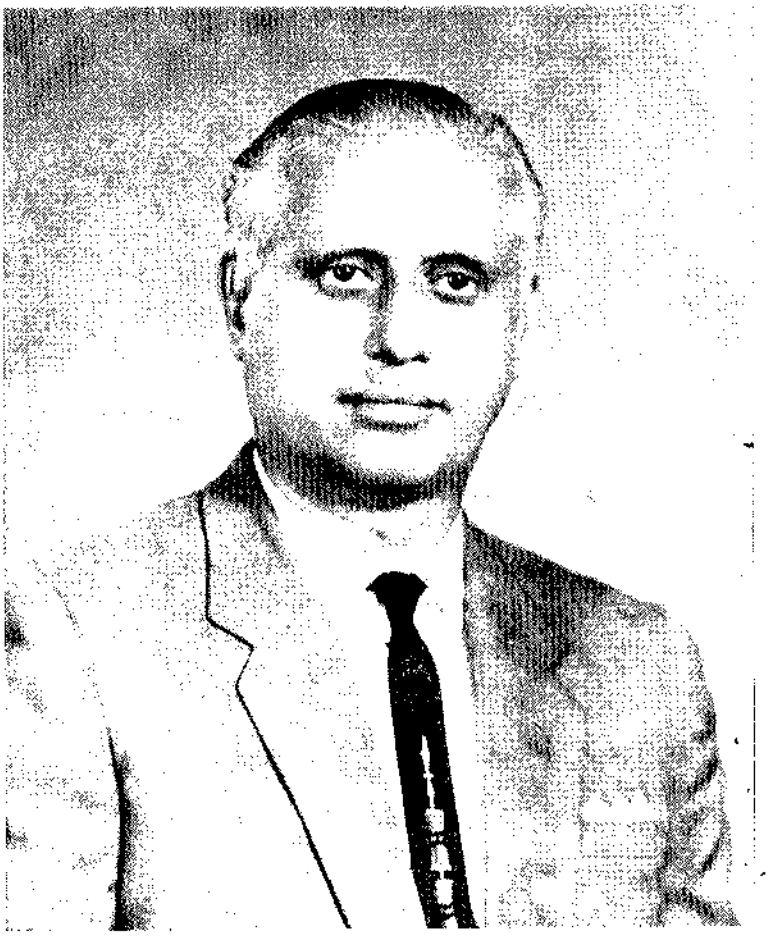
1. Dr. S. Jones retired as Director on 26-2-1970
2. Shri. K. Virabhadra Rao retired as Fishery Scientist on 30-11-'70

Obituary

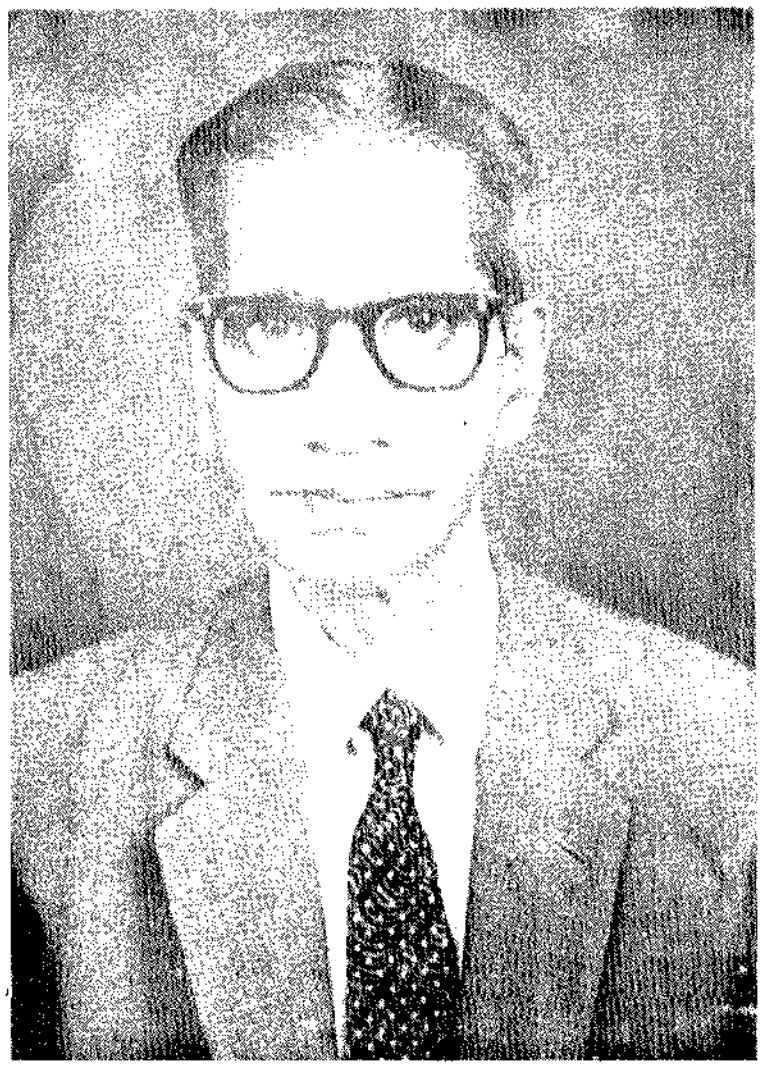
Shri. K. Hanumantha Rao, Senior Research Assistant who has been in service of this Institute at the Waltair Sub-station expired on 18-7-1970 due to accidental drowning in the sea.

Staff Position and Scientific Publications

The staff position as on 31st December 1970 and a list of the Scientific papers published by the staff of the Institute during 1970 are given at the end of this Report.



Dr. S. JONES
Retired as Director on February 26, 1970



Shri K. VIRABHADRA RAO
Retired as Fishery Scientist on November 30, 1970

LIST OF SCIENTIFIC PAPERS PUBLISHED BY THE STAFF OF THE CENTRAL MARINE FISHERIES RESEARCH INSTITUTE DURING THE YEAR 1970

Serial No.

1. Achari, G. P. Kumaraswamy 1970. Studies on new or little known polychaetes from Indian Seas. 2. *Micromaldane jonesi* n. sp. (Maldanidae). *J. mar biol. Ass. India*, 10(2): 269-273 (1968).

2. Adolph, Clement 1970. Observations on allometric growth and regeneration in palinurid lobsters. *Ibid.*, 10(2): 388-391 (1968).

3. Bapat, S. V. 1970. The Bombay Duck, *Harpodon nehereus* (Ham.). *Bull. cent. mar. Fish. Res. Inst.*, No. 21: 66 pp.

4. Bensam, P. and Mahadevan Pillai, P. K. 1970. Regeneration in the flatfish, *Cynoglossus macrolepidotus* (Bleeker). *J. mar. biol. Ass. India*, 10(2): 403-406 (1968).

5. Deshmukh, V. M. and Kuber Vidyasagar 1970. A prawn with double rostrum. *Ibid.*, 10(2): 391 (1968).

6. George, K. C. 1970. Notes on two species of flat-heads (Platycephalidae; Pisces) from the trawl grounds of the south-west coast of India. *Ibid.*, 10(2): 354-356 (1968).

7. George, M. J. and M. S. Muthu 1970. On the occurrence of *Metapenaeopsis barbata* (De Haan) (Decapoda: Penaeidae) in Indian waters with taxonomic notes on the genus. *Ibid.*, 10(2): 286-291 (1968).

8. George, M. J. and M. S. Muthu 1970. *Solenocera waltairensis*, a new species of prawn (Decapoda: Penaeidae) from Indian waters. *Ibid.*, 10(2): 292-297 (1968).

9. George, M. J. and A. Noble 1970. Occurrence of pea crabs *Pinnotheres gracilis* Burger and *Pinnotheres modiolicolus* Burger in the Indian coast. *Ibid.*, 10(2): 392-394 (1968).

10. Jones, S. and M. Kumaran 1970. New records of fishes from the seas around India-Part VI. *Ibid.*, 10(2): 321-331 (1968).

11. Kagwade, P. V. 1970. Hermaphroditism in *Polydactylus indicus* (Shaw). *Ibid.*, 10(2): 399-401 (1968).

12. Kagwade, P. V. 1970. The polynemid Fishes of India. *Bull. cent. mar Fish. Res. Inst.*, No. 18:69 pp.

13. Kanakasabapathi, K. 1970. Bibliography of contributions from Central Marine Fisheries Research Institute *Ibid.*, No. 19: 73 pp.

14. Marichamy, R. 1970. On a large sized green sawfish, *Prists zijsron* Bleeker landed at Port Blair, Andamans. *J. mar. biol. Ass. India* 10(2): 394-395 (1968).

15. Marichamy, R. 1970. On certain abnormalities in the short jaw Anchovy, *Thrissina baelama* (Forskal) (Family: Engraulidae). *Ibid.*, 10(2): 395-397 (1968).

16. Meenakshisundaram, P. T. and J. C. Gnanamuthu 1970. Large scale movements of *Caranx sexfasciatus* Quoy and Gaimard into the inshore areas of Madras. *Ibid.*, 10(2): 406 (1968).

17. Mohan, R. S. Lal 1970. *Callionymus jonesii*, a new Calliopymid fish (Pisces: Callionymidae) from the east coast of India. *Ibid.*, 10(2): 357-360 (1968).

18. Nair, P. V. Ramachandran 1970. Primary Productivity in the Indian Seas. *Bull. cent. mar. Fish. Res. Inst.*, No. 22: 58 pp.

19. Nair, R. V., K. Virabhadra Rao and K. Dorairaj 1970. The Tunas and Tuna like Fishes of India. *Ibid.*, No. 23: 94 pp.

20. Nair, R. V., S. K. Banerji, K. Virabhadra Rao, G. Venkataraman, K. V. Narayana Rao and V. Balakrishnan 1970. The Indian Mackerel. *Ibid.*, No. 24: 102 pp.

21. Noble, A. 1970. Studies on seawater off North Kanara coast. *J. mar. biol. Ass. India*, 10(2): 197-223 (1968).

22. Pillai, V. Kunjukrishna 1970. Observations on the plankton of the Bombay Coast with remarks on the hydrographic conditions and fishery. *Ibid.*, 10(2): 237-244 (1968).

23. Pillai, P. Parameswaran 1970. *Pseudodiaptomus jonesi*, a new calanoid copepod from Indian waters. *Curr. Sci.*, 39(4): 78-80.

24. Prabhu, M. S. and G. Venkataraman 1970. Mackerel and Oil sardine Tagging Programme. (1966-67, 1967-68). *Bull. cent. mar. Fish. Res. Inst.*, No. 17:38 pp.

25. Prasad, R. Raghu, S. K. Banerji and P. V. Ramachandran Nair 1970. Quantitative assessment of the potential fishery resources of the Indian Ocean and adjoining seas. *Indian J. Anim. Sci.*, 40(1): 73-98.

26. Qasim, S. Z. 1970. Some characteristics of a Trichodesmium bloom in the Laccadives. *Deep Sea Res.*, 17: 655-660.

27. Qasim, S. Z. 1970. Some problems related to the food chain in a tropical estuary. In "*Marine Food Chains*" Edited by J. H. Steele, Oliver & Boyd, London.

28. Qasim, S. Z. and V. N. Sankaranarayanan 1970. Production of particulate matter by the reef of Kavarathi Atoll. *Limnol. Oceanogr*, 15:574-578.

29. Rao, M. Umamaheswara 1970. The economic seaweeds of India. *Bull. cent. mar. Fish. Res. Inst.*, No. 20:68 pp.

30. Rao, M. Umamaheswara 1970. Additions to the algal flora of the Gulf of Mannar and Palk Bay from Mandapam area. *J. mar. biol. Ass. India.* 10(2): 366-369 (1968).

31. Rao, M. Umamaheswara 1970. On two new records of Codiaceae from India. *Ibid.*, 10(2):407 (1968).

32. Rao, P. Vedavyasa 1970. A new species of Shrimp, *Acetes cochinensis* (Crustacea: Decapoda, Sergestidae) from southwest coast of India with an account of its larval development. *Ibid.*, 10(2): 298-320 (1968).

33. Rangarajan, K. 1970. A new species of *Callogobius* (Family Gobidae : Pisces) from Gulf of Mannar. *Ibid.*, 10 (2) : 347-353 1968).

34. Sharma, G. S. 1970. An interesting case of an adult sole (*Cynoglossus semifasciatus*) with a normal eye on the 'blind' side of the head. *J. mar. biol. Ass. India.* 10(2); 401-402 (1968).

35. Sharma, G. S. 1970. Some inferences on the equatorial undercurrent in the Indian Ocean based on the physical properties of the waters. *J. mar. biol. Ass. India.* 10(2): 224-236 (1968).

36. Sivalingam, D. and P. Vedavyasa Rao 1970. A case of abnormal petasma in the penaeid prawn, *Metapenaeus affinis* (H. Milne-Edwards). *Ibid.*, 10(2): 386-387 (1968).

37. Silas, E. G. and M. Srinivasan 1970. Chaetognaths of the Indian Ocean, with a key for their identification. *Proc. Indian. Acad. Sci.*, 71B(5): 177-192.

38. Thomas, P. A. 1970. Studies on Indian Sponges-I. Two new species of silicious sponges belonging to the genera *Echinodictyum* Ridley and *Rhadberemia* Topsent. *J. mar. biol. Ass. India*, 10(2): 245-250 (1968).

39. Thomas, P. A. 1970. Studies on Indian Sponges-II. Two new species of silicious sponges belonging to the genera *Aka* de Laubenfels and *Damirina* Burton. *Ibid.*, 10(2): 251-255 (1968).

40. Thomas, P. A. 1970. Studies on Indian Sponges-III. Two species of silicious sponges of the family Ophlitaspongidae de Laubenfels (Class : Demospongiae Sollar, Order : Poecilosclerida Topsent). *Ibid.* 10(2): 256-260 (1968).

41. Thomas, P. A. 1970. Studies on Indian Sponges-IV. Additions to the genus *Corticium* Schmidt with notes on the distribution of *Corticium candelabrum* Schmidt. *Ibid*, 10(2): 261-264 (1968).

42. Thomas, P. A. 1970. Studies on Indian Sponges-V. Two new records of silicious sponges belonging to the Families Myxillidae Hentschel and Spriastrellidae Hentschel from the Indian region. *Ibid.*, 10(2): 265-268 (1968).

The following popular articles by the staff of the Institute were published during 1970.

1. Banerji, S. K. 1970. The functions of a fishery data centre. *Seafood Ex. Jour.* 2(1).

2. Nair, R. V. 1970. Is there overfishing of our inshore fishery resources ? *Indian Seafoods*, 7(4): 5-10.

3. Nair, R. V. 1970. Central Marine Fisheries Research Institute's activities. *Farm and Factory*, Madras 5(1): 41-44.

4. Rao, M. Umamaheswara 1970. We should make more use of seaweed. *Indian Fmg.*, 19(10): 35-38.

5. Seshappa, G. 1970. Mackerel - an important fish in the seas around India. *Ibid.*, 20(1): 39-41.

STAFF POSITION AS ON 31-12-1970

DIRECTOR : DR. S. Z. QASIM
DEPUTY DIRECTOR : DR. R. VELAPPAN NAIR

I. FISHERY SURVEY AND STATISTICS DIVISION

HEAD OF DIVISION : SHRI S. K. BANERJI, Senior Fishery Scientist

1. Shri D. Chakraborty, Junior Fishery Scientist
2. Shri C. R. Shanmughavelu, Assistant Fishery Scientist
3. Shri S. K. Dharmaraja, Assistant Fishery Scientist

II. FISHERY BIOLOGY DIVISION

HEAD OF DIVISION : Vacant

(a) *Pelagic Fisheries :*

1. Dr. G. Seshappa, Fishery Scientist
2. Dr. B. T. Antony Raja, Junior Fishery Scientist
3. Dr. V. Balakrishnan, Assistant Fishery Scientist
4. Shri V. Balan, —do—
5. Dr. P. Vijayaraghavan, —do—
6. Dr. N. Radhakrishnan, —do—
7. Shri K. Venkatanarayana Rao, —do—
8. Shri D. M. Punwani, —do—
9. Shri P. T. Meenakshisundaram, —do—
10. Shri K. Rangarajan, —do—
11. Shri Syed Basheeruddin, —do—
12. Shri M. H. Dhulkhed, —do—
13. Shri C. Luther, —do—
14. Shri P. Sam Bennet, —do—
15. Shri V. Ramamohana Rao, —do—
16. Shri A. Noble, —do—

(b) *Demersal Fisheries* :

1. Shri T. Tholasilingam, Junior Fishery Scientist
2. Shri V. Sadasivan, —do—
3. Dr. S. V. Bapat, —do—
4. Shri G. Venkataraman, —do—
5. Dr. B. Krishnamoorthi, —do—
6. Dr. M. Vasudev Pai, Assistant Fishery Scientist
7. Dr. M. D. K. Kuthalingam, —do—
8. Dr. (Mrs.) P. V. Kagwade, —do—
9. Shri A. S. Kaikini, —do—
10. Shri K. Venkatasubba Rao, —do—
11. Shri M. G. Dayanandan, —do—
12. Shri P. Bensam, —do—
13. Shri M. Vijaya Gupta, —do—
14. Shri K. A. Narasimham, —do—

(c) *Crustacean Fisheries :*

1. Shri K. H. Mohamed, Fishery Scientist
2. Dr. S. Ramamurthy, Assistant Fishery Scientist
3. Shri M. S. Muthu, —do—
4. Shri M. Mydeen Kunju, —do—
5. Shri P. Vedavyasa Rao, —do—
6. Shri V. M. Deshmukh, —do—
7. Dr. (Miss) M. Dharmamba, —do—

(d) *Molluscan Fisheries :*

1. Shri K. Nagappan Nair, Junior Fishery Scientist
2. Shri S. Mahadevan, Assistant Fishery Scientist
2. Dr. K. Satyanarayana Rao, Assistant Fishery Scientist

(e) *Aquaculture :*

1. Shri K. C. George, Assistant Fishery Scientist

III. MARINE BIOLOGY AND OCEANOGRAPHY DIVISION

HEAD OF DIVISION : DR. E. G. SILAS, Senior Fishery Scientist

(a) *Marine Biology :*

1. Dr. R. Subrahmanyan, Fishery Scientist
2. Dr. K. Radhakrishna, Assistant Fishery Scientist
3. Shri P. V. Ramachandran Nair, —do—
4. Dr. M. Umamaheswara Rao, —do—
5. Shri V. S. Krishnamurthy Chennubhotla —do—

(b) *Biological and Fisheries Oceanography:*

1. Shri C. Mukundan, Assistant Fishery Scientist
2. Shri K. N. Krishna Kartha, —do—
3. Shri N. S. Radhakrishnan, —do—
4. Shri M. S. Rajagopalan, —do—

(c) *Physical and Chemical Oceanography :*

1. Dr. A. V. S. Suryanarayana Murty, Fishery Scientist
2. Shri G. S. Sharma, Junior Fishery Scientist
3. Shri C. P. Ramamirtham, Assistant Fishery Scientist
4. Shri D. Sadananda Rao, —do—
5. Shri G. Subba Raju, —do—
6. Shri P. Mojumder, —do—

(d) *Museum and Reference Collections :*

1. Shri M. Kumaran, Curator

IV. ADMINISTRATION

1. Shri S. Rajagopalan, Administrative Officer
2. Shri S. Subramanian, Accounts Officer