GOVERNMENT OF INDIA
CENTRAL MARINE FISHERIES RESEARCH STATION, MARINE FISHERIES P.O., MANDAPAM CAMP, SOUTH INDIA

ANNUAL REPORT OF THE CHIEF RESEARCH OFFICER FOR THE YEAR ENDING 31st MARCH 1960

CONTENTS

I. ADMINISTRATIVE AND GENERAL

Progress in the various activities of the Headquarters Research Station and the different subordinate set-ups all along the coastline of India kept steady pace during the year 1959–60. A Research/Survey Centre was established at Cannanore, the collection of data and material from the Minicoy-Laccadives area was continued and a preliminary study was made of the fishery resources of the Andaman and Nicobar area with a view to setting up a Research Unit there. Systematic studies and collection of data

on the economically important fishes were continued at all the important fishery centres. The fishery for the mackerel and the oil sardine, which are the two major forms of commercial importance, proved to be erratic again this year. Against the 1958 landings of about 1¼ lakh tons each the 1959 catches of mackerel and oil sardine came to less than ¾ lakh tons each. Several of the other major groups also registered a decline in yield with the result that total landings of marine fishes in 1959 was only 5·8 lakh tons as against the 1958 figure of 7·6 lakh tons. The decline in the figures would have been more marked but for the improved yields in some of the minor fisheries and the encouraging results obtained in the power fishing operations especially at Bombay. Proposals for the expansion of the Research activities of the Station during the Third Five-Year Plan were formulated and accepted in principle by Government. Volume VI, No. 2 of the *Indian Journal of Fisheries* was published during the year.

The Budget allotment for the year under the heads recurring and non-recurring amounted to about Rs. 14 lakhs. The completion of the Guest House and provision of furniture for the same, provision of barbed wire fencing and installation of a few bore-well pump sets for supply of freshwater to the new colony and the Guest House were the major items of capital work carried out during the year. Renovation of the three blocks of thatched hutments in the campus was also sanctioned.

The annual requirements of scientific equipments and materials were duly purchased and made available to the scientific workers at different centres. A consignment of about 100 items of chemicals and stains have been sent to the Central Fisheries Technological Research Station (Processing Wing) at Ernakulam as a permanent transfer. A Willy's jeep with trailer and a Dinghy have been procured for use at the Ernakulam Substation. Two pablo boats for use at the Karwar and Vizhingam Research Units, indents for which were placed with the Director-General of Supplies and Disposals, are still to be received. Two Seffie Marine Diesel Engines and an outboard motor transferred to this Station under the T.C.M. Programme have been duly received. A generating set was procured for light fishing experiments.

The Library of the Research Station was considerably augmented by the addition of some rare and new books and publications, maps, etc., and by increasing the number of periodicals subscribed for. Considerable additions have been made also by exchange of publications for the *Indian Journal of Fisheries*. The Institution was enrolled as a member of the Connemara Public Library, Madras. Active steps were taken to improve the Library

facilities at the various subordinate establishments by the permanent transfer of publications, circulation and by loan of books and periodicals from the Headquarters station.

For the implementation of the Laccadives Fisheries Research Scheme one post each of Assistant Research Officer (Tuna), Research Assistant, Field Investigator, Field Assistant, Lower Division Clerk, Laboratory Boy and Peon was sanctioned. To cope up with the increased volume of work in the Library an additional post of Librarian was created. A post of watchman was also created for the Karwar Research Unit.

The following appointments of Research Officers and Assistant Research Officers were made:

Dr. R. Subrahmanyan	..	Research Officer (Marine Biology)
Shri V. Sadasivan	..	Research Officer (Fishery Naturalist)
Shri M. S. Prabhu	..	Research Officer (Sardines)
Shri K. Virabhadra Rao	..	Research Officer (Fishery Survey)
Shri C. Mukundan	..	Assistant Research Officer (Pelagic Fisheries)
Miss P. D. Nayak	..	Assistant Research Officer (Sardines)
Dr. A. K. Nagabhushanam	..	Do. Do. (Offshore Fisheries)
Shri M. Narayankutty	..	Do. Do. (Do.)
Shri K. N. Krishna Kartha	..	Do. Do. (Do.)
Shri Debidas Chakraborthi	..	Do. Do. (Statistics)

Shri P. C. George, who earlier joined the post of Research Officer (Fishery Survey), reverted to his regular post when Shri K. Virabhadra Rao assumed charge of that post.

Dr. S. Jones was confirmed in the post of Chief Research Officer with effect from 26-4-1957. Dr. R. Viswanathan, Shri P. R. Sadasivan Tampi, Shri L. R. Kasturirangan and Shri S. V. Bapat were also confirmed in the posts of Research Assistants (Selection Grade).

Dr. (Mrs.) F. Thivy, Assistant Research Officer (Marine Algology), superannuated from Government service on the afternoon of the 5th October 1959. She was re-employed in the same post for a period of one year from the 6th October 1959. Shri N. K. Velankar, Research Officer (Chemist), was transferred to the Central Fisheries Technological Research Station, Ernakulam, along with the post held by him.

Dr. S. Jones, Chief Research Officer, participated in the meetings of the Fishery Research Committee at Trivandrum in April 1959 and at New Delhi in December 1959. He attended the Conference of Heads of State Fisheries Departments held at the Ministry of Food and Agriculture, New Delhi, in April and June 1959, for formulating the Fisheries Developmental Plans under the III Five-Year Plan. He also attended the meeting of the National Board of Fisheries held at New Delhi, in December 1959. Other important meetings in which he participated during the year were the first meeting of the Standing Committee of the Indo-Norwegian Project held at Quilon, the Madras State Fisheries Advisory Board held at Madras, Second Meeting of the Committee for Oceanography of the Central Board of Geophysics held at Ernakulam and the first All-India Congress of Zoology held at Jubbalpore.

Dr. R. Raghu Prasad, Research Officer (Marine Biology), was deputed to participate in the cruise of the Soviet Oceanographic Research Vessel "Vitiaz" in the Indian Ocean. Dr. Prasad embarked on the Research Vessel at Cochin early in February 1960 by which time "Vitiaz" had already covered 124 stations in the Indian Ocean. He remained on board the ship for a period of two months during which it covered 97 stations over a distance of 8,200 miles and visited (1) Male (Maldives), (2) Tamatave and Nossi-Be (Madagascar), (3) Dzaudozi (Comore Island), (4) Zanzibar and (5) Mahe (Seychelles). Dr. Prasad disembarked from the ship at Bombay on the 4th April 1960. Dr. Prasad's participation in the cruise had afforded a further opportunity to study the organization and work of a large-scale oceanographic expedition and to get first-hand knowledge of the various techniques in Oceanography developed by foreign scientists. The studies on primary production and plankton made by Dr. Prasad on board the vessel have revealed that in the equatorial region of the Indian Ocean there are areas of very high production and some of these areas are now being exploited by Japanese fishermen. During this cruise many species of deep-sea fish formerly reported from the Pacific and the Atlantic Oceans were also recorded from the Indian Ocean.

Shri K. Virabhadra Rao who was deputed to Japan for specialized training in Molluscan fisheries returned to India in October 1959. Shri S. K. Banerjee, Research Officer (Fishery Survey), was sent to U.S.A. for advanced training in Fisheries Statistics under T.C.M. and he returned to India in March 1960. Dr. R. Viswanathan, Assistant Research Officer (Oceanography), participated as a Trainee in the International Training Course in the use of Radioisotopes in Agricultural Research at New Delhi. Dr. R.

Subrahmanyan, Dr. (Mrs.) F. Thivy and Dr. R. Prasanna Varma participated in the Symposium on Algæ arranged by the UNESCO and Indian Council of Agricultural Research at New Delhi.

Shri K. K. Parameswara Menon, Field Assistant in this Department, was awarded a prize of Rs. 500 in the competition held by the Ministry of Education for books for neo-literates for his article in Malayalam "Katalum Manushanum" (Sea and Man). Dr. G. Seshappa and Shri S. T. Nagarathinam received cash awards for their good performances in the Hindi Probodh Examination conducted by the Home Ministry in December 1958. Owing to the Hindi Instructor leaving the Department in October 1959 the Hindi Classes held at this Station have been temporarily suspended.

Mr. V. M. Naumov, a Russian Fisheries Expert, has been assigned by the F.A.O. for work in India and he has been engaged in Offshore Fisheries investigations at the Waltair Research Unit of this Station since October 1959. Shri V. Sadasivan, Research Officer, has been put as his understudy and Shri B. Krishnamurthy and Dr. A. K. Nagabhushanam, Assistant Research Officers, have also been instructed to work in close collaboration with the expert.

Dr. Karl Banse, a German Scientist, who was working at this Station as a Scholar under the Indo-German Industrial Co-operation Scheme, left for Germany in February 1960 after successfully completing his work here. Shri K. K. Tandon who was also working as a Senior Research Scholar under the Ministry of Scientific Research and Cultural Affairs Research Training Scholarship Scheme completed his 3 years' course in March 1960 and submitted the results of his work here as a Thesis for the Ph.D. Degree of the Punjab University. On his selection to the Junior Fellowship under the Council of Scientific and Industrial Research tenable at this Research Station, Shri P. S. B. R. James, Senior Research Scholar, relinquished the scholarship to take up the fellowship. Shri M. Subrahmanyan who was also working as a Senior Research Scholar was relieved during the year for taking up an appointment elsewhere. Dr. E. G. Silas joined as an Honorary Research Worker at this Station in July 1959.

The Southern Zone Study Group of the Estimates Committee of the Parliament visited this Research Station in July 1959 and studied in detail various aspects of work and activities, staff and budget allocations, etc. The Zoological Review Committee of the University Grants Commission headed by Prof. J. B. S. Haldane visited the Research Station in September, 1959 for assessing the facilities in Marine Biological work that could be made available by the Research Station to University workers.

Shri B. Ramakrishna Rao, Governor of Kerala, visited the Kozhikode Substation in December 1959. Among distinguished visitors to the Headquarters Station may be mentioned Shrimathi Lourdammal Simon, the Madras State Minister for Fisheries, Dr. M. S. Randhawa, Vice-President, Indian Council of Agricultural Research, New Delhi, Dr. L. Beatty, Canadian Fisheries Expert on Fisheries Technology, Mr. Krog Hansen, Director, Indo-Norwegian Project, Mr. Klaus Sunnana, Fisheries Leader, Indo-Norwegian Project, Dr. Rudolf H. Fritsch, Acting Director, UNESCO Office, New Delhi, Mr. M. Virat of the Pondicherry Research Institute, Shri M. R. Bhide, I.C.S., Secretary to the Government of India, Ministry of Community Development (Department of Co-operation), New Delhi, Shri P. A. Gopalakrishnan, I.C.S., Chairman, Life Insurance Corporation of India, Prof. M. S. Thacker, Director-General of Council of Scientific and Industrial Research, Shri Y. D. Gundevia, I.C.S., Indian High Commissioner in Ceylon, Shri A. C. Mukerji, General Manager, Southern Railways, Prof. K. S. G. Doss, Director, Central Electro-Chemical Research Institute, Karaikudi, Shri D. N. Banerji, Member, Central Board of Revenue, Shri R. N. Misra, Director of Inspections, Customs, New Delhi, Shri I. V. Ranga Rao, Field Officer, Small Industries Service Institute, Madras, Shri E. C. P. Prabhakhar, I.A.S., Collector of Ramanathapuram, Prof. A. B. Misra, Head of the Department of Zoology, Banaras Hindu University, Shri Ramakrishnan, Deputy Secretary, Council of Scientific and Industrial Research, New Delhi, Dr. Siro Kawaguti, Professor of Marine Biology, Okayama University, Japan, Shri E. B. Tissevera Singhe, Chairman and Director of the National Salt Corporation, Colombo, Shri M. Miskeith, Superintending Engineer, Deep Sea Fishing Station, Bombay and Mr. Rodney Jonklaas, Underwater Expert from Ceylon, while Mr. Egil Via, Norwegian Fishery Expert, Shri K. Gopinath Pillai, Director of Fisheries, Kerala, Shri P. Ananthanarayanan of the State Trading Corporation, New Delhi and Shri P. Thomas, Deputy Director, Ministry of Food and Agriculture (Department of Agriculture and Deputy Storage Adviser), Central Warehousing Corporation, visited the Kozhikode Substation.

The number of visitors to the Research Station showed a substantial increase during the year. The two Dugongs kept in the Aquarium proved to be objects of special interest as this is the unique instance of Dugongs being reared in captivity in any part of the world. Large number of enquiries received from various sources have been answered and detailed information supplied to the parties. At the instance of the Ministry of Food and Agriculture, a detailed study of the effects of the Kayankulam Kayal Reclamation Scheme in Kerala State on the Fisheries of that area was carried out by the Research Officer (Prawns) and a report embodying the results thereof

was submitted to the Government of India. The Research Station actively participated in the World Agricultural Fair organised by the Government of India at New Delhi. An exhibition was organized at the Research Station in December 1959 on the occasion of the celebration of the tenth anniversary of the Mandapam Branch of the Zoological Society of India. The various collaborated schemes and experiments and other activities referred to in the previous year's report were all continued actively except that the Nursery School at the Institution had to be closed down for want of adequate financial support. A list of scientific papers published during the year is given at the end of this report.

II. Fishery Survey

The analysis of data collected in 1959 was completed during the year and the total landings of marine fish during 1959 was estimated as 584,193 m. tons as compared to 755,774 m. tons in 1958, showing a decrease of about more than 0·17 million m. tons. The State-war break-up of the total landings for 1959 and 1958 are given in Table I.

Table I

States		Fish landings in metric tons	
		1959	1958
1. West Bengal and Orissa	..	3,962	6,267
2. Andhra	..	29,464	28,846
3. Madras	..	103,497	118,056
4. Kerala	..	191,375	294,655
5. Mysore	..	52,825	80,242
6. Bombay (including Saurashtra and Kutch)	..	198,192	222,886
7. Andaman and Nicobar	..	123	92
8. Mechanised vessels	..	4,755	4,730
Total	..	584,193	755,774

All the States showed a decline in production excepting Andhra. The landings from mechanised vessels registered an increase over the last year's

figures. The most significant decline in the catches had been in West Bengal and Orissa, Kerala and Mysore. The decline in Madras and Bombay were not significant.

The landings in West Bengal and Orissa were about two-third of those of 1958. This was mainly due to the decline in catches of prawns and other crustaceans, other clupeids, ribbon fish, other sardines and pomfrets. Despite the increase in perches, mackerel, and *Leiognathus* landings, the overall decrease was not balanced.

In Andhra State, the landings of ribbon fish and *Leiognathus* were nearly double those of 1958. Prawns and other crustaceans showed an increase of 20% and there was good landing of oil sardine during 1959 as compared to 1958 thus showing an overall increase in total landings in spite of decrease of landings of *Caranx* by 82% and of other clupeids, pomfrets, other sardines and *Anchoviella* (whose percentages of decrease varied between 10 and 37).

In Madras State, the landings of *Anchoviella*, ribbon fish, *Lactarius* and *Caranx* showed some decrease, the percentages of decrease varying from 19 to 41. On the other hand, the landings of Penæid prawns and other crustaceans, other clupeids and pomfrets increased by 52%, 41% and 36% respectively. Similarly the landings of flying fish, mackerel and *Thrissocles* were nearly 500%, 250% and 200% respectively over those of 1958. Even then, the total landings of the State declined by 12%.

The heavy decline in the landings of Kerala is due to the failure of mackerel and sardine fisheries which accounted for 90% of the net fall in the landings. The landings of oil sardine were nearly half of the last year's catches, while mackerel landings showed a decline by 56%. The catches of *Anchoviella*, *Thrissocles*, and other clupeids registered an increase during the year, but the total increase was too meagre to compensate the heavy deficiency due to failure of sardine and mackerel fisheries.

In the State of Mysore, landings of oil sardine, and cat fishes were 7 and 3 times the respective landings of 1958. Landings of *Thrissocles*, *Anchoviella*, Penæid prawns and *Leiognathus* showed significant increase but the complete failure of mackerel lowered the overall landings. Out of the gross decrease of 39,661 m. tons, mackerel alone accounted for 36,033 m. tons during the year.

The decrease in landings in Bombay State (including Saurashtra and Kutch) was mainly due to the fall in respect of landings of prawns and other crustaceans and Bombay duck and to some extent by the fall in the landings

of cat fish, ribbon fish, Sciœnids and eels. The landings of mackerel, polynemids, pomfrets and other clupeids, etc., showed some increase during the period, but these could not compensate for the deficiency caused by the fall in the landings of the previously mentioned fishes, the net short fall being of the order of 24,000 m. tons.

The salient features of 1959 fisheries were:

(*a*) Unlike last year, the mackerel fishery was a complete failure during the year. Mackerel alone accounted for 31% of the gross decrease during the year. Barring Bombay which showed some increased landings, the mackerel landings showed considerable decline in Kerala and Mysore.

(*b*) Oil sardine fishery also showed a significant decrease which was due to the fall in landings in Kerala, Bombay and Madras States. This fishery accounted for 27% of the gross decline.

(*c*) Decrease was witnessed in the landings of Bombay duck, *Anchoviella*, Sciænids, perches, *Caranx*, *Lactarius*, seer fish and sole, the percentages of decrease varying between 15 and 46.

(*d*) The low landings of ribbon fish accounted 5% of the gross fall.

(*e*) The landings of flying fish were nearly 3 times those of last year. This was due to heavy landings in Madras State.

(*f*) *Thrissocles* also showed a significant increase which was mainly contributed by Madras, Kerala and Mysore States.

(*g*) The catches of other clupeids followed by polynemids showed an increase due to the higher contribution of the States of Madras, Kerala, Bombay and Mysore.

Table II shows the overall composition of the total fish landings in India during 1959. For comparison, the corresponding figures of 1958 are also given.

Catch per unit of effort.—Table III shows the total effort in man-hours expended in each State and also the catch in kg. per man-hour. The corresponding figures for 1958 are also shown for comparison.

Table III shows that both the total effort as well as the catch per unit of effort during the period 1959 were less than those of 1958. Barring Madras, all States put less effort during the year than the last year. An increase of catch per unit of effort was witnessed in respect of West Bengal and Orissa, Andhra and Bombay while the others showed a decline.

TABLE II

Composition of fish landings

	Name of fish	Quantity landed in metric tons	
		1959	1958
1.	Elasmobranchs	23,446	24,286
2.	Eels	6,076	9,159
3.	Cat fishes	20,272	29,872
4.	*Chirocentrus*	5,428	5,549
5.	(*a*) Oil sardine	69,234	123,731
	(*b*) Other sardines	41,167	39,958
	(*c*) *Hilsa ilisha*	844	991
	(*d*) Other *Hilsa*	3,046	2,660
	(*e*) *Anchoviella*	24,477	29,346
	(*f*) *Thrissocles*	8,108	3,960
	(*g*) Other clupeids	21,211	15,525
6.	(*a*) Bombay duck	57,210	67,188
	(*b*) *Saurida*	597	238
7.	*Hemirhamphus* and *Belone*	383	348
8.	Flying fish	1,668	388
9.	Perches	9,389	11,959
10.	Red Mullets	1,526	2,166
11.	Polynemids	7,666	5,974
12.	Sciænids	20,442	25,565
13.	Ribbon fish	31,830	41,918
14.	(*a*) *Caranx*	9,773	18,133
	(*b*) *Chorinemus*	2,658	3,014
	(*c*) *Coryphæna and Elacate*	471	820
	(*d*) *Trachinotus*	2	59
15.	(*a*) *Leiognathus*	13,200	12,865
	(*b*) *Gazza*	293	343
16.	*Lactarius*	13,842	16,363
17.	Pomfrets	17,389	16,587
18.	Mackerel	62,198	123,282
19.	Seer fish	6,590	7,889
20.	Tunnies	2,866	3,239
21.	*Sphyræna*	972	830
22.	Mullet (*Mugil*)	245	729
23.	*Bregmaceros*	3,821	3,884
24.	Soles	10,360	12,856
25.	(*a*) Penæids prawns	27,632	29,204
	(*b*) Non-penæid prawns	37,805	55,987
	(*c*) Other crustaceans	2,092	1,508
26.	Miscellaneous	17,964	7,401
	TOTAL ..	584,193	755,774

TABLE III

Total effort in man-hours and catch in kg. per man-hour

States	Effort in 1,000 man-hours		Catch in kg. per man-hour	
	1958	1959	1958	1959
1. West Bengal and Orissa	9,733	4,787	0·64	0·83
2. Andhra	50,628	47,436	0·57	0·62
3. Madras	66,149	69,166	1·78	1·50
4. Kerala	95,391	63,328	3·09	3·02
5. Mysore	10,809	10,271	7·42	5·14
6. Bombay (including Saurashtra and Kutch)	80,545	52,391	2·77	3·78
TOTAL ..	313,255	247,379	2·40	2·34

A slight change in the method of collecting fish landing data was introduced in Kerala from July 1959. The same was introduced in Mysore from August 1959 and in Bombay from September 1959. Under this new scheme, instead of collecting data at fixed centres, the selection of landing centres was made at random. This permitted the calculation of estimate of sampling error of the estimate of landings. The error in the estimate of landings for the west coast of India during the last quarter of 1959 was estimated at 7%. The per cent. error of the annual estimate (which will be calculated from 1960) is likely to be lower than this.

III. FISHERY BIOLOGY

A. *Inshore Fisheries Investigations*

1. *Oil Sardine* (Sardinella longiceps) *and other Clupeoids*

(*a*) *At Karwar*: *Sardinella longiceps.*—A total of 141·789 m. tons were landed for the year 1959-60 in contrast to 90·706 for the year 1958–59. About 99% of the total catch of oil sardine was accounted for by the *rampan* nets. The catch-per-unit of effort for *yendi*, *rampan* and cast nets were respectively 0·629 kg., 2·106 kg. and 2·142 kg.

In April 1959 the size-range was 130–97 mm. with the 175 mm. size-group predominating. All specimens were found in the earlier stages of

maturity, not beyond stage II, and the two sexes were found to be in about the same numbers. This year's fishery commenced during the second week of November 1959 and lasted only for two months. The fish in the commercial catch varied in total length from 121–68 mm. with the 135 mm. and 145 mm. size-groups dominating for November and December respectively. Based on length-frequency studies, it is inferred that about 88% of the fish have their total lengths confined within the range of 130–49 mm. group and that the specimens were immature, the stages of maturity being I and II. The range of ova varied from 0·017–0·170 mm. with the peak at 0·068–0·085 mm. It was noted that the females formed slightly a higher percentage in all the size-groups except in 130–39 mm. The feeding was found to be moderate, and the fish did not appear to abstain from feeding.

Sardinella fimbriata.—The 'pedi' fishery commenced at Karwar towards the third week of September and the peak period was noticed in October. The total quantity landed at Karwar during the year was 12,679 kg. in contrast to 11,398·9 kg. for 1958–59. The fishes were encountered in *yendi*, cast nets, *gorbalæ* (drag net) and *rampan*, the latter two types used exclusively for the capture of 'pedi' shoals.

A continuation of the 1958–59 season was noticed up to June 1959. The minimum and maximum size recorded during September–March were 71 mm. and 146 mm. respectively. A progressive shifting of the mode month by month was noticed for the year, indicating that the fish had added about 30 mm. to their length in seven months' time. The monthly increment in length during the fishing season of 1959–60 thus appeared to be more or less the same as what was observed in 1958–59. It was also seen that the 110–29 mm. size group (immature ones in stages I and II) contribute much to the fishery and that the fishery was composed of one-year-old individuals. Smaller crustaceans figured prominently in the stomach analysis. *S. fimbriata* from the different centres of North Kanara are being collected and analysed.

Hilsa ilisha.—An exceptionally good catch of the Indian shad was noticed for October–November, the landings for the respective months being 5741·322 kg. and 2038·50 kg. In January 45·3 kg. were landed in one *rampan* net. About 98% of the total catch was brought by the *rampan* net. The modal size for October, November and January varied from 240–59, 240–59 and 280–99 mm. respectively. Length-frequency studies revealed that about 30% of the fish were within the range of 240–59 mm. and that the growth of the fish between November and January is about 40 mm. and it is assumed that the fish which contributed to the fishery belonged to the

same group. The fishes examined were immature. Species of *Oithona, Evadne, Acartia* and *Acrocalanus* formed the majority in the gut, and other minor forms noticed were copepod eggs, appendages of copepods, species of *Coscinodiscus, Penilia, Paracalanus, Cypris* larvæ, fish eggs and fish scales.

Opisthopterus tardoore.—The *pachki* fishery commenced in June and lasted up to September, the peak period was in August. A total of 886·521 kg. were netted (all by *yendi* operation) during the year, the size-range in the commercial catches being 61–162 mm. The 99 mm. size-group dominated the catch throughout the season in contrast to the two modal sizes of 99 and 149 mm. during the 1958–59 season.

(*b*) *At Mangalore.*—The oil sardine fishery in the area around Mangalore was very poor during this year as in the previous year. The fishery started in late October and ended abruptly by the close of December except for stray catches in January and February 1960. At Ullal the total annual catch was about 55·84 metric tons of which nearly 55·7 m. tons were landed in November. The entire catch in November was accounted for by cast net and *Chalavala* (gill-net), and of these two the gill-net recorded the higher catch per unit of effort (3·24 kg.).

Length-frequency analysis showed that the catches were supported mostly by a single age group. The modal size of this year-class was 125–29 mm. in October and it shifted to 145–49 mm. in February 1960. The dominant size-groups recorded by the various nets from October 1959–February 1960 were either the same or differed only to the extent of 5 mm.

In August, a few oil sardines obtained from *rampan* landings were found to be in spent condition. From October–January the fish were mostly immature (stages I and II) whereas in February stage III was recorded.

The food items of oil sardine consisted mainly of diatoms of which *Fragilaria oceanica* and species of *Coscinodiscus, Biddulphia, Thalassiothrix, Pleurosigma, Nitzschia* and *Rhizosolenia* were the important forms. Other items were the dinoflagellates, *Ceratium massiliensis, C. fuses, C. tripos*, tintinnids and copepods.

Sardinella fimbriata.—*S. fimbriata* were landed in small quantities in the Mangalore area. In the monthly commercial catches of the various nets there was only a single modal length group. The fish were mostly immature (stages I and II), during the November–March period.

(*c*) *At Kozhikode.*—The oil sardine fishery at Calicut during the year 1959–60 was poor; the total landings being only 1,561·16 m. tons as compared to 4,062·68 m. tons in 1958–59. More than 85% of the oil sardine

catches were landed within a period of 7 months, from August 1959–January 1960 with the highest catch in October 1959 when 539·7 m. tons were landed. A general upward trend in the oil sardine landings was noticed during the first three-quarters of the year (April–June to October–December 1959). The fishery continued up to January 1960 but came to an abrupt end by February.

Among the different gears operated for oil sardine *kolli vala* (*patten kolli* and *mathi kolli*) and *thattum vala* (boat-seines) had accounted for 72·8% and 25·11% of the total landings with 72·8% and 22·93% of the total effort respectively. Of all the gears, *kolli vala* consistently dominated in the fishing activity during the year and the CPUE (Catch per unit of effort) for this gear (9·21) was the highest. Next in importance was *thattum vala* for which the CPUE recorded was 5·53. However, the general decline of the oil sardine fishery during the year had, to a great extent, reflected on the overall low CPUE of the various gears.

The range in size of the oil sardine caught at Calicut varied from 90–179 mm. A study of the size and age composition of the oil sardine indicated the following: (1) the fishery in general was supported by three different year-classes, the modal sizes of which were around 100, 140 and 175 mm., (2) the second and third year-classes had dominated the fishery up to August 1959, (3) the new year-class had entered the fishery in September 1959 and (4) from October 1959 onwards the 130–40 mm. group was dominant and the entry of this group had resulted in the increased yield of oil sardine during the period from October 1959–January 1960. However, from the general decline of the oil sardine fishery from 1957–58 to 1958–59, it has to be inferred that the level of annual recruitment during the past two years had been very low.

Some of the other notable features concerning the oil sardine fishery were: (1) the occurrence of denser shoals within the 10 fathom area (mostly 4–8 fathom region) during the peak season and (2) the entry of the smaller size-group (140–50 mm.) into the fishery about a month earlier than during the previous season. In August, September and October fish ranging in size from 166–90 mm. quickly advanced in their stages of maturity from stage IV to stage VII. Although the fishery for the indeterminates and immature juveniles started in September, it assumed importance only after the middle of October. Analysis of sex ratio showed that while males were always more, with a ratio of 1·7: 1 in the mature group than in the immature group where the ratio was 1·3: 1.

Preliminary observations on the fat variations in the immature individuals of the oil sardine indicate that there is a higher percentage of fat storage around the visceral organs than in the muscles and that there seems to be more fat in the smaller fishes than in larger ones.

The stomachs of *S. longiceps* 120–84 mm. in length collected by different types of nets operating at depths ranging from 4–11 meters were examined from November-February. Bacillariophyceæ was more abundant than the other forms. *Fragilaria oceanica* contributed the most to the food in all the months. Myxophyceæ was represented by *Trichodesmium thiebauti* while several forms of Dinophyceæ were also present. Among the zooplankters, tintinnids, crustacean eggs, nauplii and copepods were common while *Evadne* sp., *Lucifer*, the zoea and cypris stages of *Lepas* and fish eggs were rare.

Sardinella fimbriata.—*S. fimbriata* examined from January–March 1960 showed that all of them were in stage I of maturity with the sex ratio of 1 : 1·4, the females being more. The size ranges were from 117–46 mm. and 124–56 mm. in January and February respectively with the dominant group of 125–29 mm. of January shifting to 130–34 mm. in February.

(*d*) *At Ernakulam: Sardinella longiceps.*—Work on scales of the oil sardine was continued during the year. The material was collected from Manassery and Kannamali. The ranges in size of the sardine examined during the first, second, third and the last quarter were 165–85, 165–90, 170–85 (and also 130–45) and 130–45 mm. respectively. Majority of the sardine examined possessed well-defined rings in their scales. The sardine (collected from Manassery) measuring 165–85 mm. in total length possessed 2 rings in their scales, the second one being close to the margin while those of 130–45 mm. in length had one ring in their scales (in fish collected from Kannamali). Otoliths from these sardine samples were also collected and are being examined in detail.

Length-frequency data collected during the first quarter showed that modes ranged from 150–75 mm. The range of maturity stages in April, May and June were I–II, II–IV and II–V respectively. During the same months, the percentage compositions of females were 38·0, 64·0 and 70·0 respectively. The sardine fishery was poorer in April and June than in May. Fishing operations were adversely affected by monsoon in June. *Thangu vala* (boat-seine) and *Chala vala* (gill-net) were the nets operated (in the 3–7 fathom area) for catching the sardine. During the second quarter the total length of fish showed a range from 80–195 mm. The occurrence

of juvenile sardine of modal length at 80 and 100 mm. was quite interesting. In August and September, the females formed 53·0 and 48·0% respectively.

(*e*) *At Neendakara.*—Studies on the length-frequency, sex, stage of maturity, feeding baits and growth indic s of *Sardinella longiceps* were continued during the year. The fish ranged in size from 125 mm. and 195 mm. Specimens belonging to stage III and stage IV appeared in May, June and July, while specimens examined during other months were all immature, belonging to stages I and II. Mature or spent specimens were not found at these landing places during the year.

(*f*) *At Mandapam.*—The popular "torch fishing" for *Choodai* in Palk Bay near Mandapam was almost absent during the year. Only three boats at Thangachimadam were engaged in "torch fishing" and landed small quantities of sardines. Regular *Choodai* fishing in Palk Bay commenced in May and lasted till October. In the Gulf of Mannar the fishery started in November and was continued till March. Fairly good quantities of sardines were landed in the Palk Bay centres while the fishery was rather poor in the Gulf of Mannar. As in the case of the previous year *S. albella* formed the dominant catch in Palk Bay with *S. gibbosa* as second in importance. A reverse trend was noticed in the Gulf of Mannar. Small quantities of *S. clupeoides* Blkr., a species hitherto not recorded in India, were found occurring regularly at Rameswaram Road fishing centre.

S. albella from 35–120 mm. entered the fishery in Palk Bay while fish of 65–105 mm. were found occurring in the Gulf of Mannar. The size range of *S. gibbosa* was 35–125 mm. for the Palk Bay and 72–110 mm. for the Gulf of Mannar. Data on population studies based on morphometric characters are under consolidation. Regular observations were made on food and feeding habits, age composition and maturity stages.

(*g*) *At Waltair.*—The sardine fishery at Lawson's Bay was poor during the year 1959–60. The estimated total landings of sardines for the period March 1959–February 1960 was about 36·79 m. tons forming only 5·89% of the total fish landings at this place. 98·48% of the total catch of sardines were by gill-nets and the rest by shore-seines and boat-seines. The maximum catch landed in March 1959 was 21·58 m. tons and the next highest catch of 10·97 m. tons was recorded in July. The 1959–60 fishing season for sardines commenced in October and the fishery was very poor as only 2·69 m. tons were landed during the period October–February. *Sardinella fimbriata* was the predominant species. The fishery was supported mainly by the juveniles and immature fish. *Sardinella gibbosa* was caught in considerable quantities in April, May and February. A third species, *Sardinella sirm*

was observed in the catches at Lawson's Bay for the first time during April and May. Studies on the biology of *S. fimbriata* and *S. gibbosa* were continued. Gut contents of *S. fimbriata* of different length groups indicated that in general, larger fish fed on bigger crustaceans such as *Acetes*, *Lucifer* and larval decopods along with post-larval fishes. Smaller fish fed chiefly on copepods, larval molluscs and *Coscinodiscus*. *Trichodesmium* was also observed in many stomachs. Copepods formed the chief food of *S. gibbosa*. Specimens of *S. fimbriata* examined in June and July ranged in size from 146–90 mm. and they were in stages I–III of maturity. The fish examined during October–February were all juveniles. Specimens of *S. gibbosa* examined during April and May were either juveniles or in stage I while fish in stages II, III and IV were observed in February. During June and July the fishes ranged in size from 146–90 mm. with 165 and 180 mm. groups dominant in the respective months. During November–January they ranged from 32–102 mm. with 40 and 45 mm. and 80 and 75 mm. as dominant size-groups during November, December and January respectively. *S. gibbosa* ranged from 60–135 mm. with 75 and 100 mm. groups dominant in April and 110 and 125 mm. groups dominant in May. Meristic counts and morphometric measurements were taken of various samples. The data collected are under analysis.

2. *Mackerel*—Rastrelliger canagurta

(*a*) *At Karwar.*—The 1958–59 fishery of the Indian mackerel continued till the middle of April 1959. Since the last decade this was the first occasion that such a prolonged fishing season extending for about seven months was observed. With the total catch of 37·82 m. tons in April 1959, the 1958–59 season yielded a total of 2,744·2 m. tons which is the highest recorded figure. The fishery during 1959–60 was, however, a total failure all along the North Kanara coast. At Karwar, the fishery commenced with the first operation of *rampan* (boat-seine) on 23–10–1959 and lasted till the end of February 1960. There were 71 fishing days when 140 hauls were made. The total quantity of mackerel landed was 971·11 m. tons. In December, with 53 hauls in 20 fishing days a maximum of 386·74 m. tons was landed while the lowest catch of 2·81 m. tons as a result of 9 hauls in 8 days was recorded in February. The average per *rampan* operation, the average per fishing day, catch per haul per piece and the catch per haul per man were the highest in October, though in the month-wise distribution of the total catch, it occupied only the fourth place. The quantity hauled per *rampan* varied from 54,550 kg. in November to a mere 20 kg. in January. The catch per haul per piece of *rampan* and the catch per haul per man for the

year showed a poorer figure than that of even 1956–57 (which was the worst year on record).

Studies during the year revealed that there was no mixing up of populations, nor was there any indication of different age groups appearing in the same shoal. The fishery was mostly composed of immature fish measuring 170–220 mm. though during the close of April and early during the commencement of the year's fishery it was composed of spent individuals. No segregation of the sexes was noticed amongst the shoals. Stray specimens of young mackerel measuring 100–30 mm. occurred frequently during April, May, June and August. The occurrence of these young mackerel in April in the inshore waters of Karwar was noticed for the first time. They were believed to be stragglers from the main shoal which remained outside the fishing zone. Length-frequency studies in April revealed the 220 mm. group as dominant. During the season as a whole, the 200–10 mm. group dominated as in 1957–58, whereas in 1958–59 it was the 210–20 mm. group that formed the majority. During 1959–60 growth could be traced from 180–90 mm. in October to 210-20 mm. in February while the growth from October 1958–April 1959 was from 190–220 mm.

Taken for the season as a whole, male and female specimens equalled in numbers. In the April samples, the females constituted 67·2%; the majority of the specimens above 220 mm. were in the spent condition (stage VII), indicating that spawning had taken place either in April or late March. In the samples obtained during the off-season the gonads showed a ripening condition (stages IV–V). That the period of spawning was during the off-season months was further corroborated by samples obtained in October and early November. There was, however, one female specimen in which the two lobes of the ovary exhibited different stages of maturity, the right lobe in stage V and the left lobe "running" (VI B). The fully transparent ova with usually one bit oil globule but sometimes with 3–4 oil "globulets" measured 0·85–0·94 mm. in diameter. The big oil globule measured 0·23 mm. in diameter. Another peculiarity observed in this particular specimen was that the contents of the left lobe could be completely emptied leaving behind a thin bag-like structure.

Study on the relationship between the total length, standard length and body weight was continued. In connexion with the racial investigation studies it was discovered that the Indian mackerel is characterised by six posterior finlets (both dorsal and anal). Another observation was that the total number of dorsal fin rays (including finlets) numbered 29 (and not 27). But these 29 rays were generally found only in the young fish. It was observed

that during growth, 1 or 2 (or rarely three) lepidotrichia of the first dorsal fin got shed, by the corresponding interspinous bones persisted. Instances where the last one or two rays of the second dorsal and anal fins getting modified as finlets were also noticed. Whatever these modifications were, the total number of (dorsal) interspinous bones remained constant as 29 while those of the anal were 18. Comparative studies with *Rastrelliger* species from other regions on the Indo-Pacific have been contemplated.

(*b*) *At Mangalore.*—The mackerel fishery was a complete failure in the area around Mangalore during this year. The total annual catch at Ullal amounted only to about 21·6 m. tons. Of this 5 m. tons were landed in April and May. There was no fishing during monsoon but the season started again in September. But the total catch in September and October at Ullal was only about 13 m. tons. After October, the fishery declined further. At other centres also, the fish catches were much below normal. At Ullal, *pattavala* and *kanthavala* accounted for about 90% of the total annual catch. About 90% of the *pattavala* catch was landed in September and October. Of the two nets, *pattavala* was the more important one, both in regard to total landings and catch per unit of effort.

From length-frequency studies it was seen that the catches of the April–September period were supported by the same age group which had contributed to the 1958–59 season (October 1958–March 1959). This age group disappeared from the fishery after September. From October onwards, the fishery was supported by a new age group. This was represented by a modal length of 190–94 mm. in October 1959, and 220–24 mm. in March 1960. The catches of both gill-nets and *rampan* showed the same pattern with regard to age composition, but during October 1959–March 1960, the monthly modal sizes of gill-net landings were 5–10 mm. higher than those of the latter.

Mackerel of advanced maturity (stages V–VI) occurred in the fishery from April–August 1959. From October–March 1960 the fish were mainly in stages I and II.

There was a fishery of a very minor magnitude in the Netravati estuary in May 1959 and from December 1959 to March 1960. From October 1959 to March 1960, the size frequency of fish in these catches had the same modal length as that of the marine catches, but in May 1959 the modal size was about 20 mm. higher. Catches landed by purse-seine in January at Mangalore also had the same modal length group as with indigenous gear.

The main items observed in the stomach contents were copepods, cladocera and larval bivalves among zooplankton and *Coscinodiscus* among phyto plankton.

(*c*) *At Kozhikode.*—The annual mackerel catch of 471·13 m. tons constituted 13·50% of the total landings of fish at Calicut. The seasonal catch was about one-third that of the 1958–59 season. The mackerel fishery in October and November was, however, better than the corresponding months of 1957–58.

In August and September the fishery was contributed by a smaller size-group with a modal size at 125 mm. in August and 165 mm. in September. In October the fishery was contributed by a larger size-group with the dominant size at 185 mm. The prevailing overall length of mackerel in November and December was 205 mm. and that in January–March 215 mm.

Larger mackerel, 210 mm. and upwards, were in advanced stages of maturity (stages IV, V, VI) during May–August. From October–April, mackerel were in stages I–III.

The studies on the food of mackerel was started by December. Stomach contents of fishes ranging from 204–31 mm. were analysed. The stomachs were full in most cases mainly by copepods. Phytoplanktonic forms made up a small portion of the food, composed chiefly of species of *Dinophysis, Coscinodiscus, Peridinium* and *Pleurosigma.* Large numbers of tintinnids were also seen. Among other food items were crustacean eggs and larvae, bivalve larvae, and cladocerans.

Specimens received from Andamans during this year were examined in connexion with racial studies. The vertebral column of these specimens resembles that of the local mackerel. The gill raker counts show great variation in different specimens, there being 18–24 (mostly 20–22) on the upper branch and 34–41 (mostly 36–38) on the lower branch of the first branchical arch.

(*d*) *At Ernakulam.*—Mackerel fishery at Cochin was of very moderate magnitude during the period under review. The country-crafts with *thangu vala* (boat-seine) and *aila vala* (gill-net) fished up to areas 7 fathoms deep and the purse-seine mostly in the 6–8 fathom area. During the close of the fishing season in April and May fish ranging in length between 200 and 230 mm. with the modal length 220 mm. were caught in moderate quantities. Fishing again started in October with the appearance, in significant quantities, of fish with modal lengths of 180 and 190 mm. and which increased to 210 mm. by March.

Fish in fairly advanced stages of maturity (up to stage IV) and spent conditions were noticed in April and May, of first quarter and March of the last quarter. No fish in ripe of running condition has been observed

in the catches at Cochin. Search for mackerel eggs in plankton collections off Cochin did not prove fruitful. The smallest mackerel observed at this centre (56 mm.) was collected in August from the 20-fathom area. Generally the females exceeded the males in number in the samples but a reversal of this pattern was noticed in February and March.

(*e*) *At Neendakara.*—Mackerel specimens beyond the IV stage of maturity have not been met with at any of the landing places here during the year. Fish with gonads in stage IV appeared in May and June. A sample of 6th May was interesting in that specimens of different size-groups (149–72 mm. and 221–49 mm.) were brought in by the same shore-seine haul. The smaller specimens belonged to stage I of maturity while the larger ones were in stage IV. The commercial fishery was supported by fish of stages I and II only. Studies on the food and feeding habits and otoliths were continued.

(*f*) *At Vizhingam.*—The mackerel fishery at Vizhingam was mainly based on the stock of juveniles and of the medium-sized fish. During the period under report, the fishery showed considerable improvement as compared with that of the previous year. The total landings were estimated at 66,223 kg. of which 8,897 kg., 51,012 kg., 5,152 kg. and 1,162 kg. were recorded during the first, second, third and fourth quarters respectively.

Shore-seines, boat-seines and drift nets were the main gear employed for mackerel fishing. Of these units the former two accounted for more than 90% of the total landings. Mackerel was also caught occasionally by hand-lines at Valiathura, Trivandrum.

The bulk of the commercial catches was supported by the juveniles and the medium-sized fish, while the adult fish contributed only to a small fraction of catch. During the first quarter two size-groups, 50–60 mm. and 90–140 mm., were of common occurrence in the landings; the adult fish of size range 200–50 mm. were recorded as stray specimens. But by the second quarter, the size classes 80–120 mm., 130–50 mm. and 160–90 mm. entered the fishery. Slightly bigger fish of size range 140–220 mm. with modal sizes at 180 mm. and 200 mm., were recorded during the third quarter. The size of the mackerel showed a progressive increase in the last quarter. The length composition of the fish during the quarter varied from 200–95 mm. Stray specimens of juveniles of the size class 45–70 mm. were also recorded at the end of the period.

The major portion of the commercial landings was constituted by the indeterminates and immature fish, while the adult fish, caught at different parts of the year as stray specimens, were in various stages of maturity. Thus

the fish caught during the first quarter were found to be in the maturity stages II, IV and V. Subsequently no adult fish was recorded in the commercial landings except at the close of the season. During this period all the fish measuring below 240 mm. were in stages I and II, while mackerel measuring above 260 mm. in length were in spent condition (stage VII).

The mackerel was feeding exclusively on planktonic organisms. The feeding intensity was observed to be uniform throughout the period. The preponderance of various types of the planktonic organisms found in the stomach varied from season to season. Thus during the first and the last quarters zooplanktonic forms like copepods, *Squilla* larvæ, prawn larvae, Pelecypod larvae, and *Acetes* sp. formed the important constituents, while during the second and third quarters the phytoplanktonic fraction constituted the major item of their food.

(*g*) *At Porto Novo.*—The total mackerel landed was 5·12 m. tons, the entire quantity being accounted for by a continuous and rather prolonged summer fishery. The usual August–September fishery at this centre was a failure. The bulk of the catches were constituted by spawners of 200–40 mm. size. But the possibility of actual spawners moving out of the intensely fished area was indicated.

3. *Prawns and Lobsters—(A) Prawns*

(*a*) *At Bombay.*—A comprehensive study of the inshore prawn fishery along the coast of Bombay between Dahanu and Sassoon Docks was initiated in September. Weekly observations were started on the *Dol* net catches at 4 centres, *viz.*, Dahanu, Arnala, Versova and Sassoon Docks but later observations at Dahanu had to be abandoned owing to certain practical difficulties. About 10 species of prawns and shrimps have a significant share in the fishery at all the centres. The different species and their average percentage (given within brackets) were *Acetes indicus* (26·2), *Metapenæus affinis* (16·5), *Palæmon* (*Leander*) *tenuipes* (13·8), *Hippolysmata ensirostris* (9·7), *Solenocera indicus* (9·6), *Parapenæopsis sculptilis* (8·3), *P. hardwickii* (5·0), *P. stylifera* (4·0), *Metapenæus brevicornis* (2·3) and *M. monoceros* (2·1). Besides these there were a few other species also which occurred erratically in some months, but whose contribution to the fishery was rather small when the entire region is taken into account. Few of the species mentioned were uniformly abundant in all the centres in any month. It might be of scientific interest to mention here that *Parapenæopsis hardwickii*, *Metapenæopsis novæguinea* (*stridulans*), *Atypopenæus compressines* and *Trachypenæus curvirostris* have not been recorded before from the West Coast.

Two other species, *Muyadiella pedunculata* and *Parapenæopsis acclivirostris* have not so far been recorded from Indian waters before.

Among the numerous species Penæid prawns, which are caught in good numbers in October and November, formed only about 47% of the total landings, whereas smaller species like *Palæmon* (*Leander*) *tenuipes*, *Acetes indicus* and *Hippolysmata ensirostris* accounted for as much as 50% of the total.

The months of October and November were noteworthy because of the intense breeding activity of most of these species. None of the penæids seem to spawn in inshore areas. Mature *M. monoceros* was observed only in October.

The prawn catches of the Government of India vessels consisted of *M. affinis*, *M. brevicornis*, *Parapenæopsis stylifera*, *P. sculptilis*, *M. monoceros*, *M. maxillipedo* and *Penæus indicus* in the order of their abundance. Except for the occasional capture of the juveniles of some species most of the prawns were adults. Although observations on the prawn catches of the Bull Trawlers of the New India Fisheries Limited had to be abandoned from October 1959, earlier observations showed that the catches were rather poor. They comprised *M. monoceros*, *M. affinis* and *P. indicus* in the order of their abundance. This was true up to the region of the Gulf of Cambay. North of it, in and around the Gulf of Cutch, *P. indicus* and *P. carinatus* appeared to be the dominant species.

(*b*) *At Mangalore.*—In the Mangalore area prawn fishery with indigenous gear was better during the year under report with its peak in August–October. *M. dobsoni* was the dominant species, others being *M. affinis*, *P. indicus* and *P. stylifera*. Good numbers of impregnated females were observed during August–November indicating the probability of their breeding during these months. The catches from the Netravati estuary were made up of juveniles of *M. dobsoni*, *M. monoceros* and *P. indicus*.

Mechanised vessels using other trawl landed fairly good catches from October 1959–March 1960, which might therefore be the best months for prawn fishery by this method. Composition of the species caught seemed to be almost the same as those of the indigenous gear. *P. indicus* and *P. penicillatus* were also present in insignificant numbers. Impregnated females of *M. dobsoni* in appreciable numbers were observed in these catches up to March and it seems probable that the breeding period of the species in this area might extend from October–March.

(*c*) *At Kozhikode.*—Routine collection of data from catches at Calicut and Quilandy and these mechanised vessels operating from Beypore were

continued as in previous years. The catches mainly consisted of *P. stylifera*, *M. affinis*, *M. dobsoni* and *P. indicus*. Observations on their biology have also been regularly made especially in regard to growth, maturation and breeding.

(*d*) *At Ernakulam*.—Studies on the prawn fishery at Alleppey, Chellanam and Narakkal, as part of the programme of population and recruitment studies, have been carried out during the year. On reviewing the fishery at Alleppey during the 4 years from 1956-57 to 1959-60 it became clear that the fishery has been steadily declining and that the year under report has seen the poorest landings in the 4 years. *M. dobsoni* continued to be the dominant species, especially during the peak of the fishery from May-September. Later there has been a fall in its numbers. During these months older prawns belonging to length groups of 96–100 mm. to 106–10 mm. were prominent. By November they became fewer and their place was taken by younger prawns measuring 61–65 mm. to 71–75 mm. *P. stylifera* was next in importance. Length-frequency studies have indicated that lower size-groups are recruited into the fishery some time after August and also after February. *M. affinis* occupied the third rank and was observed in maximum numbers in November and December. Its modal length group measured 71–85 mm. in February-March; but later, in November-December, groups measuring 111–40 mm. became more prominent.

The fishery at Chellanam and Narakkal was similar to that at Alleppey in regard to species and their fluctuations, both in number and size. But in respect of monthly landings those of the two southern centres were much less.

With a view to gather as much information as possible on the distribution of Penæid prawns off Cochin and in the neighbouring areas a close study of the prawn catches of two trawlers of the Government of India and two vessels belonging to the Indo-Norwegian Project has been started in the last quarter of the year. The data collected so far are insufficient to base any conclusions on them.

An investigation on the biology and fishery of *Palæmon carcinus* was initiated in September 1959 at two centres in the Vembanad lake area where this fishery is quite good. From the observations made before the end of the fishery in November it would seem that the catches mostly consisted of males between 240 and 300 mm. and females measuring 150 and 240 mm. From the number of berried females observed the period of active breeding of the species seems to be October-November. After the termination of

the fishery studies on their post-larvae and young ones have been continued in order to trace their distribution and growth.

Reports from industrialists had indicated that, contrary to the prevailing belief that there is hardly any prawn fishery south of Quilon, a fishery of some magnitude exists at certain places in the region of Kanyakumari District. The fishery starts in June along the coast extending from Cape Comorin to Kollengode, about 35 miles to the north and lasts up to about August although some prawns may be caught in later months. The nets used are those known locally as *Thattumadi* and *Vala valai* and they are operated comparatively close inshore, seldom beyond 2 miles in waters 2–7 fathoms deep. With the help of the Southern Fisheries Corporation, who were buying a good part of the catches for freezing in their Unit at Muttom, it was almost entirely of *Penæus indicus*. One noteworthy feature was that the young ones of this species were relatively few in the inshore catches compared to those at other places, the majority of them measured over 140 mm. in length in June, August and December 1959. Before the freezing companies appeared on the scene it is reported that the catches used to be shelled and dried for export to Ceylon from the Port of Tuticorin.

(*e*) *At Madras.*—*P. indicus*, *P. carinatus* and *M. dobsoni* composed the marine catches in the local fishery. The first of these species, ranging in length from 120–200 mm., formed almost the entire catch.

In addition to the studies on the local fishery the fairly rich fishery of the Pulicat Lake, about 45 miles north of Madras, was taken up in the second quarter of the year. Stake-net fishing is the most widely practised method in the Lake, and the operations are carried out at night in places 2–8 metres deep. The period January–March was the best for prawns this year. As in other estuarine environments the catches consisted almost entirely of young and immature prawns. *P. indicus* and *M. monoceros* were the important species making up the bulk of the catches while *P. carinatus* was also caught but in small numbers.

(*B*) *Spiny Lobsters*—Panulirus *spp.*

The fishery of 1958–59 season which had begun to decline in March 1959 came to a close by the end of April. It revived by about the middle of December 1959. The catches during this season had gone down strikingly, but it is difficult to furnish a satisfactory explanation for such a sharp decline. The estimated catch (numbers caught) for each month in the current and last seasons furnished in the table below gear-wise would show the extent of the fall clearly. The decline was noticeable not in numbers

alone but also in size. Lobsters of larger size (over 200 mm.) were proportionately much less, especially in the first two months of the current season and among this size males were less than in the last season. Females with eggs were also much less in numbers during the current season, except in December.

		Colachel					Muttom				
		Dec.	Jan.	Feb.	Mar.	Apr.	Dec.	Jan.	Feb.	Mar.	Apr.
Trap	..	16398	18228	9196	3255	1114	7359	14672	6920	2752	328
	..	6616	4046	1919	745	1114	4866	4608	3244	926	926
A. Hook	..	Nil	Nil	60	70	Nil	46286	21989	2222	57	267
	..	Nil	1370	V. few	Nil	Nil	12852	5212	2342	212	212
G. Net	..	3560	1064	50	Nil	Nil	Nil	Nil	58	Nil	Nil
	..	338	120	Nil	Nil	Nil	Nil	22	Nil	Nil	Nil

(The first set of figures under each gear represent the numbers for the 1958–59 season while the second series are for 1959–60.)

4. *The Malabar Sole*—Cynoglossus semifasciatus

About 241·5 m. tons of the Malabar sole, *Cynoglossus semifasciatus*, were landed at Kozhikode (Vellayil) during the year. Of this quantity as much as 164·5 m. tons were landed in October and 47·6 m. tons in November. In September which is normally the month of peak catches of this fish, only 1·2 m. tons were landed. There was practically no fishery in the area for soles during July and August and most of September. Small quantities of this fish occurred in all the other months, ranging from 0·7 m. tons in February 1960 to 10·4 m. tons in June 1959. Outside the monsoon season the monthly total catch was less than 3 m. tons in five months of the year.

Departmental collections with the boat-seine and gill-net were also continued throughout the year and the samples taken with the boat-seine were used for length-frequency studies. The dominant size was in the 90–99 mm. group; from April–June. Juveniles occurred in all these three months though there was a relative reduction in their numbers through May–June. A single juvenile in the 50–59 mm. group was encountered in September. In October, the smallest specimens caught were in the 70–79 mm. group; these and the single juvenile seen in September perhaps belonged to

the previous season's late spawning. Smaller juveniles occurred regularly from November onwards, with a dominance in December. These represent a new brood entering the fishery. An interesting point about the length-frequency distribution during the months of April-June 1959 and January-March 1960 was the occurrence of the mode of the dominant age-class in the same size-group, namely, 90–99 mm.

Occasional samples were examined for scale rings and the findings fell in line with the age-classes as seen from the length-frequency distributions.

By October all the females were in an advanced stage of maturity as expected. In November, out of 78 specimens of all sizes examined, 63 were in stage V or above. In December, out of 74 females of all sizes examined, 61 were in stage V or above. Juveniles in stage I of maturity and also indeterminates occurred in good numbers from December onwards but ripe and recovering-spent stages continued to occur in the older age-class throughout the last quarter. Most of the older individuals of the new brood had reached stage III of maturity by March when there were also a few occasional specimens in still higher stages.

Plankton collections have been examined for further study of the eggs and larvae of this species and the work is being continued.

5. *Half-beaks*—Hemirhamphus *spp.*

There were good landings of *Hemirhamphus* spp. and *Hyporhamphus* spp. in the Mandapam area. Analysis of four morphometric and four meristic characters of *Hyporhamphus georgii* by the technique of Analysis of Covariance and Analysis of Variance respectively did not reveal between area differences.

The food of *Hyporhamphus georgii* at the different stages of maturity was different, partially due to their selective nature in food habits and partially also due to the different pattern of distribution of the spawners and the spent fish. The adults of *Hemirhamphus far* and *Hyporhamphus gaoyi* feed exclusively on the sea grass, *Cymodocea.*

The present study has confined the single spawning of both *Hyporhamphus georgii* and *Hemirhamphus marginatus* by the investigations on the relation between ova diameter frequencies and the seasonal variations of the male and female maturity. The fecundity and sex-ratio of these two species have been investigated in detail.

6. *Seer fish*—Scomberomorus guttatus

The species constituted 3·7%, 6·8%, 57·2% of the total estimated fish landings at Lawsons Bay in March, April and May respectively. The very

high percentage composition in the month of May far exceeded any previous record and the estimated total catch of the species was more than double the peak catches during the past two years. Teleosts formed the bulk of the food of which species *Anchoviella*, *Sardinella*, and *Thrissocles* were the important items besides which crustaceans were also observed mainly represented by *Squilla*. Females were of a higher percentage in the samples examined than males. Majority of the specimens observed in March were in an advanced state of maturity while immature females were dominant in April and May. Length measurements showed that three modes were present in March namely 380–400 mm., 440–60 mm. and 500–20 mm. and from April–June modes at 360–80 mm. and 440–60 mm. remained constant. Morphometric measurements and meristic counts were made with a view to finding out racial differences.

7. *Mullets*—Mugil *spp.*

Detailed biological studies on the two species mullets, *viz.*, *Mugil cephalus* and *Liza macrolepis* from the Pullamadam lagoon (near Palk Bay) were continued with special reference to their growth rate. Preliminary observations made on the various aspects are detailed below. *Mugil cephalus*—The stomach contents of juveniles showed Foraminifera forming the major item in the food taken along with decayed organic matter and algæ. The 'breaks' observed in the circuli on the scale of fish collected between December 1958 and January 1959 did not occur in any month during the year. Therefore, it is doubtful whether these 'breaks' could be taken as annuli. During December–March immature gonads (stages I–II) were seen in fish beyond 200 mm. (length to caudal fork—L.C.F.). Nematode parasites belonging to the genus *Paranisakis* were found in the body.

Two distinct size-groups, 97–139 mm., and 205–301 mm. were caught in the lagoon in January. But the latter size-group no longer occurred in the catches from March. It is of interest to note that when these large-sized mullets (about 205–301 mm.) scarcely occurred in the lagoon catches on 3-3-1960, fish of about 321–407 mm. were caught on 5–3–1960 in the shallow areas of the Gulf of Mannar around the Manauli island, by the same net. These fish were in stage II of maturity. Continued observations on this differential distribution of the size-groups might throw some light on their spawning behaviour.

Liza macrolepis.—The food of juveniles is basically the same as that of *Mugil cephalus*. *Pleurosigma*, *Navicula* and *Nitzschia* formed the major items in the food of fry. Mature and spent fish obtained in the catches from the sea had mainly Copepods and Diatoms in their stomachs. Although

mature individuals were encountered in the lagoon and Palk Bay catches from June–January, the peak period for them was from June–September, when they were caught in the sea by *Vidu valai* and cast nets. They ranged in size from 186–313 mm. Younger size-groups, about 85 mm. were caught in the lagoon almost throughout the year, the largest size caught being 232 mm. Detailed studies on the food, maturity and growth rate are under progress. The weekly departmental plankton collections from Palk Bay and Gulf of Mannar during June–August were examined for the occurrence of the larval stages but with little success.

8. *Tunnies*—Katsuwonus pelamis

Since the earlier g neral survey of the fishing industry of Minicoy Island in the Laccadive Archipelago, with special reference to Tuna fishery, the study of the biology of tunnies was actively being pursued. Although thunnids occur along the Indian Coast their larval forms are not known. It has been possible to collect and identify the early larvæ of *Katsuwonus pelamis* and *Neothunnus macropterus* from the Laccadive Sea.

Knowledge of the kind of organisms on which skipjack (*Katsuwonus pelamis*) feeds and the relative abundance of different organisms are of importance to our understanding of the aggregations and behaviour of skipjack in the Laccadive Sea. The major items of food may be divided into (i) crustaceans, (ii) cephalopods and (iii) juvenile and larval fishes. Among the crustaceans stomatopod larvæ, mysids and megalopæ predominate. Fishes consist of juvenile of Balistidæ, Ostraciontidæ, pipe fishes, etc. Organisms of various sizes are found. The.e does not seem to be any selective feeding. Instead they appear to snap any organism that "wriggles" or swims in the open sea. Most of the stomachs were either empty or with only traces of food materials excluding bait fishes. Therefore the hungry fishes migrating for food towards the coral reefs and lagoons which sustain a comparatively rich fauna appear to contribute to the fishery.

Mature gonads are found mostly throughout the year. But the occurrence of ripe gonads during certain months along with spent gonads indicates that period as the spawning per.od. Gonads in the most mature stages but not yet shed are found in November and December. But spent ones are not found until April. Therefore the active spawning period is between these periods. The continued occurrence of spent ones up to August suggests that it is a prolonged one. The studies on ova diameter reveal two spawning periods within the season by the presence of two peaks. The fecundity in relation to fish length and weight was also completed. The unequal sex ratio with males predominant during the spawning period and subseqeuntly

the females when the spent fishes are found in catches to suggest that the spawning females most probably avoid the bait.

9. *Molluscs*

The data collected while collaborating with the scientific staff of the Madras State fisheries and the F.A.O. Underwater Expert in the survey of the Pearl Oyster beds off Tuticorin were analysed. The survey of a few paars such as the Tholayiram paar, the Pernando paar and the Devi paar was carried out in a detailed manner. The Tholayiram paar is the biggest with an area of about 9·84 sq. kilometres and a total population of about 9,84,00,000 oysters. The analysis of the size-frequency distribution of oysters of the Tholayiram paar clearly indicates that they belong to the same brood. Since they have not attained the minimum fishable size, it is felt that the oysters should be allowed to grow for one and half years or more before they are fished. The survey also indicates that the Pernando paar has an area of about 0·20 sq. kilometre with a population of less than 2,00,000 oysters and the Devi paars about 0·13 sq. kilometre with a population of less than 50,000 oysters. The survey carried out on the southern paars did not reveal the presence of any live oysters at present in any of these paars. Only dead oyster shells were found in most of the places. Regular weekly collections of plankton and water samples were made from the Tholayiram paar area from December 1959 onwards and a detailed analysis of the water samples for various nutrient salts, salinity, dissolved oxygen, etc., is in progress. The study on the seasonal gonadial variation of the adult pearl oysters was started during the month of March 1960.

B. *Offshore Fisheries Investigations*

(*a*) *At Bombay: Commercial trawling operations.*—The two pairs of Bull trawlers of the New India Fisheries Limited operated from December 1959 onwards. One pair of these vessels did not operate from the post-monsoon period to December 1959. Hence the total catch was reduced from 36,15,648 kg. during 1958 to 27,25,478 kg. during the year 1959. Among the commercially important species being studied at Bombay, Eels constituted 14·44%, *Karkara* 10·27%, *Ghol* 6·51%, *Dara* 3·68%, *Koth* 2·01%. The catches from January–April were high due to concentration of trawling in the grounds off North Kutch, Dwaraka and Porbunder of which the North Kutch area had shown rich grounds of *Karkara*. During the monsoons the operations were confined to south of Veraval in the Cambay and Bombay areas and eels formed the major fishery during the period.

A total of 2,98,919 kg. of fish were landed by the Government vessels. 50·7% of these landings composed of *dhomá* (mixture of small Sciænids like *Johnius* sp. and *Otolithus* sp.). The others, in order of abundance, were Elasmobranchs 20% (of which Sharks formed 20%, Skates 18% and Rays 62%); Prawns 9·7% *Ghol* 5%, Cat fishes 4·6%, Clupeoids 2·7%, *Karkara* 1·2%, *Koth* 0·7% and others 5·1%. The peak periods of abundance were from April-May and October–February. A salient feature of the Otter trawling operations was the consistent good catches of *dhoma*. A study of the composition of the species constituting *dhoma* fishery, their abundance, distribution and fluctuations will be of great value to the development of Fish Meal Industry proposed to be started at Sassoon Docks from the ensuing fishing season. At present the operations of the Government trawlers were confined to the Bombay region where the bulk of *dhoma* was landed. The few voyages made in other areas along the Konkan and Gujarat coasts also brought large quantities of *dhoma*. These fish have been found abundantly around the 15–20-fathom areas.

Three vessels of the Government of India, M.L. *Sagarkanti*, M.L. *Meera* and M.F.V. *Jheenga* operated from Veraval. The first one operated the gill-n ts and the latter two vessels operated the trawl net. These vessels together landed 1,11,633·49 kg. of fish during the year. M. L. *Meera* operated for the maximum number of days (130) and landed the maximum quantity of fish (64,820·69 kg.). M.L. *Sagarkanti* operated for 87 days and landed 13,472·45 kg. of fish. M.F.V. *Jheenga* operated for 43 days and landed 33,340·35 kg. of fish. This vessel had the maximum catch per hour during the year followed by M.L. *Meera* and M.L. *Sagarkanti*. The operations at Veraval were closed down in the last w e'k of February 1960.

Fishery and Biology of Important Species. (i) *Dara* (Polydactylus indicus).—A study of the fishery of *dara*, exploited in offshore areas by commercial trawlers since 1956–57, showed that they were mainly concentrated in 1,200 sq. miles of fishing grounds located off Luchington Shoals at the entrance of the Gulf of Kutch, and off Dwaraka (68° 30′–69° 00′ E. and 22° 30′–23° 00′ N.). The period off occurrence always extended from November–March of the following year as seen from the systematic trawling operations conducted from 1956–59. The average catch of *dara* per hour of trawling in 1957 was 129·5 kg. which declined to 76·6 kg. in 1958 and improved to 97·9 kg. in 1959. At the peak periods of December–February the catch per hour varied from 178·8–294·1 kg. in 1957, 52·8–301·9 kg. in 1958 and 140·1–314·2 kg. in 1959. During 1960, however, these areas were not regularly visited since the discovery of rich *Karkara* grounds in

regions north and north-west of these areas around the 20-fathom line and hence poor catches of *dara* were recorded in the catches in 1959–60.

Length-frequency studies showed three distinct modes at 400, 550 and 650 mm. during January–March with an additional mode at 750 mm. in February. This pattern was found in the earlier and later months of the previous year also. Length/weight relationship showed that at 350 mm. the fish weigh 1 lb. (*ca.* 500 kg.) increasing at the rate of 300 gm. per cm. up to 600 mm., 150 gm. per cm. up to 720 mm., 500 gm. up to 1,120 mm. and 750 gm. up to 1,300 mm., to attain 60 lb. (27·2 kg.) in weight.

Most of the fish between 200 and 500 mm. were juvenile, 510–750 mm. immature and those above 800 mature. Spawners were recorded during May–June in the Gulf of Kutch. Further studies are necessary for understanding the nature of spawning and maturity. The adult and large-sized fish over 500 mm. feed mainly on smaller fish like species of *Johnius*, *Otolithus*, *Polynemus*, *Coilia* and *Cynoglossus*. Crustaceans like prawns, crab and *Squilla* were also found in good numbers in the stomach of smaller fish. Juveniles of less than 500 mm. are mainly predators of shrimps and crabs.

(ii) *Ghol*—(Pseudosciæna diacanthus).—A slight increase of 2,510 kg. was observed in the *ghol* landings of the Bull trawlers over last year (1958). The annual catch of *ghol* formed 6·51% of the total landings of the trawlers and occupied fifth rank in the order of abundance, while in 1958 it formed 4·38% of the total catch, occupying eighth rank. The fishery has been steady since 1957 and the peak landings for the year were observed in February, March and April.

From a study of the fishery of juvenile *ghol* at Versova, it would seem that specimens of 30–100 mm. observed in September are the products of spawning in July, August and these grew to a size of 200–50 mm. in about six months. Analysis of length-frequency data of trawler landings showed three to four modes in certain months while only two or even one in other months were recorded. The intensity of feeding in juveniles was observed to be more during September–December when prawns formed nearly 70–80% of the diet. In December, the food consisted mostly of fish which formed 47% of the gut contents and prawns diminished in proportion. Adult fish were found at stage IV of maturity and over from April–June. Spent fish were recorded from August and by October almost all the adults were found in the spent or recovering stages which continued up to March. The peak spawning period extended from September–November indicating protracted spawning. Ova diameter studies indicate the presence of only one spawning in the fish during the year. The study of scales showed

the fishes of 300–450 mm. had one growth check, 550–650 mm. 2 checks, 700–800 mm. 3 checks, 850–950 mm. 4 checks and 900–1,000 mm. 5 checks. Six rings were found in specimens of 1,000–1,100 mm. group. These growth checks coincided with the length-frequency modes up to four or five rings.

(iii) *Koth* (Otolithoides brunneus).—The major part of the *Koth* catches was made by Bull-trawlers of the New India Fisheries which amounted to 56,198 kg. or 2·06% of the total catch during 1959. Adults were completely absent in these catches. The lengths ranged from 270–1,025 mm. when inshore landings were also taken into account. Length-frequency polygons indicate that 0-year fish were represented around 175 mm., 1-year fish at 396 mm., 2-year fish at 595 mm. and 3-year fish at 805 mm.

Examination of gut contents showed that the *Acetes indicus* formed the dominant item among prawns and *Coilia dussumieri* and *Bregmaceros maclellandi* among fishes. The study of intensity of feeding showed that there were two distinct periods, one of high feeding activity during March–June and the other of low intensity from December–February.

Few mature fish were landed in offshore catches. Ova diameter studies of gonads collected during 1958–59 indicate the presence of one spawning in the year and that the ova are shed at one time.

Scale studies indicate that at 418 mm. the first ring is formed. Twelve rings were present in the scales of fish of 1,490 mm. long. Low-feeding intensity during November–February every year seems to be responsible for the formation of these rings. In the otoliths, however, the third ring corresponded to the first ring on the scale, the fifth to the second and the sixth to the third ring.

(iv) *Karkara* (Pomadasys hasta).—*Karkara* constituted 10·27% of the landings of the commercial trawlers for this year, whereas in 1958–59 they amounted to 5·4% only. It was noticed that the trawlers started operating in new grounds off North Kutch. The catch per hour in these areas ranged from 221·33–397·92 kg. per hour.

Age and growth studies with reference to otoliths showed the presence of clear growth checks of one ring in fish of 130–240 mm. length, two rings in 250–360 mm. These growth checks coincide with the length-frequency modes. Detailed studies are being carried out to establish the age of these fishes.

Analysis of stomach contents showed a predominant crustacean diet composed of *Squilla*, prawns and crabs. Fish also formed an important

item of food. Occasionally molluscs, *Echiurus* and polychætes were also found.

The study of maturity indicated the presence of mature fish from April–July and spent fish from August–October. Only one spawning in a year is indicated in the ova diameter studies.

(v) *Wam* (Muræsesox talabonoides).—*M. talabonoides* constituted 14·44% of the total landings of the trawlers and occupied the first place in order of abundance in the commercial trawler landings. Total lengths of 144 specimens of *M. talabonoides* ranged from 260–1,965 mm. Specimens examined for food contents revealed the presence of teleostean fish, namely *Synagris japonicus, Platycephalus indicus* young eels, prawns and crabs. A few ovaries of *M. talabonoides* were studied to understand the maturation in the fish. Ova diameter studies point to the presence of only one spawning in a year. Otoliths examined show clear growth checks. Further data are being collected to correlate the checks with the length of the fish along with the other biological aspects, to understand age and growth. The skeletal study revealed the phenomenon of hyperosteosis in various skeletal parts. Teratosis of the caudal region was found to be common among both the species, the cause and nature of this mutilation is yet to be determined.

(vi) *Bombil* (Harpodon nehereus).—Length-frequency studies of fish collected at Versova during April–May 1959 showed one mode at 95 mm. Fishing was suspended from June–September. During October–December more than 50% of commercial catches consisted of juvenile fish below 200 mm. total length.

Maturity studies showed that the percentage of males was slightly higher during March–April (34%) while in May it was (25%). Among the females the percentage of mature fish between stages V and VI was highest in March 1959. Similarly spent fishes were recorded in high percentages in May 1959. The ovaries of all specimens examined during September were in stages I and II of maturity. During the last week of October fishes of advanced stage V of maturity were noticed. In November, however, 25% of the catch were found at this stage.

The study of stomach contents showed that *Harpodon* fed mostly on smaller fishes. This diet, in the order of abundance, consisted of *Bregmaceros maclellandi, Polynemus heptadactylus, Coilia dussumieri, Harpodon nehereus* and *Otolithus* sp., while in May this consisted of *Acetes* sp., *Leander tenuipes* and *Solenocera* sp. The feeding activity appeared to be considerably lower during September and gradually increased during October–November.

Raciation studies of *Harpodon* collected from Jaffrabad, Versova, Janjira-Murud and Masulipatam based on eleven morphometric characters indicate significant differences among seven characters at 1% level. This showed that populations of the different centres did not come from a single homogen ous stock. The catches of Versova and Janjira-Murud appeared to come from the same or closely related stocks. The Jaffrabad catches seem to originate from another independent stock.

(*b*) *At Ernakulam.*—From April–June 1959 the cutters PRATAP and ASHOK of the Government of India Offshore Fishing Station continued their bull-trawling activities in area 108 lying off Cochin and landed 1,21,651 kg. of fish with an average of 1,237 kg. per hour of trawling. During the monsoon break which followed, these vessels were reconverted into otter-trawlers and M.T. Ashok was removed to the newly opened offshore fishing unit at Vizagapatnam and M. T. Pratap was left at Cochin to continue the work independently with the help of an 84′ otter-trawl.

During the period from September–February Pratap landed a total quantity of 1,04,358 kg. of fish spending 626·74 hours in actual trawling. The average yield worked out to 167 kg. per hour, which is very much lower than the seasonal averages realised by bull-trawling in the previous years from the same grounds and the composition of the catch also did not show significant changes. 'Miscellaneous small fishes' formed the major portion of the catches which contained larger proportion of *Nemipterus japonicus* and *Lactarius lactarius*. Prawns were scarce.

1957–58 season seems to have yielded the best results as far as the total catches were concerned. Examination of the data shows that there is a consistent decline in the rate of yield of fish in February and June. The decrease noted in June is borne out by the results of the other vessel also but that noted in February is found in the matter of bull-trawling only. The reason for this consistent decline in the catch rate in June cannot be attributed to lesser amount of effort in that month, but it has to be considered as a regular phenomenon, possibly bought out by environmental factors.

During the four seasons in which the cutters were operating from Cochin the exploratory fishing was carried out in 15 areas distributed from Calicut to Cape Comorin in depths ranging from 13–50 metres; but with the exception of 4 areas, *viz.*, 106 A, 108, 110 and 111, lying off Cochin and Alleppey all the other areas have been visited only occasionally. Of the total fishing effort put in by these vessels as much as 85% was spent in those areas.

In the months of February and March 1960 two voyages were undertaken by Pratap to Wadge Bank areas, from where altogether 19 hauls were

Table showing the average catch-per-unit-of-effort (kg. per hour) of trawling during the four seasons

	1956–57	1957–58	1958–59	1959–60*
September	..	..	..	60
October	..	..	..	252
November	..	672	..	168
December	..	1215	..	189
January	..	1203	611	135
February	..	859	536	191
March	406	1036	1498	..
April	454	1462	1367	..
May	450	1364	1206	..
June	218	520	564	..
Yearly Average ..	424	1038	954	167

* Otter trawling.

taken. The catches were not particularly encouraging although very rich in variety. It consisted mostly of species of *Chætodon, Lethrinus, Holocentrus, Lutjanus,* etc.

In January and February two Tuna-fishing voyages were undertaken by the research vessel Kalava of the Indo-Norwegian Foundation and the purse-seiner Bangda of the Deep Sea Fishing Station, Bombay. During the first voyage 7 tunas were caught from waters around the Laccadive Islands and 2 from near the main land in Kalava's trolling line. Tuna shoals were seen in many places but attempts with purse-seine were not successful. Second voyage was undertaken along the 25–30-fathom line off the coast from Cochin to Cape Comorin. During this trip 6 tunas were caught in trolling line and one in the drift net but none was caught in the purse-seine which was operated twice. *Euthynnus affinis, Neothunnus macropterus* and *Katsuwonus pelamis* were represented in the catch.

Shrimp trawling: (i) *By boats of the Offshore Fishing Station, Cochin.*— The small fishing vessels DURGA, TARPON and SAMUDRA of the Offshore Fishing Station, Cochin, continued to carry out shrimp trawling operations during the period under report. With the exception of a few hauls taken from areas 111 and 110 and a voyage by DURGA to Mangalore where she did Bull-trawling, all the other operations were carried out within 25 miles from Cochin fairway light buoy in areas 108 and 106 A, in depths ranging from 5–55 m. The total landings of these three vessels from April 1959–February 1960 amounted to 3,33,349 kg. over a trawling time of 1,598·6 hours; the average catch being 208·52 kg. per hour. The monthly catch rates varied from 35 kg. per hour in June to 283 kg. per hour in October. The catch returns were found to be distinctly higher in the post-monsoon months than in the pre-monsoon months.

The total catch of 3,33,349 kg. at the rate of 208·52 kg. per hour realised by these boats during the current season is more than double the catch realised by the same boats in the previous season; the catch of the previous season being 1,43,222 kg. at the rate of 104·54 kg. per trawling hour.

'Miscellaneous small fishes' constituted 48·8% of the catches while the other categories were Prawns (19·2%), *Lactarius lactarius* (8·5)% and sharks and rays (7·6%). From October–February there was a progressive increase in the landings of 'miscellaneous small fishes' raising from 13,508 kg. in October to 53,047 kg. in February. In September and October when the trawlers operated in deeper waters beyond 37 metres depth *Nemipterus japonicus* formed the dominant catch and constituted more than 80% of the total catch. While prawn catches were poor in the earlier part of the season there was a significant rise in their occurrence in January and February when they formed 15·9% and 19% respectively of the total landings in those months. From November–February *Lactarius lactarius* formed one of the important category. Its percentage in the total catch varied from 6·3–13·3% in certain months.

(ii) *By boats of the Indo-Norwegian Foundation.*—Although some of the medium boats of the Indo-Norwegian Foundation commenced fishing in late September the full fleet comprising of the boats M_2, M_3, M_4 and Flying fish started shrimp-trawling operations only from October. In early December ASHTAMUDI joined the operations and in the middle of December M_1, the boat hitherto engaged in Purse-seining, joined the trawling fleet. Since December all these vessels except FLYING FISH were working off Cochin. Fishing was mainly carried out at 5–25 fathoms depth in area 108.

Details of catch

Months	Total catch (kg.)	Catch/hour (kg.)
September 1959 ..	2,243	57·5
October ..	25,627	262·2
November ..	17,172	111·2
December ..	39,573	111·2
January 1960 ..	62,280	140·8
February ..	76,509	177·9
TOTAL ..	2,23,404	AVERAGE .. 151·37

In September the fishing operations were poor. The best catch return of 262 kg. per hour was realised in October but the rate of yield came down to less than half in the next month and remained steady in that condition till the end of December. From January onwards the catch rate was seen to increase indicating the same trend observed in the catches of the small vessels of the Offshore Fishing Station.

In September, October and even in early November, when the post-monsoon fishery was not established in the shallower regions, these boats were concentrating in the deeper regions (20–25 fathoms) to capture the *Kilimeen* (*Nemipterus japonicus*) which were then plentiful in those regions and formed 85% of the total catches of these months. November onwards, with the boats shifting their operations to the shallower grounds, 'miscellaneous small fishes' comprising *Lactarius lactarius*, Sciænids, Carangids, Upeneids, Ribbon-fish, Cat-fish, etc., began to dominate in the catches. Prawns appeared in small quantities in November and constituted 22% in December, 32% in January and 49·6% in February.

Purse-seining.—The boat M_1 started experimental Purse-seining off Cochin in area 100 from late September for catching mainly sardine and mackerel. In September no shoals were encountered. In October a total of 4,295 kg. of fish were landed of which mackerel and sardine respectively constituted 56·5% and 42·6%. In November lesser mackerel and sardine shoals were met with and major portion of the 7,524 kg. of fish netted consisted of elasmobranchs and *Sardinella fimbriata*. In December and in the first week of January a total quantity of 44,569 kg. of fish was landed of

which 43,179 kg. was oil sardine. Mackerel was very few. After the first week of January the boat M_1 joined the trawling fleet.

Biology of Nemipterus japonicus.—Detailed studies on the fishery biology of *Nemipterus japonicus*, a percoid fish occurring abundantly in the trawl catches were taken up from the beginning of this season. In September, this fish constituted more than 80% of the total catches of the small vessels operating in areas 106 A and 108 in depths over 37 m. In the subsequent months the fish was scarce in the catches since the trawlers shifted their operations to the shallower waters of depth 13–27 m. But from February onwards it started to appear in the shallow waters also and were caught in large quantities. While the modal size of this fish fluctuated between 120-30 mm. in September-December it advanced to 140 mm. in January-March. In the latter period specimens of 80–100 mm. were also encountered which indicated recruitment of the smaller size-groups. The species begins to attain maturity from September and by October-November majority of the fishes between 100 and 150 mm. were in stage IV and above. The number of mature specimens declined in December and from January onwards immature specimens of stage II and below dominated in the catches. Prawns, polychætes and fish were the common food elements met with in the stomachs.

(*c*) *At Tuticorin*.—During the period under report frequent trips were undertaken on board the vessels of the Offshore Fishing Station, Tuticorin, and the fishing data collected were analysed and compiled. Six vessels were operating for varying period of the time during the year. The area of fishing was within a radius of 12 miles from Tuticorin. Bottom-set gill-nets, driftnets, long-lines, revolving chain hooks and trolling lines were used. The data are summarised in the following table:

Name of vessel		Number of sets	Total catch (kg.)	Catch/set or/100 hooks (kg.)	Sharks and rays (%)	*Chroinemus* (%)	Perches (%)	*Caranx* (%)
Sardinella	Bottom-	73	7131	98·40	30·6	18·2	20·9	7·2
Sagar Sundari	set	36	48·4	133·50	26·8	33·1	21·5	6·8
Sagar Kumari	gill-	30	1022	34·10	48·0	..	12·5	15·5
Meenakshi ..	nets	76	5405	71·70	19·0	17·0	10·6	39·7
Sagar Kumari ..	Drift-	18	162	9·00	57·7	..	..	..
Sagar Sundari ..	nets	10	131	13·10	36·1	..	..	..
Sagar Sundari ..	Long-	33	200	2·27	..	..	50·0	..
Meenalochani ..	lines	29	238	2·73	..	..	58·1	..
Gudjon ..	R.C. Hooks	11	1215	157·10	100	..	..	..

It was seen that bottom-set gill-nets were the most successful. Trawling could be done only off Pinnakayal as the ground elsewhere is unsuitable for the purpose. SAGAR KUVARI brought a total catch of 3,113 kg. over 58 hours of trawling with a catch per hour of 53·61 kg. Prawns constituted 26·14% of this catch. Drift-nets and long-lines were ineffective while revolving chain hooks were promising. Trolling was unsuccessful. In the bottom-set gill-nets sharks, rays, *Chorinemus*, perches, and *Caranx* were the important fishes caught. The last three were taken in greater quantities during May-June and in September.

(*d*) *At Waltair.*—Work was undertaken in October 1959 in collaboration with Mr. Naumov, F.A.O./Fisheries Expert and in pursuance of the programme the research staff of the Unit availed of the voyages of the fishing trawlers of the Deep Sea Station, Government of India. Six trawling trips of M.V. ASHOK and four of M.V. SEA HORSE were utilised for scientific observations and collection of fish specimens up to end of March 1960. The first trip in the month of November on board M.V. SEA HORSE was of a more exploratory nature and it was observed that the catch off Visakhapatnam was predominantly *Anchoviella* spp. The vessel was stationed at Lion's Rump for fishing in the area around the mouth of Mahanadi. Trawling was conducted at seven areas and the Scientific Officers who participated in trawling made notes of common fish occurring in these grounds, other important fishing data, besides temperature recording and collecting specimens for further laboratory examination.

The area of operation for M.V. ASHOK was mainly off Orissa Coast in depths ranging from 18–24 fathoms. In addition to making collection of specimens, the Officers who participated in these cruises recorded the fishing data, nature of bottom, temperature, etc.

The work of analysis of the fish collections is being continued in the laboratory with special stress on the breeding and feeding habits of the major and more important species occurring in these waters.

(*e*) *At Calcutta.*—A total number of twenty-six voyages were performed by the West Bengal Fisheries Trawlers, Kalyani I-V during the period under report. The voyage of Kalyani I was a complete failure and unproductive as the vessel met with rough weather and heavy damage. Table on next page gives details of the fish catch of the different vessels.

Information such as the general catch area of operation, depth range were gathered from the Master after the vessel's arrival, at the fish landing centre (shore base station).

Name of vessel	Number of voyages	Fish catch (in kg.)			Total catch in kg.
		'A' class	'B' class	'C' class	
Kalyani II ..	6	531·00	83515·87	254·46	84301·33
Kalyani III ..	7	4358·31	49991·45	1584·16	56933·92
Kalyani IV ..	7	893·39	27656·45	1926·31	30476·15
Kalyani V ..	5	1436·00	61757·98	2813·92	66007·90

Periodical voyages were made in Kalyani III and V (which are the only two vessels in which lodging facilities are available) by the scientific staff of this Unit in order to collect detailed data on the total catch per haul, catch composition, length measurements of important groups of fishes, etc., of the different offshore fishing areas. It is obvious that Black Pagoda is the most productive fishing ground. It is also of interest to note that each of these areas is domir.ated by different groups of fishes. When the catch composition of those different fishing regions is analysed it is seen that *Sciæna* spp. and glass-fish (*Kurtus indicus*) occur in large quantities in Sand Heads, off Mahanadi, Devi and Prachi rivers. Fourteen species of Sciænids were obtained of which the commonest forms were *Sciæna glauca, S. carutta* and *S. aneus.* The other sciænids are identified as *Sciæna diacanthus, S. axillaris, S. bleekeri, S. semiluctosu, S. coibor, Sciænoides brunneus, S. microdon, Otolithus ruber, O. argenteus, Umbrina russelii* and *Umbrina macropterus.* Pomfrets and other small perches formed the major catch of Black Pagoda. Though the three varieties of Pomfrets are available the commonest species is *Pampus argenteus.* The major catches in False Bay are clupeids; the common forms are *Pellona indica, P. elongata, Engraulis telara* and *Raconda russelliana.* 'Swatch of no grounds' is noted for quality fishes such as species of *Lutjanus, Parastromateus,* and *Pomadasys.*

There is some evidence from the data so far collected that the fish production is more during the winter season; December and January were the most productive periods when 1,39,119·10 kg. were obtained which formed more than half the total landings for the year. A gradual decrease in the catch was noted after January right through to April. No fishing activities were undertaken by the West Bengal Fisheries Trawlers during the monsoon periods May–July. When expressed in terms of percentage out of the total catch "A class" constituted 3·00%, while "B class" 93·30% and "C class" 3·70%.

Sciænids formed the most important catch constituting 63% of the total; a peak period in the abundance of Sciænids fishery was noted in the month of January. It was also noted that there is a remarkable increase in the fishery of clupeoids in the month of January constituting the next important catch during this year. Though glass fish (*Kurtus indicus*) occurred in almost all the catches, when compared with the landings of the previous year there was an appreciable decrease in the catch.

The activities of the fishing trawlers were confined to Western channel, S.W. of Puri coast, mouth of Chilka off Devi and off Prachi, Black Pagoda, off Mahanadi and False point at a depth of 3–30 fathoms. Off Devi and Prachi river-mouths were most frequently fished.

Biology of Kurtus indicus.—Samples of glass fish (*Kurtus indicus*) were collected from the West Bengal Fisheries Trawlers K II–V from off Devi and Prachi river-mouth, Black Pagoda and off Mahanadi river. The predominance of this fish was noted in Devi and Prachi river at a depth of 8–20 fathoms. A total number of 421 specimens were examined, ranging from 48–122 mm. in length. Nearly 60% of the specimen were females in the immature stage. The analyses of the stomach contents revealed that these fishes feed more on crustacea such as species of *Acetes*, *Squilla*, Penæus and Cumaceans.

Though *K. indicus* occurs in almost all the months the peak period of its landing was during January when it formed more than 1/12 of the catch. In the month of April it was landed in very small quantity.

Biology of Sciæna glauca.—The fishery of this species during the year 1959–60 was good and of the total landings of 1,49,767·87 kg. of Sciænids at the shore-base station by the West Bengal Fishery Trawlers about 40% constituted *Sciæna glauca* and the remaining 60% included other species. The peak period in the abundance of Sciænids was observed in the month of January.

Samples collected, both on board the vessels and also from the Shore Base Station, were studied with a view to elucidating various aspects of the biology of the fish. From the length-frequency data collected, it was observed that size-range varied from 45–210 mm. Almost all the specimens of *Sciæna glaucus* measuring less than 134 mm. were found to be immature, those between 135 and 152 mm. were found to be maturing and those beyond 153 mm. were found to be mature. 75% were male and 25% female. 20% were mature, 30% maturing and the remaining 50% immature. The three main types of food items observed in the stomachs of the fish were teleosts,

crustaceans and molluscs. Besides these, polychæte larvæ and sand particles were also observed in fair quantities along with diatoms and hydrozoan remains.

C. *Physiology and Marine Fish Farming*

The dynamics of osmotic regulation in *Tilapia mossambica* were studied. Fish weighing from 0·1–50 kg. were used after acclimation to tap-water, 50% sea-water and sea-water at 15°, 20°, 25°, 30°, 35° and 40° C. The results showed that for a 20 gm. fish the effective range of operation where the osmotic load on metabolism is inversely proportional to the salinity of the environment is within the narrow range of 30–35° C. This indicates that for *Tilapia* a temperature range of 30–35° C. in the environment would be well suited for osmotic regulation.

Field observations on the factors leading to the incursion of countless number of *Chanos* fry into the creek at Pamban indicates that the fry do not confine, within their limits, to any particular food element available there. But their spatial distribution in the creek and their preference for the really warm fringes of the shallow creek indicate that the warm environment is very essential for sustaining their relatively higher metabolic rate. The laboratory findings in which the cold sensitiveness of *Chanos* fry was demonstrated earlier thus finds further support.

In April 1959 the entire stock of fish in the ponds was fished out. The yield varied from 195–455 kg. per hectare in the different ponds as against only a maximum of 220 kg. per hectare during the previous year under more or less the same conditions. *Chanos* had attained an average length of 300 mm. during the year. Although all possible attention had been bestowed in improving the results the low survivial rate of the fish caused by various conditions of the ponds, some of which are beyond control at the present state, have prevented a further increase in yield, while the data indicate a level below the optimum yield.

After the harvest, the ponds were prepared and restocked with *Chanos* fingerlings from the lagoon adjoining the fish farm. The principal objects of the culture experiments during the year have been (1) to compare the growth of the fish without artificial feeding of the fish or manuring of the ponds unlike during the earlier year, and (2) to observe the growth of the fish beyond the first year and to ascertain any practical advantage in this. A fall in the growth rate of the fish as compared to that in the previous year has been indicated so far. This might be largely accounted for by the absence of artificial enrichment of the ponds and the lack of adequate fish food. The results thus point towards the need for some kind of artificial enrich-

ment of the ponds to improve the normally available conditions. As regards the practical aspects of culturing the fish in these ponds beyond one growing season, the 1960-61 data will have to be awaited.

Preliminary trials on the possibilities of having smaller separate compartments in the same site for field experiments on nursery management have been started.

IV. Marine Biology

A. *Planktological Investigations*

(*a*) *At Kandla.*—The work on planktological condition of the Kandla creek was started in August 1958 and was in progress during the year. In the zooplankton the common forms present were *Acartia*, *Labidocera*, *Centropages*, *Eucalanus*, Pseudodiaptomids, *Rhincalanus*, *Euterpina*, *Oithona*, *Corycæus*, crustacean eggs and larvae and bivalve, gastropod, echinoderm and polychæte larvae and tintinnids. Fish eggs and larvae were also observed in August–November and then again from February-April. Medusæ and Protozoans were present in collections during June–August or September. Copepods were in abundance in August, February and April, whereas crustacean larvae reached their peak in April followed by minor rise in July. Chætognaths appeared in moderate numbers in collections during November–March.

(*b*) *At Karwar.*—Plankton displacement volume showed that the post-monsoon months are the most produc ive and that showed maximum production in the North Kanara Coast and Ankola the minimum zooplankton population was richer towards the south and more of the phytoplankton dominance is met with at Karwar and Chendia.

Primary phytoplankton maximum was in the month of September and there was also a secondary peak in January. Diatoms were found to bloom only once during the period of observation, in September at Karwar and the important species were *Fragilaria oceanica* and *Nitzschia*. A slight dominance of diatoms observed at Kumta in August was cont ibuted by *F. oceanica* and *Thalassiothrix* sp. In Chendia the dominant forms in the peak period were *Nitzschia*, *Thalassiothrix frauenfeldii* and *Chætoceros* spp. *Chætroceros* spp. were the dominant form at all centres during the secondary peak period. *Coscinodiscus* spp. were found to occur all through the year though only in small numbers. *Trichodesmium* sp., which was found in April, disappeared in May and appeared again in January–March, but was never found to dominate at any place except at Chendia, where it showed minor blooms. Collections from Chendia were very rich in dinoflagellates

comprising mostly of *Ceratium tripos*, *C. fusus* and *C. furca*, all of them appearing later at other places as minor constituents. The rise thus seen continued later at all centres and by December–February *Ceratium massiliense*, *C. macroceros*, *C. vultur* and *C. trichoceros* were common. *Ceratium dens* and *C. tripodioides* occurred in still less quantity. Dinophysids and Peridinians were rare at Karwar and Ankola while tintinnids occurred only in the post-monsoon period.

Evadne were common in September, whereas *Penilia* dominated later. Copepods were abundant during September–October with *Acrocalanus* and *Oithona* sp. as major constituents. At Kumta *Acarita* was dominating. *Sagitta enflata* was dominant at Karwar and Chendia, whereas at Ankola and Kumta, *S. bedotei* seemed more predominant.

Appendicularians were quite common at Karwar and they were found dwindling in numbers towards the south. Various planktonic larvæ were abundant in November–February.

Fish eggs and larvae were most frequent in August–October. Clupeoid and Carangid eggs and larvae were common among the samples. Eggs and larvae of eels were also found.

(*c*) *At Mangalore.*—The analysis of plankton collected from 4-fathom area of Ullal revealed that plankton was poor from June–September 1959. During April and December 1959, January and February 1960, Plankton volumes were high. During the other months of the year the displacement volumes were moderate.

The monsoon phytoplankton bloom was not observed during this year. Among diatoms *Coscinodiscus* spp., *Chætoceros* spp., *Thalassiothrix* sp. and *Hemidiscus* sp. were poorly represented during the monsoon period. The diatom *Fragilaria oceanica* in abundance was observed in August. In November, due to swarming of *Noctiluca* a minor red-water phenomenon was observed in the inshore waters. An almost exclusive Radiolaria swarm was noticed in December as in the previous year. A phytoplankton bloom in lesser magnitude was recorded in January 1960. The common diatoms were *Coscinodiscus*, *Biddulphia*, *Thalassiothrix* and *Bellarochea* sp., *Trichodesmium* sp. *Noctiluca* continued to be present from January–March in appreciable numbers.

Lucifer, cladocera and copepods were dominant from April–July 1959. In August and September, penæiod zoea, fish larvae, and copepods were dominant. From October–December, cladocera and copepods were dominant. From January–March 1960, larvae occurred in swarms only in May

1960. Hydromedusæ, ctenophores, *Sagitta*, *Oikopleura*, cirripede nauplii, brachyuran zoea, were all minor constituents of the plankton.

(*d*) *At Kozhikode.*—During the year under report, studies on the magnitude of standing crop of phytoplankton were conducted with the net collections and sediments obtained by centrifugation. The seasonal cycle of phytoplankton was more or less of the same pattern as in the previous years, with a rich but short primary bloom during the south-west monsoon attaining its peak in August, and a secondary bloom of medium intensity during January–March, which was absent for the last two years. The standing crop in general was better than that of the preceding year and the poorest period was November–December.

Fragilaria oceanica was abundant in collections after the primary bloom, but became scarce quickly. This year its bloom was not a sustained one. *Noctiluca miliaris* was present throughout the monsoon season but was rarely abundant as to discolour the water. During the hotter months, swarms of *Trichodesmium* and *Zooxanthellæ* were sometimes seen.

Quantitative data on the fluctuations in the pigment units showed, that the magnitude of the crop was generally rich. It is also indicated that there might be an equally rich standing crop of nanoplankton. The estimation of the organic production in the sea by the 'dark and clear' bottle method was initiated.

Investigations on the possible relation between polychætes and bottom fisheries, with special reference to *Cynoglossus* fishery, were started. Stomach contents of *C. semifasciatus* obtained from landing grounds at Vellayil and from Departmental hauls were examined. Young of polychætes appeared suddenly in the bottom mud on 29th September. The 2-fathom area was the richest throughout, being dominated by *Prionospio pinnata* until December and by a mud-borrowing Pholadid during December. Adults of *P. pinnata* were never found in the area studied.

The plankton samples taken were poor in polychætes. Pelagic phases of *P. pinnata* were common during September–October. Polynoid larvae were observed during October and *Loimia* larvæ during December–January.

The *Cynoglossus* fishery was not good this year at Calicut. It commenced considerably late (during the last week of September) probably owing to the unusual prolongation of monsoonic weather. This fish was found to feed actively during the commencement of the fishery. In later months (January onwards) the stomachs were mostly empty. During September–November *Prionospio pinnata* was the dominant element in the stomach

contents (as well as in the bottom mud) and during December a mud-borrowing Pholadid (in the stomachs of *C. semifasciatus* as well as in the bottom mud). Larvae of *Pectinaria* were found in the stomachs in appreciable numbers during March; young ones of *Pectinaria* have been found in the bottom mud since February. Although the bottom fauna was almost completely depleted by the beginning of February, young ones of *C. semifasciatus* appeared in small numbers in the *paithu-vala* catches of February and March. The above observations are interesting since they strongly suggest that this bottom-feeding fish is not a selective feeder.

(*e*) *At Mandapam.*—Studies on organic production from six stations in the Gulf of Mannar were continued. Part of the data collected from the original station were processed. It was found that the magnitude of gross production for the two years from July 1957 was almost the same, in spite of monthly variations and shifts in the periods of maxima.

Studies on the plankton of the inshore waters off Mandapam were continued. The salient features of the plankton were:

1. The summer bloom of phytoplankton started as usual but the magnitude of standing crop seemed to be noticeably low, particularly in the Gulf of Mannar during the season. The phytoplanktonic dominance, as usual, continued up to October in Palk Bay, while it was only for a relatively shorter duration in the Gulf of Mannar.

2. There was a bloom of *Trichodesmium* in the Gulf of Mannar early in May.

3. During the first week of November there was a swarming of *Lucifer* in the Gulf of Mannar, while *Creser's acicula* swarmed in Palk Bay and the Gulf of Mannar during the second and third weeks respectively. By the end of November *Pleurobrachia* appeared in large numbers in Palk Bay and by the beginning of December they were common in the Gulf of Mannar. Trends in the species composition of copepods occurring in the inshore waters of the Gulf of Mannar were studied.

Studies on the chætognaths of the Gulf of Mannar and Palk Bay for 1954–58 were made. The analysis of the samples were completed and the data were studied in relation to the hydrographical conditions.

The chætognaths from Plankton collections made by R.V. Kalava during three cruises to the Laccadives were studied. After a cursory examination of the material, 18 species of chætognaths belonging to the genera *Sagitta, Krohnitta, Eukhronia* and *Petrosagitta* were reported. A very

interesting feature noted during the work is the very high incidence of parasites in these arrow worms.

Eggs of *Hemirhamphus* sp. were collected and attempts were made to rear them in the aquarium. Only a few of the eggs hatched out and it was possible to keep the larvae alive only for four days. Attempts were also made on a few occasions to rear the planktonic eggs in the aquarium tanks without much success.

(*f*) *At Madras.*—During the year under report work was started since June 1959 on the investigation of the plankton from all respects, particularly phytoplankton, on the waters off Madras. The pigment content of the water, displacement volume of plankton and dry-weight were all recorded besides noting the nature of the flora and fauna.

Except for brief periods, zooplankton has been dominant as regards bulk during most of the period. It is possible there is a seasonal fluctuation but the data on hand a e not sufficient to warrant conclusions. Some relevant data (monthly averages) recorded are given below:

	Harvey unit	Vol. ml.	Dry wt. mgm.	Harvey unit	Vol. ml.	Dry wt. m.gm.
I. Predominantly phytoplankton	13,920	9·7	467·5	298	3·3	202·3
II. Mixed plankton surface	..	37·6	1627·4	..	9·5	288·9
III. Mixed plankton bottom	..	40·5	1168·4	..	6·0	246·9
IV. Predominantly zooplankton	..	39·6	1315·3	..	7·3	328·3

B. *Oceanographical Studies*

(*a*) *At Bombay.*—During the year under report, hydrological observations were continued at Light House (L.H.) and Floating Light Vessel (F.L.V.) Stations near Bombay. At F.L.V. the mean salinity was 33·69‰, while at L.H. it was 31·81‰. The mean values for dissolved oxygen, inorganic phosphate and total phosphorus at F.L.V. were 4·0 ml./l., 0·49/μg. at P/l. and 1·36/μ, at P/l. respectively. The corresponding values at L.H. were respectively 4·3 ml./l., 0·84/μ at P/l. and 1·79/μ at P/l. Surface chlorophyll at Fl.L.V. ranged from 0·50-1·80/μg./l., with a mean of 1·00/μg./l.,

corresponding to a mean standing crop of phytoplankton equivalent to 27 mg. of carbon per cubic metre of sea-water.

In addition, vertical distribution studies were carried out at F.L.V. during June–December 1959. The results indicated the following ranges in integral mean concentrations of chemical constituents: salinity, 34·30–35·89; dissolved oxygen, 2·2–4·1 ml./l; inorganic phosphate, 0·26–0·76/μg. at P/l., and total phosphorus, 0·93–1·88/μg. at P/l.

With the aim of evolving a simple field method for phosphate "surveys", an attempt was made to extract the Molybdenum Blue in which form phosphate is usually estimated. It was found possible to develop a procedure in which the final blue colour is stable for 8 days, the optical extinction (in 1 cm. cell) per microgram phosphorus being 0·1.

(*b*) *At Karwar.*—Temperature was generally low during July–September which coincides with the South-West Monsoon. In the post-monsoon period it rose constantly marking a slight fall in October and again rose to have a secondary fall in January. Lowest record of temperature at Karwar was observed in the first part of August, whereas towards the south it was observed in succession at Chendia, Ankola and Kumta, in the second half of August, in the first fortnight of September and in October respectively. pH and salinity were also on the decline in the South-West Monsoon period, Karwar being considerably affected due to the influx of freshwater. Decrease of pH at Chendia and Ankola was only slight. Dissolved oxygen content was high during July–August. In Chendia and Ankola high concentration of this was in the month of September only. Phosphates remained low throughout but nitrites showed a little peak in August and another one in March. Concentration of silicates were very high at Karwar diminishing smoothly and successively towards the south in the North Kanara Coast.

(*c*) *At Mangalore.*—In April and May 1959, the surface temperature of sea-water was high and so also the salinity value, *i.e.*, 36·0‰. However, both values declined considerably during the monsoon period. In August the salinity was lowest. From September onwards the water temperature, pH and salinity values gradually increased.

(*d*) *At Kozhikode.*—Studies on the seasonal changes in the hydrological factors of the inshore and offshore waters of the Calicut coast were continued. Offshore collections were totally interrupted from June–August due to bad weather.

In general, the temperature of the inshore water was higher than that of offshore waters in November, January and February and lower during

the rest of the period, excepting in April and October when it remained the same. Surface salinity of the inshore waters was higher in April, October, November, February and March and lower during the rest of the period than of offshore waters. Excepting in April the bottom salinity was always higher in offshore waters. Surface phosphates were lower in the inshore area than in offshore area during the period from October–December and higher in the rest of the period and except in October, bottom phosphates were always higher in offshore waters. Surface silicates of the inshore environment were lower than of offshore one from October–February and higher during the rest of the period; except in October bottom phosphates were always higher in offshore waters. Nitrite cont nt of the inshore waters was in general lower than that of offshore waters. pH of both the waters remained more or less same. Surface oxygen of the inshore waters was higher than that of offshore waters in April, October, November, December and January and lower during the rest of the period; the bottom oxygen was higher in the inshore area from November–March and lower during the rest of the period. Surface total phosphorus of the inshore environment was lower than that of offshore one in April, December and January, March and higher during the rest of the period and except in the months of April and January, bottom total phosphorus was always higher in the inshore waters.

(*e*) *At Ernakulam.*—During the year under review, oceanographical investigations were carried out in the waters of the Arabian Sea along the South-West Coast of India and also the waters around the Laccadive Islands.

During January–February 1959, the shelf was occupied by more or less isothermal water down to 75 m. The waters were also well oxygenated. From the vertical temperature structure it is seen that the thermocline was below 100 m. and in some stations, the upper limit of the discontinuity layer corresponded to the 150 m. level. Stable conditions were observed in the months of March and April in the shelf waters. In the month of May 1959, typical pre-south-west monsoon conditions were seen. The temperature continued to be high in the whole of the waters of the shelf and was more or less uniform in the upper layers.

From June–September 1959 the active period of the South-West Monsoon, the shelf along the coast was occupied by water of low temperature, low oxygen content and rather high salinity. This was particularly seen during the latter part of the monsoon, in the whole of the shelf except in the shallow, near-shore waters. The thermocline and the oxygen-poor layer had both shown an upward trend and by the end of September, except for a thin layer of 10 m. at the surface, the entire body of water was of low temperature,

high salinity and very low oxygen content of less than 0·5 ml./l. All these point to the presence of upwelling at this time of the year and an analysis of wind records show favourable winds for at least part of the period.

The conditions during October–December 1959 indicate a gradual change-over from the monsoon conditions. In early October the surface temperature was low. The thermocline continued to be shallow and the oxygen-poor layer fairly high up indicating the persistence of upwelling. In late October and November the downward migration of the discontinuity layer as well as layer of oxygen-minimum had commenced and there is evidence of "down-welling".

The conditions in January 1960 were more or less similar to those of the same month last year. By February the salinity had shown a rising trend while the temperature was more or less the same as in January. Oxygen content was quite high down to 100 m., below which there was a very sharp decrease to values less than 0·5 ml./l. The thermocline was below 90 m. and in some observed at 120 m. The sinking, which had commenced in December, was still present in February.

In the Laccadives offshore waters the temperature distribution showed the presence of more or less isothermal water down to 50 m. The discontinuity layer was observed between 75 and 150 m. A salinity maximum was seen to occur within a tongue of high saline water at about 100 m. From the nature of the density surfaces and the computed geopotential anomalies it is inferred that there are circulatory water movements around the islands at practically all levels down to 500 m. The layer of oxygen minimum was seen to be present below 150 m. extending down even to 1,000 m.

The characteristic features of the waters near Cochin noticed during the post-monsoon season are (1) the surface salinity of the waters was low throughout the season sometimes going as low as 32‰, (2) the temperature of the waters had decreased and the subsurface layers exhibited high salinity. It is inferred that during this period the whole of the continental shelf is occupied by water which has upwelled from subsurface levels, (3) a characteristic uplift of the thermocline had occurred which was situated at a depth of 75–100 m. normally (for a greater part of the year) being now at about 10–70 m., (4) an examination of the oxygen distribution showed that the dissolved oxygen content of the surface layers off Cochin was uniformly high sometimes even exceeding the saturation value. But there was a steep decrease from about 10–20 m. downwards the values at deeper levels becoming very low.

With still more or less the same features the season proceeds till early October but a transition was conspicuous towards the end of the month and in the following winter. Even in early October upwelling was prevalent and as a consequence the surface temperatures were low. The salinity and dissolved oxygen contents also seem to support the above phenomenon. But towards the end of October there was a marked change. The rapid decrease of the dissolved oxygen content from about 10–20 m. noticed earlier was not prevalent during later October and the discontinuity layer had migrated down and a sharp thermocline was not evident even at 50 m. depth.

The winter characteristics were well developed during December. The temperature had increased and likewise the dissolved oxygen contents also. Even at 50–75 m. the dissolved oxygen values were very near saturation. The layers up to about 50–75 m. were completely mixed, the waters being mostly isothermal. The salinities in the mixed layer also were low. From an examination of the hydrographic data sinking seemed to be prevalent during December in these regions. The thermocline had migrated farther down and was evident only at about 100–50 m. Within the thermocline a salinity maximum had developed which was not found during the previous seasons.

C. *Algology*

During the year under review the taxonomic study of the algæ, collected from the Pearl beds off Tuticorin during the Pearl Fishery of 1958–59, was completed. One new genus of the *Lophothalieæ* was also recorded and this was critically studied.

Since there was no further change in the colonization and stabilization of the algal flora on the experimental boulder in Palk Bay, near Mandapam the observations were since centred on some of the more dominant species such as *Laurencia* and *Spyridia*. An attempt was made to measure the growth rate of the population as a whole in terms of dry weight per square centimetre of substratum surface (measured on a horizontal place), at regular short intervals so as to get an idea of the algal productivity, *i.e.*, the rate of production of material by the algæ from the inorganic material of the sea.

Work on the agar manufacture and resources was continued. *Gracilaria crassa* was found to be an equally good source of high grade agar as *Gelidium* and *Gracilaria lichenoides*. Adequate methods of handling this species as well as *G. corticata* for agar were found out. In the case of the latter addition

of lime was found to increase remarkably the gel strength of the agar. A new method of obtaining colourless agar from *Gelidium* and *Gracilaria* was found. This method also improves the porous texture of these agars. An estimate based on local sea-weed collections and harvesting of the resources in the dominant species of agarophytes of the Pamban and adjoining islands indicated a production of 2·6 m. tons of refined agar.

CENTRAL MARINE FISHERIES
RESEARCH STATION,
Marine Fisheries P.O., Mandapam Camp,
South India,
March, 31, 1960.

S. JONES,
Chief Research Officer.

V. LIST OF PUBLICATIONS DURING THE YEAR 1959–60

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