

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

**ANNUAL REPORT OF THE DIRECTOR FOR THE  
YEAR ENDING 31st MARCH 1961**

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## I. ADMINISTRATIVE AND GENERAL

Steady progress was maintained during the year 1960-61 in the implementation of the various programmes of work under the normal and Second Five-Year Plan schemes both at the Headquarters Station and the different subordinate establishments covering the entire coast-line of India. Systematic studies and the collection of data, on the economically important fishes, were continued at all the important fishery centres. Active efforts were continued to be made for the collection of scientific data and material from the Minicoy-Laccadive area and these studies have yielded very interesting results. The Centre at Minicoy is being strengthened by the appointment of an Assistant Research Officer there. A preliminary study was made of the fishery resources of the Andaman and Nicobar area with a view to exploring the possibility of setting up a research unit there under the expanded activities of the Research Institute during the Third Five-Year Plan period. A new research centre at Cannanore was opened with adequate complement of staff to intensify the studies on mackerel and sardines and also the general ecological problems there.

The total landings of marine fish during 1960 were estimated at 878,242 metric tons which was the highest figure recorded since 1950 and was nearly three lakhs metric tons higher than the figure for 1959. The fish landings in all the States registered increase over those of 1959, but the most outstanding increases were recorded in Kerala, Mysore, Maharashtra and Gujerat, while the landings by mechanized vessels also registered some increase. Volume VII, No. 1 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 Rs. Eleven and Three lakhs respectively. Among the important items of capital works that were taken up during the year mention could be made of the renovation and extensive repairs to the laboratory blocks at the Research Institute at its Headquarters Station. This work is over in respect of two blocks and the remaining works are also expected to be completed within the next few months.

A supply of underwater diving equipment required in connexion with our projected studies on exploratory survey of the pearl and chank beds off Tuticorin has recently been received from the United Kingdom. Two Pablo Boats intended for the Karwar Research Unit and Vizhingam Research Centre have been received through the Directorate-General of Supplies and Disposals.

The library of the Research Institute was considerably augmented with the acquisition 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* but requests for exchange facilities with our Journal are constantly on the increase and in view of the limited quota prescribed for exchange and free distribution of the Journal, a number of requests could not be fulfilled. A list of research publications from the Institute during the year is given at the end of the Report.

The following appointments of Assistant Research Officers were made during the year.

Shri S. Mahadevan, Shri G. Raju (he, however, relinquished the post subsequently), Shri P. T. Thomas, Shri M. J. Pradhan, Dr. V. S. Durve, Shri M. R. Patil.

Shri M. Krishna Menon, Research Officer (for Prawns), who was due to retire from service on 13-1-1961 on attaining superannuation, was granted extension of service for one year.

Sanction has been accorded by Government for the conversion of 68 temporary Class I, II, III and IV posts in the Research Institute into permanent ones with effect from 17-12-1960 and action for the confirmation of staff against these posts has been taken.

Dr. (Mrs.) F. Thivy, Assistant Research Officer (for Marine Algology), who was re-employed in the same post for one year from 5-10-1959 on attaining superannuation, relinquished the post on completion of the re-employment period. Dr. S. V. Job, Officiating Assistant Research Officer (for Physiology) in this Institute, relinquished his post on selection to the post of Reader in Zoology under the University of Madras. Dr. R. Viswanathan and Shri T. Joseph who are holding permanent appointments in this Institute were relieved of their duties here to take up appointments under the Atomic Energy Commission, Bombay, and the Central Inland Fisheries Research Institute, Barrackpore, respectively. A number of temporary staff members were declared quasi-permanent during the year.

Dr. S. Jones and Dr. R. Raghu Prasad, Research Officer, participated the Standing Fisheries Research Committee meetings at Puri in December 1960, and later in February 1961. Dr. S. Jones participated at the meeting on deep-sea fishing operations convened by the Ministry at Cochin. He also held

discussions then with Dr. Snyder, the Co-ordinator of Indian Oceanographic Expedition, regarding oceanographic work and other related matters.

Dr. S. V. Bapat and Shri M. J. George, Assistant Research Officers, and Dr. R. Prasanna Varma, Research Assistant, have been deputed for advanced training in Canada, U.S.A., and Japan respectively during the year.

The number of visitors to the Institute showed a substantial increase during the year. The following were the more important distinguished visitors to the Institute:

Dr. S. A. Beatty, Food and Agricultural Organisation, Processing Expert.

Dr. David C. Rife, Deputy Scientific Attache, U.S. Embassy, New Delhi.

Miss M. Bryant, UNESCO Fellow from Liberia.

Miss Gillespie, WHO Nursing Adviser.

Dr. David D. Keck, National Science Foundation, Washington.

Mr. Raphael S. Truc and Mr. N. M. Marajas, Philippine Scholars.

Shri Bishnuram Medhi, Governor of Madras State.

Shri P. Kakkan, Minister for Public Works, Madras State.

Shri K. R. Damle, Secretary to the Government of India, Ministry of Food and Agriculture.

Dr. A. T. Sen, Member, Union Public Service Commission.

Shri B. K. Kapoor, High Commissioner for India in Ceylon.

Shri H. K. Ghazi, Director of Fisheries, Madras State.

Shri Y. Krishnan, Accountant-General, Madras.

Shri S. Sounderarajan, Deputy Accountant-General, Madras.

Dr. A. N. Kappanna, Director, Central Salt Research Institute, Bhavnagar.

Shri P. I. Chacko, Deputy Director of Fisheries, Madras.

Dr. A. P. Kapur, Deputy Director, Zoological Survey of India.

Dr. S. Z. Qasim, Reader in Zoology, Aligarh University.

Shri K. T. K. Thangamani, Member, Parliament.

Col. B. M. Chakravarthi, Director, Electronics Research and Development Organization, Bangalore.

Col. K. K. Mehta, Chief Inspector (Electronics), Ministry of Defence, Bangalore.

Prof. Von Brandt, Director, Institute of Nets and Materials, Hamburg, Mr. Hareide Sr., Member of Norwegian Parliament and Member of Norwegian India Foundation, Mr. Idar Letnes, Marketing Expert of Indo-Norwegian Project, Shri A. I. George, Director of Fisheries, Kerala, and Shri P. M. Thomas, Deputy Director, Ministry of Food and Agriculture and Deputy Storage Adviser, Central Warehousing Corporation, visited the Kozhikode Substation of this Institute while Srimati Lourdhammal Simon, Minister for Local Administration and Fisheries, Madras, and Shri Kishan Chand, Joint Secretary, Ministry of Food and Agriculture (Department of Agriculture), New Delhi, visited the Ernakulam Substation and the Madras Unit respectively.

The Research Scholars working under the Ministry of Scientific Research and Cultural Affairs and the Council of Scientific and Industrial Research continued to make satisfactory progress with their researches. The Central Marine Fisheries Research Institute has recently been recognized as a centre for post-graduate research work leading to the Ph.D. Degree of the Banaras Hindu University in respect of candidates possessing the M.Sc. degrees of that University. The Pool Officer of the Council of Scientific and Industrial Research (Dr. E. G. Silas) attached to this Institute is making satisfactory progress with his research work.

The activities of the Institute were filmed by the Films Division of the Ministry of Information and Broadcasting. The Institute continued to extend help and facilities to a number of student parties from Universities, colleges and schools, who wanted to acquaint themselves with the research work carried out here. Facilities for study were also extended to a number of individual scientific workers. The M.Sc. students of Zoology of the Madras University were given training in Marine Biology in our laboratories by special arrangements and lectures were given by our staff at Headquarters and subordinate establishments to the All-India Fishery Trainees from the Central Inland Fisheries Research Institute, Barrackpore. Students, from a large number of educational institutions, visited the Institute.

## II. FISHERY SURVEY

The analysis of data collected in 1960 was completed during the year under review and the total landings of marine fish during 1960 were estimated at 8,78,242 m. tons as compared to 5,84,193 m. tons in 1959, showing an increase of about three lakhs metric tons. It may be noted that the landings of marine fish in 1960 had been the highest since 1950. The Statewar break up of the ~~total~~ landings for 1960 and 1959 are given in Table I.

TABLE I

State	Fish landings in metric tons	
	1960	1959
1. West Bengal and Orissa ..	5,532	3,962
2. Andhra ..	56,720	29,464
3. Madras ..	1,07,810	1,03,497
4. Kerala ..	3,44,605	1,91,375
5. Mysore ..	1,00,557	52,825
6. Maharashtra ..	1,27,172}	1,98,192
7. Gujerat ..	1,27,982}	
8. South Andaman ..	129	123
9. Laccadive Islands ..	509	..
10. Trawler catches ..	7,226	4,755
<b>TOTAL ..</b>	<b>8,78,242</b>	<b>5,84,193</b>

It will be seen from Table I that landings in all the maritime States of India showed improvement as compared to those of 1959. The most significant increase in the catches had been in Andhra, Kerala, Mysore and Maharashtra and Gujerat. The landings from trawlers also registered a significant increase.

The landings in West Bengal and Orissa increased by about 1,500 metric tons as compared to those of last year. This was mainly contributed by increased landings of other sardines, sciaenids, penaeid prawns, *Chirocentrus*, elasmobranchs, ribbonfish, seer fish and *Anchoviella*.

In Andhra landings were nearly double. This was due to unusually heavy landings obtained in North Andhra during the first quarter of 1960. The landings of clupeids in the State showed an increase of about 10,000 metric tons. Significant increase was also noticed in the landings of elasmobranchs, mackerel, silverbellies, sciaenids, pomfrets, carangids, red mullets, perches, cat-fish, *Lactarius*, polynemids, soles and eels.

In Madras State landings of ribbonfish, *Lactarius*, perches and cat-fishes showed some decline. But this decline was more than compensated by

increased landings of flying fish, carangids, elasmobranchs, clupeids, *Leiognathus*, crustaceans and soles.

The landings in Kerala were increased by 1,53,230 metric tons. This was due to successful fisheries of oil sardine and mackerel. The increase in the landings of sardine and mackerel came to the tune of 1,35,000 metric tons. It had been observed that the heavy landings of oil sardine created a glut condition thereby discouraging fishermen from fishing. If the fishermen had fished all along, the landings in Kerala would have been much higher than the reported figure. Apart from oil sardine and mackerel, there was a significant increase in respect of landings of *Caranx*, cat-fish, *Anchoviella*, *Lactarius*, soles, tunnies, and *Sphyraena*. Some decline in the landings of ribbonfish, other sardines, prawns, *Thrissoles*, pomfrets, *Chorinemus*, and *Chirocentrus* was, however, noticed during the year in this State.

Increased landings in Mysore were mainly due to higher landings of mackerel. In fact the mackerel landings in the State was the highest recorded since 1950. An appreciable increase in respect of landings of *Anchoviella*, carangids, seer fish, *Lactarius*, pomfrets, soles and tunnies was also noticed. A significant fall was also recorded in the landings of cat-fish, prawns and *Thrissoles*.

The landings in Maharashtra and Gujerat showed increase by about 57,000 metric tons. The landings of sardines, other clupeids, Polynemids and *Chirocentrus* showed a decline. But this decline was more than compensated by increased landings of Bombay duck, *Hilsa*, prawns, elasmobranchs, pomfrets and cat-fish.

Table II shows the overall composition of the total marine fish landings in India during 1960. For comparison, the corresponding figures of 1959 are also given.

It will be seen from Table II that an increase of about 1,91,000 metric tons was accounted for by increased landings of oil sardine, and mackerel. *Harpodon nehereus*, carangids, elasmobranchs, *Anchoviella*, *Hilsa*, flying fish, tunnies and *Bregmaceros* accounted for an increase of nearly 107,000 metric tons. A further increase of about 27,000 metric tons was due to small increases in the landings of cat-fish, sciaenids, pomfrets, soles, silver bellies, prawns, seer fish, red mullets and *Sphyraena*.

As against these, a decline of about 25,000 metric tons resulted from decreased landings of ribbonfish, other sardines and polynemids.

TABLE II  
Composition of marine fish landings

Name of fish	Quantity landed in metric tons	
	1960	1959
1. Elasmobranchs	35,561	23,446
2. Eels	6,140	6,076
3. Cat-fish	25,041	20,272
4. <i>Chirocentrus</i>	5,320	5,428
5. (a) Oil sardine	1,89,016	69,234
(b) Other sardines	32,003	41,167
(c) <i>Hilsa ilisha</i>	3,345	844
(d) Other <i>Hilsa</i>	8,443	3,046
(e) <i>Anchoviella</i>	35,885	24,477
(f) <i>Thrissocles</i>	7,522	8,108
(g) Other clupeids	20,274	21,211
6. (a) <i>Horpodon nehereus</i>	1,08,564	57,210
(b) <i>Saurida</i> and <i>Saurus</i>	482	597
7. <i>Hemirhamphus</i> and <i>Belone</i>	213	383
8. Flying fish	6,470	1,668
9. Perches	9,804	9,389
10. Red mullets	2,568	1,526
11. Polynemids	6,649	7,666
12. Sciaenids	24,947	20,442
13. Ribbonfish	17,467	31,830
14. (a) <i>Caranx</i>	21,583	9,773
(b) <i>Chorinemus</i>	4,212	2,658
(c) <i>Coryphaena</i> and <i>Elacate</i>	654	471
(d) <i>Trachynotus</i>	9	2
15. (a) <i>Leiognathus</i>	15,760	13,200
(b) <i>Gazza</i>	634	293
16. <i>Lactarius</i>	14,502	13,842
17. Pomfrets	21,850	17,389
18. Mackerel	1,33,655	62,198
19. Seer fish	8,650	6,590
20. Tunnies	5,615	2,866
21. <i>Sphyræna</i>	1,985	972
22. <i>Mugil</i>	895	245
23. <i>Bregmaceros</i>	6,096	3,821
24. Soles	14,103	10,360
25. (a) Penaeid prawns	31,759	27,632
(b) Non-penaeid prawns	36,271	37,805
(c) Other crustaceans	2,570	2,092
26. Cephalopods	462	348
27. Miscellaneous	11,263	17,616
TOTAL	8,78,242	5,84,193

The higher landings of oil sardine were due to its increased landings in Kerala. While the oil sardine fishery in 1959-60 was a dismal failure, it was very good in 1960-61 season. The oil sardine catch in 1957, which was the highest since 1950, was higher than this year's catch by only 2,453 metric tons. Actually the catch of oil sardine in 1960 could have been considerably greater, but because of glut conditions fishermen did not go for fishing on many occasions at many places. The amount of effort put in in 1960 was about only 64% of that of 1959. The mackerel fishery on its turn also was highly successful during this year. The total catch of mackerel exceeded even that of 1958 and in fact was the highest since 1950. Out of the total mackerel landings of 133·655 metric tons, 81,882 metric tons were landed in Mysore. The improved landings of *Harpodon nehereus* were due to enhanced yields in Gujerat which account for 72% of the total Bombay duck landings. It was significant that while exceptionally good catches of Bombay duck were landed in Jaffrabad area in Gujerat, the Bombay duck fishery in Maharashtra was a failure during 1960. In fact the catch of Bombay duck in Jaffrabad area was so heavy that there was a glut which restricted normal amount of fishing. Increased landings of carangids and seer fish were due to the increase in their catches in all the maritime States. Barring Mysore, elasmobranchs landings showed improvement in all the States. The augmentation of the landings of *Anchoviella* was mainly due to its heavier landings in Kerala, Andhra and Madras. Good fishery of *Hilsa* in Gujerat increased the total yields of the fish. The augmentation of the total landings of flying fish was entirely due to its heavier landings in Madras where the flying fish fishery is showing a steady improvement for the last three years. The higher landings of tunnies were mainly due to increased landings of the fish in Kerala. The significant increase in respect of landings of *Bregmaceros* and *Mugil* in Maharashtra enhanced the total catch of these fishes. Increased landings in Kerala, Maharashtra and Gujerat, Andhra and West Bengal and Orissa resulted in the overall improvement in the landings of cat-fish. The improvement in the landings of sciaenids was mainly due to increased landings of the fish in Andhra and Kerala. The total landings of pomfrets registered increase because of their heavier landings in Gujerat and Andhra. While the improvement in the landings of soles was due to their increased landings in Kerala, that of silver bellies was on account of their higher landings in Andhra. The higher landings of prawns were due to their enhanced yields in Maharashtra and Gujerat. Total landings of red mullets registered increase because of their heavier landings in Andhra. The landings of *Sphyræna* showed improvement in all the maritime States except West Bengal and Orissa.

The decline in respect of landings of ribbonfish was due to its reduced landings in Madras and Kerala. The fall in the landings of other sardines and polynemids was similarly due to their decreased landings in Kerala and Maharashtra.

Table III shows the seasonal variation in the catch landed in the different maritime States of India. These do not include the catch landed at Laccadives and Andaman and those landed by trawlers.

**TABLE III**  
*Seasonal variations in catch*  
(Figures in Metric Tons)

States	Period				Total
	I Quarter	II Quarter	III Quarter	IV Quarter	
West Bengal and Orissa ..	1,567	411	405	3,149	5,532
Andhra ..	22,062	12,276	8,467	13,915	56,720
Madras ..	22,078	29,873	33,525	22,334	107,810
Kerala ..	33,109	22,201	97,612	191,683	344,605
Mysore ..	7,246	793	4,605	87,913	100,557
Maharashtra ..	28,512	15,866	12,870	69,924	127,172
Gujerat ..	16,295	16,548	6,288	88,851	127,982
<b>TOTAL ..</b>	<b>130,869</b>	<b>97,968</b>	<b>163,772</b>	<b>477,769</b>	<b>870,378</b>
Per cent. ..	15.04	11.25	18.82	54.89	

From Table III it will be seen that nearly 55% of the landings were made during the last quarter of the year, which is the most productive part of the year. In fact, in all the States of West Coast and also in West Bengal and Orissa, the bulk of the landings was made in the 4th quarter. The increased landings in Kerala and Mysore during the last quarter were primarily due to incursion of mackerel and oil sardine in the inshore fishing grounds of these States. The incursion of Bombay duck, pomfrets and *Bregmaceros* in the fishing grounds was the main reason for more landings

in the last quarter in Maharashtra and Gujerat States. In Andhra, the highest landings were obtained during the first quarter when good catches consisting mainly of clupeids were obtained in N. Andhra. In Madras, there were not much seasonal variations in the landings.

*Catch per unit of effort.*—Table IV shows the total effort in man-hours expended in each State and also the catch in Kilogramme per man hour. The corresponding figures for 1959 are also shown for comparison.

TABLE IV  
*Total effort in man-hours and catch in kilogramme per man-hour*

States	Effort in 1,000 man-hours		Catch in kg. per man-hour	
	1960	1959	1960	1959
1. West Bengal and Orissa ..	7,182	4,787	0.77	0.83
2. Andhra ..	48,548	47,436	1.17	0.62
3. Madras ..	66,849	69,166	1.61	1.50
4. Kerala ..	39,972	63,328	8.62	3.02
5. Mysore ..	9,879	10,271	10.18	5.14
6. Maharashtra ..	23,228	52,391	5.47	3.78
7. Gujerat ..	20,615		6.21	
8. All India Total ..	2,16,273	2,47,379	4.02	2.34

Table IV shows that the total effort expended during 1960 was less than that in 1959. The catch per unit of effort registered improvement over the last year's. The most significant decline in the amount of effort put in took place in Kerala, Maharashtra and Gujerat. In Kerala the oil sardine and mackerel fisheries were so successful that a glut condition prevailed. Fishermen did not go for fishing on many occasions, even though shoals were sighted. If the fishermen of Kerala had put in effort as in other years, the total landings in the State could have been considerably higher. In Jaffrabad area of Gujerat, the Bombay duck fishery was highly successful

and this again created glut condition in the area thereby curtailing the fishing effort normally put in other years. The amount of fishing effort in Maharashtra was lower probably because of lesser availability of fish in the area during the year.

### III. FISHERY BIOLOGY

#### A. Inshore Fisheries Investigations

##### 1. The Oil Sardine and Other Clupeids

###### (a) At Karwar

*Sardinella longiceps* (Oil sardine).—The fishery started in late October and ended abruptly by the close of November, except for stray catches in December. The total landings at Karwar were estimated at 95.26 kg. as against 1,14,789 kg. for the previous year. The whole catch was accounted for by the *rampan* nets. The size range recorded for the season was 142–205 mm. The dominant size in the commercial catches of October was 165 mm. while in November, besides the 165 mm. group, there was a minor mode at 185 mm. in the length-frequency analysis. The females formed 51.8% of the samples analysed. The specimens examined during the season October to November were in maturity stages VII and II. The minimum and maximum sizes of the intra-ovarian eggs were 0.085 and 0.102 mm. respectively. Food consisted mainly of phytoplankton. *Chaetoceros* sp., *Thalassiothrix frauenfeldii* and *Coscinodiscus jonesianus* were present in the guts. Species of *Ceratium* were also found. Among copepods, *Oithona* sp. and *Acrocalanus longicornis* were the important items. Copepod nauplii were present in smaller numbers.

*Sardinella fimbriata*.—The 1959–60 “Pedi” season continued up to August 1960, and the current season (1960–61) commenced at Karwar in September. The catches recorded were poor compared to those in the previous years. Twenty-seven samples totalling 2,440 specimens were measured for length-frequency analysis. The forward movement of the mode could be traced from 90 mm. in September 1959 to 140 mm. in August 1960, indicating a probable growth of 50 mm. in 12 months. The 1960–61 season showed the abundance of the 100–119 mm. size group. Length-frequency studies revealed that the catches were supported mostly by a single age-group and that the fishery was constituted by the juveniles. The maturity stages recorded in April were I to IV, in May I and II, in August II and III, and from September to December I and II. The size range of the opaque intra-

ovarian eggs was found to be 0.340-0.476 mm. Food and feeding habits were also studied.

*Sardinella albella*.—The fecundity, maturation and spawning periodicity of *S. albella* were worked out during the year under review. It was observed that the number of mature eggs in the ovaries of the gravid females measuring 146-55 mm. varied roughly from 10,000 to 13,500 and that the left lobe of the ovary produces more eggs, than the right one the number being directly proportional to the size of the ovary. The ripe transparent eggs varied in diameter from 0.680 mm. to 1.020 mm. with the peak at 0.833-0.867 mm. The yolk was clear and segmented and provided with a single oil-globule (0.102-0.119 mm.). The absence of multiple modes in the ova-diameter frequency polygons indicated the existence of only one spawning season in a year for this fish; the duration of spawning may be extended over a long period.

(b) At Mangalore

*Sardinella longiceps*.—The oil sardine fishery in the Mangalore zone was better this year compared to last year. The fishery commenced in the second week of July at the southern centres and later extended to the northern centres. Relatively heavy landings were recorded especially in October and December. The annual catch at Ullal was about 78 metric tons as against about 55 tons last year. The first catch here was observed on 21st August. October-December was the most productive quarter, the total catch being about 28 tons in October and about 18 tons in December. The November landings were negligible. The January catch was slightly less than that of December but there was no oil sardine fishery at this village in February.

The cast net and the gill nets *mananguvala*, *chalabale*, and *idabale* were the main types of gear operated at Ullal. In October the major portion of the catch was accounted for by the castnet and in December by the *chalabale*. Both the types of nets were generally operated 1-2 miles from the shore (1-4 fathoms). In regard to the annual catch and the catch per unit effort, *chalabale* ranked first at Ullal. At other centres, shore-seines (*rampani* and *kairampani*) and boat-seines (*paithuvala* and *arakkollivala*) were the important types of nets used. The length-frequency studies showed that two age-groups were present in the fishery. Of these, the older one had been represented in the catches of last year also, while the younger one was newly recruited into the fishery this year. The latter first appeared in the catches in July. The older age-group could be recognised in the fishery up to the end of December. However, the bulk of the catches of this year was supported by the younger

age-group. The average annual male to female ratio was 0.48-0.52. Mature fish (stages IV and V) which belonged to the older age-group were recorded from April-August. A few spent (Stage VII) and recovering (Stage II) specimens were observed in September and October. Fish of the age-group newly recruited this year were below stage III in maturity.

A gross study of the stomach contents showed that the food consisted mainly of diatoms (*Fragilaria*, *Coscinodiscus*, *Biddulphia*, etc.) as in previous years.

(c) At Cannanore

*Sardinella longiceps*.—During the last quarter of the year under review, regular investigations on the oil sardine fishery were initiated at the Cannanore Research Centre. Mostly, oil sardine were landed by the boat-seines (*Mathikollivala*) and gill-nets were not operated exclusively for oil sardine. The 140-44 mm. size-group dominated the commercial catches, with the 145-49 mm. group coming next in importance. Studies were also carried out on the food and feeding habits of the species. The phytoplankton elements represented by species of *Biddulphia*, *Fragilaria*, *Coscinodiscus*, *Pleurosigma*, *Triceratium* and *Rhizosolenia* occurred much more than the zooplankton elements represented by tintinnids, copepods and larval bivalves. All specimens examined during the last quarter of the year under review were in maturity stages I or II. The fishery proved to be a fairly good one in the early part of the season when oil sardines were sold at very cheap rates for food and manure.

(d) At Calicut

*Sardinella longiceps*.—The estimated oil sardine landings reported at Calicut during the year 1960-61 amounted to 7,677.89 metric tons forming 96.48% of the total catch by all the gears operated for oil sardine as compared to 1,561.16 metric tons in 1959-60. The best catches, exceeding 1,000 metric tons per month were recorded during October and December 1960 and January 1961. Among the different quarters of the year, the period October-December 1960 alone accounted for 3,213.12 metric tons. More than 90% of the year's oil sardine catches were made during the months August 1960 to March 1961. The bulk of the oil sardine fishery this year was chiefly supported by the second year class, the abundance of which was very consistent throughout the year. Assuming that the abundance of the oil sardine in the inshore waters in a particular season is indicative of an increase in the rate of annual recruitment during that year, the success of this year's oil sardine fishery, chiefly contributed by the second year class, may be

attributed to the fairly good oil sardine fishery reported in 1958-59 season. Among the different gears operated for oil sardine, 6,767.63 metric tons were landed by *kollivala* and 807.89 metric tons by *thattumvala*. The oil sardine catches made by other gears were insignificant. *Kollivala* had landed 88.15% of the total oil sardine spending 73.64% of the total effort, whereas, *thattumvala* with 20.33% of the total effort, had caught 10.52% of the total oil sardine catches. Among the different gears, the highest catch per unit of effort of 18.28 kg. was recorded by *kollivala*. The general improvement in the oil sardine fishery had, to some extent, reflected on the overall high values for the catch per unit of effort for the different gears as compared to the figures during the previous year. Although oil sardine ranging in length from 80 to 204 mm. included the first to fourth year class individuals, the bulk of the fishery was supported by the second year class ranging in length from 130 to 150 mm. The regions fished for oil sardine extended from 3 to 14 fathoms but the heaviest concentrations of oil sardine shoals appeared to be in the 8-12 fathom region.

1201 Specimens were examined for maturity and spawning studies. In May the stages I and II were noticed in the earlier period and stage III in the last week. Stage IV was noticed in June. In July in addition to stage IV there was a notable entry of indeterminate (juvenile) stages. August witnessed mostly bigger fish, the majority of which had slightly advanced further from stage IV. A salient feature noticed this month was the occurrence of partly spent individuals, provisionally termed as stage IV *b*, which were recognized for the first time during the present investigations. Immature sardine again entered the fishery in the last week of August and appeared to continue in September (except for three days when specimens above 170 mm. were spent, mostly completely but some partially. From October onwards the fishery was mostly comprised of immature sardine, the larger sizes being in the spent-resting condition, the number in this category being small from January).

The sexes were about equal in numbers unlike in the previous year when the males were more numerous. Fecundity estimates fluctuated widely between 40,000 and 75,000. An instance of hermaphroditism was noticed in August, the left gonad having developed into an ovary and the right one abnormally into an ovotestis.

Studies on fat variations indicated that among the immature fish both the muscle and visceral fat started increasing from July, suddenly shot up in September and reached the maximum in December. Among the larger

fish only the spent sardine showed an appreciable quantity of visceral fat during September-October but that too started declining from November onwards.

270 Specimens fished mostly by *mathichala vala* and *pattenkollivala* were studied for the stomach contents and also for age and growth. They were fished at the depth range of 4-22 metres. Their size ranged from 87-187 mm. Most of the specimens were immature (in stage I).

Of the Bacillariophyceæ in the stomach contents, *Fragilaria oceanica* was predominating during most of the months. The other predominating forms were *Thalassiosira* sp., *Coscinodiscus* sp., *Thalassiothrix frauenfeldi*, *Pleurostigma* sp. and *Nitzschia* sp. Amongst the Dinophyceæ *Dinophysis caudata* was very common. The same was true with copepods that represented the zooplankton.

Otoliths of one specimen measuring 143 mm. showed one ring and of one measuring 140 mm. showed two rings; no rings were noticed on the opercular bones.

(e) At Ernakulam

*Sardinella longiceps*.—At Kannamali the oil sardine fishery was moderate in April and poor in May. There was no sardine catch in June. In August there was a moderate fishery but this again declined in September. *Thanguvala*, *nona vala* and *chalavala* were used in the fishing.

The dominant mode in length frequency in April and May was at 145 mm. In August the modes ranged from 130-175 mm. while in September, the mode was at 140 mm. During April-May the females formed nearly 50% of the catches; in August 44% were females and 16% were indeterminates; in September the females formed 60% of the catch. The maturity stages were II and III respectively in April and May but V in August (with a few in stage IV also). After September no material was collected from Kannamali.

At Manassery there was no sardine fishery in April and May; in June small catches were obtained in *thanguvala* and *chalavala*. A moderate sardine fishery commenced towards the end of July and persisted up to end of September, *nona vala*, *chalavala* and *thanguvala* being operated. While the fishery was quite good in October, the largest sardine catch of the year was obtained in November. In December the fishery was better than in October. *Thanguvala* was operated.

The modal length in June ranged from 160–165 mm. In July fish having 110 mm. mode occurred. In August the modes ranged from 115–140 mm. The dominant mode in September was at 145 mm. During the third quarter the mode remained at 145 mm. In January, the modal lengths of sardine obtained in *thanguvala* and *chalavala* were 145 mm. and 175 mm. respectively while in February they were 145 and 180 mm. respectively. In March the *thanguvala* sardine showed 145 mm. mode.

The June samples were in stages IV–V of maturity. In July the majority of juveniles were indeterminates. In August the large sardine were in stage V. In September the juveniles were in stage I and the large ones in V and partly spent condition. The October samples were in stage I. In January the *thanguvala* sardine were in stage I and gill-net sardine in spent-recovering condition. In February also the same maturity conditions continued. In March the fish obtained in *thanguvala* were in stage I.

Scale studies were continued, the length ranges of the sardine examined during the first, second, third and last quarter being 150–180 mm., 170–190 mm., 140–190 mm. and 160–190 mm. respectively. A great majority of the sardine examined possessed distinct scale-rings. Otoliths collected are being examined.

(f) At Vizhingam

*Sardinella longiceps*.—The oil sardine supported a minor fishery at Vizhingam during the year under report. Altogether 19,161 kg. of the fish were estimated to have landed during the nine months from July 1960 to March 1961. The commercial landings of the species were confined to one or two days in a month. Gill nets and shore-seines were employed in the fishery. The catches were composed of juveniles with indeterminate and immature gonads.

The total length during the season ranged from 55 mm. to 200 mm. The modal lengths were 100 mm., 145 mm. and 160 mm. respectively for the second, third and fourth quarters of the year under report.

Analysis of the gut contents showed that the food consisted of planktonic organisms with phytoplankton predominating.

(g) At Mandapam

*Dussumteria* spp.—The Rainbow Sardines form one of the important fisheries of the Rameswaram Island as well as in the area in and around Mandapam. Investigations were taken up since the middle of July 1960

in order to study the potentialities of the fishery, the composition of the year-class fished, the species composition, and the general biology of this fish.

The samples analysed consisted of catches taken from Palk Bay as well as from the Gulf of Mannar side, the tackles used in landing them being boat-seine in the former case and shore-seine in the latter case. *Kolavalai* (Drift-gill net) catches were not included since it is selective in fishing. The fishing had been dull in the Gulf of Mannar while in Palk Bay regular landings were made from July to October. In all 964 fish were analysed in 16 samples of which 164 fish were specially studied for detailed morphometric and body proportions measurements. Statistics on the intensity of fishing and the length frequency of commercial catches were maintained for future evaluation of the fishery.

The fishery in the Gulf of Mannar side is made up of two seemingly different varieties unlike what was hitherto supposed as being homogeneous whereas Palk Bay shows only one of the above forms in the landings. The body proportions and other counts are distinctly different that it is now easy to differentiate them in the field itself without much difficulty. The determination of the exact species involved is engaging the attention.

A pattern of growth of the fish, their entrance into the fishing and disappearance therefrom seems evident from the data analysed. The fishery is supported mainly by the maturing as well as spawning individuals ranging in size from 120 to 150 mm.

## 2. *The Mackerel—Rastrelliger canagurta*

(a) *At Karwar.*—A total of 2,684.56 metric tons of mackerel had been landed at Karwar during the year, the *rampan* being the principal gear employed. The season started during early October and came to an end by the first week of January. It was noticed that as the season advanced and the size-group increased, the shoals of *Rastrelliger* showed a tendency to move further and further away from the shore. Since the season was very short, no secondary peak in production was observed as in certain previous years.

There were 75 fishing days when 178 hauls were made using 91,593 pieces of *rampan* net. The maximum catch and the maximum unit effort were recorded in November (1,303.9 metric tons and 45.21 kg. respectively). The quantity landed per *rampan* per haul varied considerably from a maximum of 99,174 kg. on 2nd December to 273 kg. on 10th November. These dates also showed the highest and the lowest figures respectively for any single day.

Studies on recruitment by a quantitative evaluation of the size-groups entering the fishery were initiated during the year. Analysis of the month-wise and seasonwise landings showed that three different stocks were fished. However, the fishery was mainly dependent on the 190–215 mm. size-group which accounted for 75.6% of the total. Small fish of the size-range 150–175 mm. contributed 8.65% while large fish of the range 230–255 mm. formed 2.2%.

Samples from different types of units on any particular day did not show any appreciable difference either in the range of size or in the mode. Only the large sizes occurred in the samples from April to August and these disappeared after mid-December. At the commencement of the season in the first week of October the smaller group (165–170 mm.) constituted the fishery. From late October to late November the dominant group was 190–195 mm. while from end of November to March a higher size-group (215 mm.) dominated.

The commercial fishery at Karwar was dependent on immature mackerel (stages I and II). There was no segregation of sexes during shoaling. The spawners were generally the large fish which did not enter the inshore waters in very large numbers. They were believed to come from a different stock. The appearance of fish in stage V during early September and the presence of spent fish in the catches of October–November would suggest that these fish had spawned during September.

The study on the relationship between the total length and standard length, and their relation to body weight was continued. Stomach contents of more than 250 mackerel were exhaustively studied by the number method. In June, July and August, stomachs analysed from Karwar *yendi* samples had a good number of diatoms. *Chatoceros* sp., *Fragilaria oceanica*, *Thalassiothrix frauenfeldi* and *Nitzschia seriata* were found abundantly. The major item of the gut-contents from *rampan* net was frequently sand. Samples from the off-shore collections (*pattabale*) had a good number of dino-flagellates and many zooplankton elements.

(b) *At Mangalore.*—The mackerel fishery at Ullal appeared to be better this year with a total catch of 81.6 metric tons in contrast to the year 1959–60 when the total estimated catch was only 21.6 metric tons. The season commenced in August 1960 with the highest monthly total catch of 40 metric tons. There was a declining trend from October onwards (with the exception of March 1961). About 72% of the catch of mackerel was landed by *idavaie* and *pattabale* (gill-nets), these nets ranking first and second respec-

tively in catch per unit of effort. The cast net and the *kanthabale* ranked third and fourth respectively. Mackerel were not recorded this year in the *chalavala* and *kollivala*.

Mackerel of the size-range (120–194 mm.) contributed to the fishery from August to October when the small-meshed nets (cast-net and *idabale*) were used for the fishing. During April and from September to March, bigger mackerel (of size range 192–244 mm.) were caught in the *kanthabale* and *pattabale* which have a 2" mesh. The length-frequency data indicated that the fishery was constituted by more than a single year-class.

During the quarter April–June there were more females (males 31, females 69) than males; during other months of the year the sex-ratio was fairly constant. Maturity stages III and IV were dominant in the April–June period. Stage III was recorded during the July–December period but the majority of fish during this period were in stage I. From January to March stage II was dominant.

Ova diameter measurements from a stage III ovary showed four modes in the frequency distribution.

Studies on food and feeding were also continued. Phytoplankton elements were dominant in the stomach contents from April to August (except in the case of stray specimens from the Netravati estuary). From the second half of August to March, zooplankton elements (*Evadne*, *Penilia* and copepods) were dominant.

(c) *At Cannanore.*—The mackerel fishery was good at Cannanore during the year with estimated total landings of 208 metric tons, 151.43 metric tons and 322.79 metric tons respectively during the second, third and last quarters. The highest level of abundance of the mackerel in inshore waters during the year was noticed during the months of December and January when more than 60% of the catch was landed. The nets used were the boat-seines and gill-nets the former contributing the bulk of the catches.

The fishery was mainly supported by the medium-sized and juvenile fish and to some extent by adults. Investigations at this centre were initiated only towards the end of the first quarter. Stray specimens of juveniles measuring 110–140 mm. (with mode at 120 mm.) were noticed at the close of the quarter. During the second quarter the fishery was mainly supported by the juveniles (110–120 mm.) and medium-sized mackerel (140–190 mm.) of which the latter group was dominant. The fishery during the third and fourth quarters was mainly supported by the size-group 180–230 mm. with

the mode at 210–220 mm. Thus there was a considerable increase in the size of the mackerel that contributed to the fishery in the third and last quarters of the year.

The majority of specimens examined from commercial catches were in maturity stages I and II. No mackerel above 230 mm. in total length was recorded during the period under report. At the close of the season stray adults (below 230 mm.) were in stage III of the maturity. The two sexes were about equally represented in the commercial landings.

Volumetric and quantitative analyses of the stomach contents showed that the mackerel were feeding actively on planktonic organisms and there were two peak periods of feeding—one during September–November and the other during January–March. On the whole, the phytoplanktonic fraction dominated over the zooplanktonic fraction in the food although during certain months the latter was the predominant item in the stomach contents.

(d) *Calicut*.—The total landings of mackerel at Calicut (Vellayil) during the year were 1,020.98 metric tons; there were no landings in the first quarter. The main nets operated were *ailachalavala*, *ailakolilvala* and *pattenkollivala*, the respective landings of the three nets being 92.19 metric tons, 882.68 metric tons and 46.11 metric tons. Three dominant size-groups, 195 mm., 205 mm. and 215 mm., entered the fishery at different periods of the year; of these the 215 mm. group, however, appeared to persist throughout the season except in November 1960. The specimens examined were in maturity stages I and II during the season.

A preliminary examination has been completed of the scales of 483 mackerel specimens during the year. The material was drawn from different centres on the West Coast from Karwar in the north to Vizhingam and neighbourhood in the south. It was found that at all the centres, specimens below 220 mm. in total length showed no indications of rings in their scales. A small percentage in the 220–229 mm. group showed the rings in the Karwar and Mangalore samples while in the Calicut samples even this group was completely devoid of rings. Rings occurred in specimens of all the centres in the 230–239 mm. group though there was a variable percentage of specimens without rings also. It may be assumed that rings were present in the scales in practically all specimens at all centres in the size-groups of 240 mm. and above, although a few of these (particularly from Vizhingam) had also to be classified as “not clear” or “doubtful” and require more detailed examination.

Examination of data on the racial studies of mackerel was continued. Some of the body characters of the Andamans and local samples were compared; slight variations were noticed in some of the body proportions between the two samples. The proportion of the body weight at ventral origin to the body length was found to be mostly above 4.0 in the Andamans sample and mostly below 3.8 in the local sample. The caudal portion appears to be longer in the Andamans sample than in the local sample. The length of the mandible and the height of the body at anal origin were found to be more or less the same in the Andamans specimens while in the local sample the former measurement was found to be slightly more than the latter.

The work on the anatomy of the mackerel was also in progress during the year. A detailed study on the skeletal system has been completed. The main skeletal features in which the Indian mackerel differs from the other forms of mackerel have been noted.

In the digestive system, the arrangement of the hepatic caecae and the shape of the liver appear to have significance from the systematic point of view.

(e) *At Ernakulam.*—The mackerel fishery was of moderate magnitude during the year, but showed clear improvement over that of the previous year. The peak landings occurred during the October–December period. The bulk of the landings were made by the gill-net units. Boat-seine, shore-seine and purse-seine operations accounted for a lesser share of the catches. Stray members of mackerel occurred in the trawl catches from 15–17 fathom area off Cochin during the December–March period. There was also an organised backwater fishery in the Cochin backwaters for the first time during January and February.

Length-frequency studies showed that in April and May the modal size was 210 mm. Juveniles in the range of 110–150 mm. started appearing in the trawl catches in May from the 8–10 fathom area off Cochin. During July and August fish of the modal sizes 130 and 160 mm. respectively appeared in the boat-seine catches. In September the modal size was 190 mm. The fishery of October and November was supported by the 200 mm. modal size. From December to March the mode remained steady at 210 mm.

The male to female ratios were 36: 64, 49: 51, 53: 47 and 44: 56 respectively for the 1st, 2nd, 3rd and 4th quarters of the year. The mackerel

examined during April-June were mostly in maturity stages III-IV. Specimens examined in the January-March period showed proof of "spent resting" condition of the gonads. One spent female was available in March with a few large residual eggs in the ovary.

Food studies were continued. Feeding was moderate to good from April to September. Active feeding was noticed from October to March. Copepods predominated among the food items. A wide variety of diatoms and dinophysids were also met with in the stomachs in smaller quantities. Some of the juvenile mackerel (150-160 mm.) examined in June fed exclusively on fish post-larvæ.

(f) *At Vizhingam.*—The estimated total landings of mackerel at Vizhingam during the season of 1960-61 were 42,391 kg. this showing a slight decline over the landings of the previous year. The estimated landings were 1,241 kg., 28,279 kg., 5,777 kg. and 7,094 kg. respectively for the four quarters of the year. Well over 50% of the total catch of the season was landed during the second quarter. Shore-seines, drift nets and boat-seines accounted for the major portion of the catch. A small quantity of the fish was landed by hooks and lines.

The size-range in the commercial catch was 45-280 mm. During the second quarter mackerel of 190 mm. total length dominated the landings. Two distinct modes were evident during the third quarter, namely, at 70 mm. and 205 mm. The 230 mm. group was predominant during the last quarter.

Both phytoplankton and zooplankton organisms were noticed in the gut contents in addition to fish remains. *Phyllosoma* larva, *Alima* larva, *Cypris* larva, copepods, other crustacean remains, bivalve larvae, gastropod larvae, *Skeletonema costatum* and *Nitzschia* were observed in the stomach contents.

(g) *At Porto Novo.*—As in the past year, the August-September fishery for mackerel was a total failure this year also, the fish having occurred in the catches on two solitary occasions. However, the catches in the preceding summer were very considerable though of short duration (March end to June) compared with the previous year, thus accounting for 19,134.89 kg. out of the total year's mackerel catch of 20,187.89 kg. *Thoorivalai*, *edavalai*, *nanduvalai*, *valavalai* and cast-net were the gear used for mackerel fishing.

Data on length frequency indicated a fall in the dominant size-range from 200-240 mm. of last year to 190-200 mm. There was no appreciable

difference in the sex composition of the population from that of the preceding years and the bulk of the landings were composed of individuals in stage VI (a) of maturity. At the peak of the fishery, there was much of night fishing very close to the shore (within 5 fathoms). The few oozing females that were obtained came from the night catches, from nets that operated beyond the 10 fathom line. Comparison of day and night catches pointed to the possibility of the spawning activity being intense during the early hours of the night. Intensified efforts to artificially fertilize the oozing eggs did not yield results. While evidently the summer mackerel fishery coincided with the spawning season of the fish, regular samples of inshore plankton (from the same area where fishing was intense) analysed during the period did not contain any fish eggs that could be reasonably attributed as belonging to mackerel.

Feeding was very intense and almost indiscriminate throughout the season, during day as well as night. Gut contents largely reflected the composition of inshore plankton and its fluctuations.

### 3. Prawns and Lobsters

(a) *At Kandla.*—The prawn fishery of Cutch, composed chiefly of *Metapenaeus monoceros*, has been a total failure during this year unlike the bumper fishery of the previous year. This is believed to be more or less a direct influence of the failure of the monsoon this year and the high salinity of the water in the creeks.

Table V shows the dominant size-groups of the species occurring at the various fishing centres.

A new size-group was entering the fishery in June and October 1960 which was composed of small individuals (51–60 mm.). The larger individuals (91–100 mm.) were seen in the fishery for a brief period as in April and December 1960. At Tuna-Sangat the dominant size-range of the individuals constituting the fishery was 56–115 mm. At Luni where observations are available from August to December it was seen that *M. monoceros* occurred in considerable numbers only during August (91–95 and 111–115 mm.) and September (71–75 mm.). It was dwindling in numbers in October (91–95 mm.). At Mandvi, the outermost observation on the Cutch coast, *M. monoceros* were rare throughout the period of observation, viz., October–December 1960 except in November 1960.

The bigger size-groups are found in the catches as one proceeds from the inner to the outer gulf which is suggestive of migration of *M. monoceros*

from the inner creeks to the open sea at a time where the individuals attained a dominant size of over 60 mm. The individuals also disappeared from the inshore waters after they attain a size-range of 111-115 mm. or so. It is also observed that there is no uniform progression in the modal length of this prawn throughout the year which is due to the entry of new size-groups into the fishery.

TABLE V

	Surbari	Kandla	Tuna-Sangat	Luni	Mandvi
	mm.	mm.	mm.	mm.	mm.
April	.. 26-30	96-100	No data	No data	No data
May	.. 31-40	66-70	66-70	No data	No data
June	.. 41-50	51-55	56-60	No data	No data
July	.. No data	56-60	61-65	No data	No data
August	.. 56-60	56-60	56-60	91-95 and 111-115	No data
September	.. 51-55	61-65	71-75	71-75	No data
October	.. 31-35	51-60	76-80	Rare 91-95	Very rare
November	.. 26-30	61-65	76-80	Absent	71-75 and 81-85
December	.. 31-35	91-100	91-95	Absent	Very rare
January 1961	.. No data	66-75	91-95	No data	No data
February	.. No data	No data	Very rare	No data	No data
March	.. 21-30	76-85 and 51-60	Rare 111-120	Very rare	No data

The prawn fishery at Adesar camp which is situated in the little Rann of Cutch, still interior to Surbari, lasted from September to December. At this place there is a lake-like formation whose source has been the river-water. This generally has connexion with the creek at Surbari during July-September under normal rainfall and becomes land-locked in October as the rains come to an end. But in the present year under report this area was

land-locked during the monsoon period itself as there was no sufficient rains to establish prolonged connexion with the creek. The prawn fishery of Adesar camp is due to the migration of the prawns—*M. monoceros* with the lake-like formation from the creek during a spring tide following the first showers when the water in the lake was extremely spread enough so that the creek could establish connexion into the lake during the spring tide. Later with the gradual drying up of the water, it has been completely cut off from the creek. The salinity of the water at Adesar camp ranged from 5.22‰ in August to 38.9‰ in December. The dominant size of *M. monoceros* was as follows in different months:

September	October	November	December
106–110 mm.	116–120 mm.	121–125 mm.	121–125 mm.

Females of this prawns measuring 135 mm. to the maximum observed size of 146 mm. were in immature condition or early maturing stage and the ovary was not well developed also. The same species of prawn of a similar size-range caught from the marine environment during January–March in stray numbers showed better developed ovary and was in late maturing stage.

Observations as the prawn landings are available during the period August–December and March at Luni and during October–December at Mandvi. It is of interest to note that the quantitative composition of the catches in the water gulf region (Luni and Mandvi) was distinct from that of the inner gulf. The catches from the latter (Surbari, Kandla and Tuna-Sangat) are dominated by *M. monoceros*. The other types of prawns noticed in the fishery were *Leander stylifera*, *Metapenaeus brevicornis* and *Penaeus indicus*. At Luni *Metapenaeus brevicornis* and *Penaeus indicus* dominated the catches *Monoceros* was noticed in considerable numbers during August–September. At Mandvi the prawn fishery was constituted by another species of *Leander*, *Hippolysmata* sp. and *Parapenaeopsis sculptilis* in October, *Acetes* sp. and *M. brevicornis* in November and *M. brevicornis* and *Parapenaeopsis stylifera* in December. *M. monoceros* was rare throughout. This difference in the quantitative composition of the catches may perhaps be related to the nature of the sea bottom as in the inner gulf it is primarily muddy while on the outer gulf it is primarily sandy.

(b) At Bombay: Inshore Fishery.—Study of the inshore prawn fishery of this region by analysis of regularly collected weekly samples from the

commercial catches of the 3 centre, viz., Arnala, Versova, and Sassoon Docks was continued as before. Two types of bag nets, the larger 'dol' nets and the smaller 'bokshi' are the gear used in the fishery. The operation of the larger type continued throughout the year at Sassoon Docks, but was suspended at the other 2 centres during the monsoon period. The 'bokshi' was worked practically all the year round close to the shore at Versova and Arnala.

About 25 species of prawns and shrimps have been recognized in the commercial landings so far out of which about 8 are important, contributing significant proportions of the catches at various times. The occurrence of the others has been rather unsteady and all of them together may account for only a small part of the landings.

Among these 8 species *Palaemon (Leander) tenuipes* seems to occupy the first place. Excepting October, November and December in all the other months it has formed a fairly high percentage, even beyond 60% in April and May. In these months on some days it formed up to 90% of the Versova and Arnala landings. The bulk of the catches consisted of adult prawns 40-60 mm. in length.

*Acetes indicus* probably stands second in abundance when the entire year is taken into consideration. It was caught in 'dol' nets operated near the shore at Versova and Sassoon Docks. In June, it contributed the bulk of the landings at Sassoon Docks. At Arnala, however, the landings were insignificant.

- *Metapenaeus affinis*.—Though fairly good quantities were caught in the months of September, October and November it was much less in abundance than in the corresponding period of last year. During the months of abundance most of the prawns caught were adults measuring 100-150 mm.

*P. hardwickii*, *P. sculptilis*, *P. stylifera*, *Solenocera indicus* and *Hippolyssmata ensirostris* were the other species caught in fairly good numbers in various months. *P. sculptilis* was a conspicuous element in the catches of the 'bokshi' net at Arnala, but in the other two centres it occurred only in small numbers. Besides these species another, viz., *Atypopenaeus compressipes* sometimes formed the major portion of the prawn landings at Versova in January and the two following months.

*Off-shore fishery*.—Off-shore fishing operations of the Government of India vessels continued throughout the year, using different types of nets.

Their catches consisted of a variety of species along which *P. indicus*, *P. pencillatus*, *M. monoceros*, *M. affinis*, *P. stylifera* and *P. sculptilis* seem to be more important.

Biological data relating to these species particularly of *M. affinis* were collected as usual. Feeding of *M. affinis* was noted to be not active in September and January–March. Sex ratio varied from week to week; but on the whole females showed a slightly higher percentage. The species seems to be a continuous breeder; but November and December and March–May form the period of maximum activity. It is likely that the species may live for over three years. The fat contents of the muscles have been noticed to vary with the stages of maturity of the gonads and sex.

(c) *At Mangalore.*—The inshore prawn fishery in the Mangalore area was comparatively more or less a failure during the year under report. At Ullal the landings were poor during September and October and later in the year there was practically no catch of prawns. *M. dobsoni* was the dominant species at Ullal; at other centres *P. stylifera* and *M. dobsoni* were both prominent.

Mechanised vessels using otter trawls landed fairly good catches. The Government of India trawlers 'Durga' and 'Tarpon' also operated off Mangalore at depths ranging from 8–21 fathoms during the period 21–11–1960 to 2–3–1961. *P. stylifera* dominated the catches from November to March; previously the dominant species was *M. dobsoni*. *M. affinis* and *P. indicus* occurred only in smaller numbers. The capture of a good number of mature and impregnated females of the former in April 1960 and also from November to February 1961 may provide some indication of the breeding period of the species in the region.

The Japanese fishing vessel "Kaiko Maru" surveyed the waters off Mangalore and Karwar coasts from 25–1–1961 to 27–2–1961 between 10 and 64 fathoms. The prawn catches were poor. *M. monoceros* contributed 69·8% of the catches. *P. stylifera* and *M. affinis* also occurred in appreciable numbers.

Group fishing conducted on 25–2–1961 by 'Kaiko Maru', 'Durga', 'Tarpon' and the Training Centre boat showed an interesting feature in the distribution of prawns. *M. dobsoni* did not occur beyond 10 fathoms whereas *M. monoceros* was rare within 10 fathoms.

(d) *At Ernakulam: Off-shore fishery.*—The off-shore catches by the mechanised vessels operating from Cochin were composed, as usual, of a

number of species with different species dominating from month to month. *M. dobsoni*, *M. monoceros*, *M. affinis* and *P. indicus* were the more common species. Good numbers of *P. monodon* along with large-sized *P. indicus* were caught 10–12 miles South-West of Cochin in the 15–20 fathoms area during November, which is rather unusual.

A study of the fauna associated with prawns in the fishing grounds has been started from the beginning of this season. A number of crabs, sand lobsters and *Squilla* sp. were always found along with prawns. In addition the flat fish *Cynoglossus semifasciatus* was also frequently present.

*Palaemon carcinus*.—Observations were continued on the fishery and biology of *P. carcinus*. At the 2 centres of observation the trend of fishery followed the same pattern during this season. From June the catch increases and reaches a peak in August. There is a considerable fall in September; but in the following month it again improves and finally declines in November and December.

Analysis of length-frequency data seems to indicate that males belonging to 2-year classes are common in the commercial catches; but in regard to females only one-year class is represented. Males were more in number at the beginning, but as the season advanced the number of females steadily increased and by August they were more. From October an attempt was made to ascertain the distribution of the species at certain centres along the Pampa River. Except at one point, where juveniles were present, at all other centres those caught were adult males probably indicating that females belonging to the same year class had all descended to reach the breeding grounds and eventually got caught.

(e) *At Colachel*.—Observations on the lobster and prawn fisheries of the Kanyakumari District were continued during the year under report.

The lobster fishery restarted this year a little earlier than usual, in the second half of November. The catch, however, does not appear to have been large. In December the fishery was brisk and the estimated total landings were slightly better than those of 1959, though not even half of that of the corresponding month of 1958. In January 1961 the estimated total landings were not so good as those of the previous month. The data relating to the landings of the following month are rather incomplete. In March the total landings seem to have dropped still further and at both Colachel and Muttom only basket traps were used in their capture. The estimated totals for each month during the current season are furnished below in tabular form together with those of the corresponding months of the various seasons to

facilitate comparison. On the whole the landings have shown some improvement over that of 1959-60.

	Colachel		Muttom	
	1959-60	1960-61	1959-60	1960-61
December	6,954	7,525	17,718	18,160
January	5,536	4,489	9,842	13,746
February	1,919	..	5,586	..
March	745	1,064	1,138	2,298

In the last annual report it has been pointed out that lobsters belonging to larger length groups of over 200 mm. were proportionately much less than in the previous year. This tendency does not seem to have persisted in the year under report though no marked improvement either has been noticed.

The percentage of berried females caught at Muttom is definitely more in all the months except December than in the last season; but at Colachel the opposite is the case.

*Prawn fishery.*—The prawn fishery along the Kanyakumari District started in May; but the landings were rather poor. The catches of 'Vala Valai', one of the types of gear used in these parts for the purpose, consisted almost exclusively of *P. indicus*. In the *thattumadi* (a type of boat-seine) small quantities of *P. stylifera* and stray individuals of *M. monoceros* were also caught.

It improved considerably in the next month and extended northwards up to a few miles south of Vizhingam. Though correct statistics of landings are not available the catches seem to have been fairly good judging from the numbers the two freezing companies operating here were able to collect. In the following quarter also the fishery remained active with hardly any change in the composition of the landings. In a collection of prawns numbering over a lakh sorted at the Southern Fisheries Corporation Unit at Muttom 0.81% was made up by *P. monodon*, 0.07% by *M. affinis* and still less by *P. carinatus*. Over 99.0% was contributed by *P. indicus* alone. The vast majority of prawns belonging to the last-mentioned species were over 140 mm. long, well beyond the size commonly observed in brackish water catches.

The fishery seems to have come to a close at practically all centres of the District by the middle of October in the third quarter. Towards the close of the season the shore-seine, locally called *kara madi* was also in use at some centres and at Colachel the *netholi valai*, in common use there during the month seem to have captured small quantities of *Acetes* and young ones of *P. stylifera*.

(f) *At Madras.*—The fishery and biology of prawns of Madras and the Ennore and Pulicat lakes continued to be studied as before. No well-marked season of abundance was noticeable at Madras and the fishery showed great fluctuations. The boat-seine (*Thuri vala*) was the chief type of gear used in waters 10–25 metres deep. *P. indicus* was the most abundant species, comprising 80–100% of the catches. The rest was usually made up of *M. dobsoni*, *M. affinis* and *P. stylifera*.

At Ennore fishing was done mainly by cast-nets in depths of 3–6 metres, catches varying from 5 kg. to 25 kg. per day. *P. indicus* was the main species caught.

Pulicat lake with its unbroken connexion with the sea throughout the year has proved to be a rich fishing ground for prawns. Stake nets operating at nights in shallow water, 3–10 metres have caught fairly good quantities of prawns, especially in the last 2 quarters. *P. indicus* and *M. monoceros* made up the bulk of the catches in all months. *P. carinatus* and *M. dobsoni* occurred in quite small numbers.

Study of marine plankton for tracing life-histories of prawns was also continued.

#### 4. *Malabar Sole*—*Cynoglossus semifasciatus*

The fishery of the Malabar sole, *Cynoglossus semifasciatus*, at Calicut was better during 1960–61 than in the previous year; the month of peak commercial landings was September (as is usual along this coast) unlike last year when the fishery was delayed and the peak catches were obtained in October. The total estimated catch of the first quarter at Calicut (Vellyil) was 9.26 metric tons; in the second quarter the total was 484.5 metric tons, all of this being landed in September alone; in the third quarter the estimated landings showed a steep decline to 24.6 metric tons (including the catches reported from locally operating mechanised boats) while in the fourth or last quarter of the year, there was only some negligible landings of this fish at this Centre.

The boat-seines *thattumvala* and *paithuvala* were the two gears that yielded all the sole catches of September, the former accounting for as much as 456.9 metric tons out of the total of 484.5 metric tons. The fishery (of September) was intermittent and unsteady.

Departmental *paithuvala* collections were continued normally once a week throughout the year and these yielded material for length-frequency and maturity studies even after the season of the commercial fishery. Two modes were noticed in the length-frequency curve for September, one at 110–119 mm. and a less dominant one at 140–149 mm. 57.6% of the catches of this month was estimated to fall in the length groups between 110 mm. and 129 mm. while 21.7% was estimated to fall in the length groups of 140 mm. and above. Juveniles of the new brood began appearing in the catches from the second week of November and these formed the mainstay of the fishery during the rest of the year.

The September fishery consisted mainly of individuals in stage IV of maturity. Further advanced stages appeared in gradually increasing numbers in the succeeding two months but as juveniles entered the fishery even in November, it would appear that spawning commenced much earlier than usual and most probably in the off-shore waters. Indeterminates and stage I individuals dominated the catch from November to March, though occasional stage II individuals were also encountered in the new year class in February and March. Spawning appeared from the trend of occurrence of the juveniles in the catches that the period of peak spawning was in the third quarter of the year.

##### 5. Mulletts

Based on the continued biological studies on the two common species of mulletts around Mandapam, viz., *Mugil cephalus* and *Liza macrolepis* with special reference to their growth-rate certain broad generalizations are made.

*M. cephalus*.—The fishery consists of juveniles (about 75–305 mm. LCF), their recruitment at about 75–145 mm. (LCF) size taking place in January; the older size-group fails to occur in the catches by about April and thereafter. Those beyond 200 mm. (LCF) are in I–II stages of maturity. This appears to spawn once in a year for a brief period. Favourable fishing season is from January to May-June. Growth in a calendar year for the juveniles is about 160 mm. It is a bottom feeder subsisting on foraminifera mixed with decayed organic matter and certain filamentous matter. It harbours the larval nematode parasite (genus: *Panisakis*) in the body cavity.

The length-weight relationship was worked out.

*L. macrolepis*.—The fishery consists of juveniles, maturing and spent adults. The recruitment, at about 75 mm. (LCF) size, extends from December to June-July. Maturing and spent fish ranging from 186–313 mm. (LCF) are regularly caught in the sea, their peak season being from June to August. Food of juveniles is basically same as those of *M. cephalus*. But maturing and spent fish feed mainly on harpacticoid and cyclopoid copepods and diatoms, food of the fry consists of *Pleurosigma*, *Navicula* and *Nitzschia*.

Studies on this apparent shift in the food habits from immature to maturing and spent stages; maturity studies by measurement of ova-diameter and growth-rate by length-frequency and scale studies are under progress.

#### 6. Tunnies

In addition to the completion of the work and consolidation of the data on the biology of the skipjack (*Katsuwonus pelamis*) of Minicoy with special reference to its spawning and feeding habits and the biology of Minicoy principal tuna bait *Lepidozygous tapeinosoma*, the following works were also done at this centre.

With a view to gather some information on the probable causes of fluctuations of tuna fishing at Tuticorin in the light of the biology of tunnies the following data on two important species of tuna *E. affinis* and *N. macropterus* were collected—the length frequency, length-weight relationships, sex ratio, morphometric measurements, etc.

There were good landings of tunnies at Tuticorin from July to November 1960 by the boat/whiffing live unit the composition consisting mostly of *Euthynnus affinis* and *Neothunnus macropterus* and occasionally *Auxis thazard*. It was interesting to note that when most of *E. affinis* had gonads of both sexes in the IV and V stages those of *M. macropterus* contributed to the fishery were males in the immature stages. *Kishinoella tonggol* also were landed in good numbers.

#### 7. Molluscs

Studies on the seasonal gonadal variation of the adult pearl oysters, started during the beginning of 1960 could not be continued after the end of the pearl fishery season due to want of regular supply of specimens. Gonads of the oysters examined during the months of April and May were found to

be almost full with ripe reproductive elements in the follicles. In the month of May a few oysters were also found to be partially spent. Pearl fishery commenced at Tuticorin on 22nd March 1961 and is likely to continue up to the middle of May 1961. More than 1,500 divers are engaged in this fishery and an average of 3 lakhs of oysters are fished every day. Samples of pearl oysters are regularly purchased from the retail market during this pearl fishery season also and are measured and the condition of the gonads noted.

During November-December the underwater survey of pearl and chank beds (collaboration work) was continued when Dr. F. B. Salvadori, F.A.O. Underwater Expert, was in Tuticorin. In the absence of a suitable launch work was commenced from the northern area of the central sector. A total number of 150 stations were fixed and the nature of the bottom and depth were recorded. As the sea became very rough towards the beginning of December, the work was discontinued after the middle of December.

### *B. Off-shore Fisheries Investigation*

#### *(a) At Bombay*

During the period under report areawise analysis of the fishery data collected by the off-shore fishing boats at Bombay was completed for the year 1960. Seven vessels of the Government of India, Deep Sea Fishing Station, were carrying out fishing operations in 1960; out of these only M.F.V. *Jheenga* worked in all the months of the year. The operations of the other vessels, viz., M.F.V. *Bumili* (11 months), M.F.V. *Bangada* (4 months), M.F.V. *Champa* (5 months), M.L. *Sagar Pravasi* (6 months), M.L. *Sagarkanti* (3 months) were restricted to some months of the year. With the exception of one long-line trip by M.F.V. *Bangada* in April 1960 and six daily gill-net trips by M.F.V. *Meera* and M.L. *Sagarkant* in October, 1960, all the other operations were carried out with trawl nets. These vessels were mostly working in areas nearabout Bombay and occasionally off Saurashtra coast. All these seven vessels put together landed a total catch of 428,471 kg. of fish in 1960 whereas the two pairs of Bull trawlers of the New India Fisheries Limited landed during the same period 4,247,960 kg. of fish.

The Bull trawlers of the New India Fisheries Limited continued to work throughout the year. During this year they worked in 29 areas lying between area '43' and area 'Z' and landed a total catch of 4,248,060 kg. of fish spending a total effort of 5,167.50 hours of actual fishing. Overall average catch-per-unit-effort worked out to 822 kg./hr. The most salient feature of this year's operation is that these boats have extended their operations

to the northernmost areas (Q, R, S, T, U, V, X, Y) which were not systematically sampled so far. The fishing operations in this virgin area were generally successful with the result it is seen that more than 70% of the total effort was expended there. 'Ghol' and 'Karkara' fishery were particularly good in these areas. The Dwaraka region (areas K, L, M, N) which is known to yield better catches of 'Dara' and 'Koth' was not fished during this year with sufficient intensity. The fishing effort spent in Veraval region (areas 2 and 3) and in Porbunder region (areas A, B, D, E, H, I) were more or less of the same order as in the previous years. 'Wam,' Cat-fish and 'Ghol' were the important catches from Veraval region while 'Dhoma', 'Ghol', Cat-fish and elasmobranchs predominated the catches from Porbunder region. In Bombay and Cambay regions fishing operations were as usual scrappy.

'Dara' (*Polydactylus indicus*) investigations.—'Daras' formed only a small component of the landings of the off-shore fishing vessels this year. The trawlers of the Government of India, Deep Sea Fishing Station, landed 886 kg. of 'Dara' forming 0.206% of their total catches. The bull trawlers of the New India Fisheries Limited landed a total quantity of 86,065 kg. of 'Daras' which amounted to 2.03% of their total catch. The average rate of yield was 16.16 kg./hr. More than 93% of this total quantity of 'Daras' was obtained from areas N, Q, R, S and U in the months of October, November and December. They ranged from 350–850 mm. in length and they were mostly immature; the gonads of the larger fishes being in II and III stages of development in December.

The significant decline in the total catch of 'Dara' this year is perhaps due to the lesser amount of effort spent in Dwaraka region which is considered to be the main 'Dara' fishing ground. Gill-net fishing for 'Dara' started at Satpati and other fishing villages. Detailed investigations are planned for the coming season. Very small (150–200 mm.) juveniles of 'Dara' are obtained in small numbers almost throughout the year in the Dol-net catches of Versova and sometimes in Sassoon Docks.

'Wam' (*Muraenesox talabonoides*) investigations.—The Government of India vessels landed a total quantity of 6,706 kg. of eels during 1960. It accounted for 1.56% of the total catch. The New India Fisheries trawlers landed 298,200 kg. of 'Wam' during the same period. The average rate of yield was 57.7 kg./hr. and it accounted for 7.01% of the total catches. The yield of 'Wam' was particularly good from Veraval region. Very large quantities of eels were landed from area 'Q' in the month of August

1960 when an average yield of more than 350 kg./hr. of eels was realised. It was also observed that this catch contained a fair percentage of *Muraenesox cinereus* as well. Size of eels caught by these vessels ranged from 1,220 cm. to 1,700 cm.

'Koth' (*Otolithoides brunneus*) investigations.—The bull trawlers of the New India Fisheries Limited landed 31,845 kg. of 'Koth', forming only 0.75% of the total catch for 1960. This is the lowest annual percentage catch of 'Koth' in the trawler landings. Another feature noted was the paucity of adult 'Koth' in the catches of the previous three seasons (1958-61). This and the poor fishery for 'Koth' could be due to two reasons, namely, (i) the lesser exploitation of the recognized Koth-rich areas, and (ii) the lesser amount of the standing crop of 'Koth'. Results of the areawise analysis of the catches show that first is true. The trawlers of New India Fisheries Limited spent only 367 hours out of a total trawling time of 5171 hours in the areas K, L, M and N (Dwaraka region) which have proved to be rich in 'Koth', while the vessels have spent 383 hours in area 'R' in the month of March 1960 alone. It is further seen that whenever areas K, L, M and N were fished fairly good catches of 'Koth' were reported (C.P.U.E. of 199 kg. in February 1960 in area 'K', 154 kg. in January 1960 in area 'K', 100 kg. in December 1960 in area 'K'). The second factor, namely, the lesser amount of the standing crop of 'Koth' cannot be verified with the data available.

The Off-shore Fisheries Station trawlers landed very small catches of 'Koth'.

Studies on the inshore catches of 'Koth' indicate that the fish attains 385 mm. in size at the completion of one-year. Length-frequency distribution of 'Koth' from the catches of the trawlers for past three seasons shows out three modes, at 385, 525/595 and 805/875 mm., which can be said to be representing the I, II and III year classes. This is in agreement with the findings of the study of scales of 'Koth'. 'Koth' of the inshore catches appear to be mainly of '0' and 'I' year class.

Stomach contents of 1565 'Koth' were analysed and the fish are seen to prefer *Acetes indicus*, among prawns and *Coilia dussumieri* and *Bregmaceros macellandi* among the fishes. The feeding intensity of the fish are found to be least during the cold months, November to February, when rings are presumably laid on the scales.

Gonad studies indicate that the 'Koth' probably begin spawning by the end of monsoon period and continue to spawn for about six months, as evi-

denced by the prolonged recruitment of young 'Koth'. The individual fish spawns once a year and exude all ova at one time.

'Ghol' (*Pseudosciaena diacanthus*) investigations.—'Ghol' landings of the bull trawlers of New India Fisheries Limited were good this year with an increase of 1,05,542 kg. in the annual catch (0.15%) over that of last year (1959). The percentage of 'Ghol' to total catch this year (1960) is 6.66. The increase in the annual catch of 'Ghol' as well as total catch this year (1960) seems to be due to concentration of effort in the areas P, Q, R, S, T, U, V, X, Y, Z of the Cutch region which had not been fished during the previous years. The peak landings of Ghol were in the months January, February, March and April. From May onwards the catch of 'Ghol' declined and August to October was the period when the landings of 'Ghol' were very poor. From November through December the landings of 'Ghol' gradually increased. This seasonal fluctuation in the catch of 'Ghol' may be indicative of seasonal movements of this species in this region (Maharashtra and Gujarat waters) which has to be studied in detail.

30–50 mm. post-larvae and 50–100 mm. small juveniles occurred from the end of June through July, August in the dol-net fishing at Varsova and Sassoon Docks. 100–150 mm. and 150–200 mm. groups were dominant in September and October, 200–250 mm. group in November and December. From January onwards few juveniles appear in the dol-net catches at Ver-sova and big Ghols are landed in good numbers.

The feeding intensity of juveniles was observed to be high during September to December. Prawns constituted nearly 80% of the stomach contents of the juveniles during this period. *Acetes indicus*, *Parapenaeopsis stylifera*, *Parapenaeopsis* sp., *Solenocera* sp., *Hippolysmata ensirostris* were the important species of Prawns observed in the stomach contents. *Bregmaceros macclellandi*, *Polynemus heptadactylus*, small sciaenids (Doma), *Coilia dussumieri*, *Thrissocles* sp. were the fish items.

The spawning season in this species is protracted extending from June to September. From October to March specimens in stages I, II, III (and recovering I, II, III) were encountered. From April onwards specimens in stage IV appear in the trawler landings as well as local dol-net landings and during May-June most of them were in stage V or early VI. From July to September spent or partially spent and few recovering spents were encountered.

Examinations made on the scales and otoliths of 800 fishes ranging from 50–1,150 mm. showed growth rings on them. The percentage of scales with

minimum marginal growth (circuli count in the terminal zone) is high from August to January, which appears to be the time of formation of the rings in the scales. The translucent rings on the otoliths appear to be formed during the period October to December. The average length of fish showing I, II, III, IV, V, VI, VII, VIII rings on their scales has been found to be 446, 683, 809, 899, 995, 1,043, 1,076, 1,135 mm. respectively. There seems to be a fairly good agreement between the size of the age-groups observed in the length-frequency distributions and the average size of fish having I to V rings on their scales. Thus the modes at 425/475, 675/625, 775/825, 875/925 and 975/1,020 mm. can be taken as representing the age-groups I, II, III, IV and V respectively. The results of studies on otoliths are more or less in close agreement with those scales.

'Karkara' (*Pomadasys hasta*) investigations.—Biological studies of *Pomadasys hasta* were continued during this period. For the period January 1960 to December 1960, 469,562 kg. of 'Karkara' were landed by the New India Fisheries Limited and constituted 11.28% of the total catch. 'Karkara' fishery was best in the month of November and the catch-per-unit-effort was 211.47 kg./hour. In April, May and September the fishery was moderate the yield ranged from 32.91 to 88.53 kg./hour while from June to August it was very poor. Good 'Karkara' catches were recorded from the areas R, Q, N and V. The highest catch record for the season was from the area N in the month of February 1960, and the catch-per-unit-effort for the same was 636.61 kg./hour.

The graphical picture of length frequency data shows that in the months of May, January and February there are two modes while in April, June, September, October, November, December and March there is only one mode at different size-groups. Otoliths were studied for growth study and it showed that the otoliths from the fish ranging from 130 to 240 mm. show one ring; 250 to 360 mm. range 2 rings; 370 to 480 mm. size-group 3 rings; 490 to 560 mm. size-range 4 rings and 570 mm. onwards 5 rings.

Analysis of stomach contents showed that majority of stomachs were empty or with a very little digested matter. In the rest of the cases *Squilla*, prawns, crab, etc., in highly digested condition, was noticed in the stomach contents. Occasionally fishes, bivalves, *Echiurus* and polychaetes were also observed in the stomach contents.

From April to June the ovaries of *P. hasta* were observed in advance stage of maturity and in September they were in VI stage. In November-December the ovaries were in spent recovering condition.

'Bombay Duck' (*Harpodon nehereus*) investigations.—During 1960-61, 3,988 specimens were measured for length-frequency studies at Versova. In addition, 344 specimens were examined in the laboratory for collecting biological data. Body measurements of 105 specimens from Jaunput (Orissa) were taken and the data remains to be processed for studies on delimitation of stocks.

The results of the investigations carried out during the year confirm the findings arrived at earlier. The following conclusions can be arrived at based on observations made during the last three years, since 1958:

(i) The breeding season appears to be continuous with a peak breeding season lasting three to four months from December to March or so, (ii) The minimum length of the fish at first maturity has been found out to be 210 mm. in total length. (iii) The individual of the species spawns only once a year as seen by the frequency distribution of ova diameter measurements. (iv) The number of mature ova in a fish measuring 210 mm. in total length is considerably less than fish varying between 240 and 280 mm. The range of variation being 14,000-30,000 in smaller and 80,000-140,000 in bigger fish. (v) The data on length-frequency studies support the observations on the breeding season, *i.e.*, continuous breeding as evidenced by the presence of smaller groups throughout the year. As such the length-frequency data have to be carefully studied before determining the age and the rate of growth based on it. (vi) From the pooled length-frequency data for the years 1958-59, 1959-60 and 1960-61 two modes can be made out at 127 mm. and 217 mm. with slight variations. They probably appear to represent the one-year old and two-year old fishes. (vii) Assuming that the fish attains a length of 217 mm. in total length at completion of two years, then it can be said that it attains first maturity at two years of its life. (viii) The commercial catches of Bombay duck along the Maharashtra coast indicate a gradual decrease in landings from 1956 to 1959. The landings during 1956 accounted for 76,458 metric tons as against 27,279 metric tons in 1959 although the fishing method, the fishing grounds and the fishing effort remain more or less the same. During 1960 the fishery was a failure but exact figures are not yet available for comparison. (ix) The catch composition indicates that the fishery is mainly supported by juvenile fishes. Fish beyond the minimum size of maturity accounted for only 18%, 21% and 20% during 1958-59, 1959-60 and 1960-61 respectively. The percentage of fish which might have spawned for the second time during the current year was as low as 10.

## (b) At Veraval

Three off-shore fishing vessels of the Government of India M.L. *Meera*, M.L. *Sagarkanti* and M.F.V. *Bumili* operated from Veraval during the year under report. The results of the operations of these vessels are delineated in Table VI given below. The three vessels between them landed 37,289.03 kg. of fish during the last two quarters of the period M.L. *Meera* recorded the maximum catch followed by M.L. *Sagarkanti* and M.F.V. *Bumili*. M.L. *Sagarkanti* had the maximum number of fishing days (96) followed by M.L. *Meera* (52) and M.F.V. *Bumili* (8).

The landings of the 'Dangri' (*Johnius hololepidotus*) were few and far between during the year. Only 36 specimens ranging in length (870-1,070 mm.) were available for study owing to the paucity of landings.

Fishery biological studies were initiated on the 'Red fish' or 'Sea bream', *Argyrops spinifer* (Family—Sparidae) which formed a sizable part of the catches of M.L. *Meera*. Over 1,100 specimens were measured for length-frequency studies, the length-range being 130-364 mm. For the study of weight-length relationship, data were collected from 123 fish. Ovaries in stage VI (I.C.E.S.) having 'speckled' appearance were collected in December 1960. Studies on food and feeding habits and on growth checks on scales are in progress.

TABLE VI

Showing the results of the off-shore operations during the year ended 31-3-1961.

## I. M.L. MEERA

Period	No. of fishing days	No. of fishing hours	No. of hauls	Catch per hour kg.	Catch per haul kg.	Total catch kg.
Quarter ending 31-12-1960	35	161-10	138	71.63	83.65	11,544.99
Quarter ending 31-3-1961	17	64-40	47	77.74	106.96	5,027.00

## A. Quarter ending 31-12-1960

(i) Areas fished, in the descending order of fishing-hauls within brackets } 21-69 (Off Porbander—November, 1960)  
4D; 3E; 3C  
(12) (3) (2)

Range in depth	..	20·13-38·40 metres.
Gear employed	..	(a) Larsen Trawl H.R. 46' F.R. 50'
		(b) Shrimp Trawl H.R. 39' 4" F.R. 30' 10"
(ii) Areas fished, in the descending order of frequency of fishing hauls within brackets	}	20-70 (Off Veraval—November 1960 and December 1960) 6B; 5C; 5B; 6A; 6C; 5D; 1A; 6D (42) (40) (10) (7) (6) (5) (4) (1)
Range in depth	..	23·80-42·80 metres.
Gear employed	..	(a) and (b) as in (i), plus Nylon nets.

*B. Quarter ending 31-3-1961*

Areas fished in the descending order of frequency of fishing hauls within brackets	}	20-70 (Off Veraval) 5B; 6B; 6A; 5C (19) (19) (7) (2)
Range in depth	..	23·80-42·10 metres
Gear employed	..	(a) Larsen Trawl H.R. 46' F.R. 50'
		(b) Shrimp Trawl H.R. 39' 4" F.R. 30' 10"

*Catch Composition*

Sl. No.	Composition of the catch	Weight kg.	Sl. No.	Composition of the catch	Weight kg.
1	'Dhoma'	2,655	15	Red Perch	50
2	'Pervi'	590	16	'Bangada'	35
3	'Ghol'	251	17	'Pallva'	35
4	Prawns	233	18	'Kati'	28
5	Sharks	178	19	'Tam'	22
6	Miscellaneous fish	165	20	'Wakti'	21
7	Rays	130	21	'Koth'	14
8	'Dara'	127	22	'Bakas'	10
9	'Red fish'	100	23	'Surmai'	10
10	'Wam'	94	24	'Pomfret'	8
11	Cat-fish	70	25	'Chand'	5
12	Skates	70	26	'Chor Bombil'	5
13	'Karkara'	67	27	Lobsters	2
14	'Karli'	50	28	Squids	2
TOTAL ..					5,027

II. M. L. SAGARKANTI

Period	No. of fishing days	No. of fishing hours	No. of hauls	Catch per hour kg.	Catch per haul kg.	Total catch kg.
Quarter ended 31-12-1960	32	185-00	57	22.45	72.87	4,153.51
Quarter ended 31-3-1961	64	277-15	97	25.92	74.07	7,185.23

A. Quarter ended 31-12-1960

- (1) Areas fished in the descending order of frequency of fishing hauls within brackets } 21-69 (Off Porbander—November 1960)  
 4D; 4C; 3D  
 (4) (3) (2)
- Range in depth .. 23.80-29.30 metres
- Gear employed .. Nylon gill-nets—mesh 5½"—16 pieces
- (2) Areas fished in the descending order of frequency of fishing hauls within brackets } 20-70 (Off Veraval—November and December 1960)  
 6A; 5B; 5A; 6B  
 (28) (10) (5) (5)
- Range in depth .. 29.30-51.20 metres
- Gear employed .. Same as in (1).

B. Quarter ended 31-3-1961

- Areas fished in the descending order of frequency of fishing hauls within brackets } 20-69  
 (3) (1)  
 20-70  
 5B; 6A; 6B; 5C; 5A  
 (43) (20) (16) (10) (4)
- Range in depth .. 27.0-49.0 metres
- Gear employed .. (a) Nylon gill-net—mesh 5½"—16 pieces (in January 1961)  
 (b) Bottom set gill-net—mesh 5½", 46" —16-17 pieces (in February 4, March 1961)

Sl. No.	Composition of the catch	Weight kg.
1	Pomfret	3,000·22
2	Sharks	1,517·64
3	'Pallva'	922·00
4	Cat-fish	354·50
5	'Ghol'	339·07
6	Miscellaneous fish	187·26
7	'Karli'	185·00
8	Tuna	168·00
9	'Bing'	144·50
10	Leather skin	118·00
11	'Surmai'	71·54
12	'Kati'	35·00
13	'Chand'	18·00
14	'Tam'	17·00
15	'Red fish'	16·00
16	'Rawas'	16·00
17	Mackerel	15·00
18	Sole fish	15·00
19	Rays	14·00
20	'Karkara'	13·50
21	'Wam'	12·00
22	'Koth'	6·00
TOTAL ..		7,185·23

## III. M.F.V. BUMILI

Period	No. of fishing days	No. of fishing hours	No. of hauls	Catch per hour kg.	Catch per haul kg.	Total catch kg.
Quarter ended 31-12-1960	8	39-05	28	240·67	334·94	9,378·30

Areas fished in the descending order of frequency of fishing hauls within brackets } (a) 18-72  
 3D; 4C; 5D; 6D  
 (3) (2) (2) (2)

Range in depth .. 25·60-40·30 metres  
 (b) 19-72  
 2B; 2A; 3A;  
 (2) (1) (1)

Range in depth	.. 40.30-49.40 metres (c) 20-69 5F (2)
Range in depth	.. 54.90-58.56 metres (d) 20-70 5B; 5C; 6B (8) (3) (2)
Range in depth	.. 25.60-40.30 metres
Gear employed	.. (a) Russian Trawl 45' (b) Larsen Trawl H.R. 81' (Big) F.R. 87' 3"

(c) At Ernakulam

*Government of India trawlers.*—M.F.V. Pratap continued its Otter trawling operations off the coast between Calicut and Cochin but mainly concentrating her fishing effort between Ponnani and Alleppey, as in the previous year, at depth ranging from 24-49 metres. A total of 1,23,417 kg. of fish were landed up to the end of January 1961. The catches were poor in December 1961 on account of heavy concentration of jelly fish between Cochin and Quilon as evidenced by the low catch rate (114.5 kg./hour). The catch varied from as low as 87.9 kg./hour in June to as high as 203.8 kg./hour in January. During April-May the average catch per hour was 168 kg. and during October to December 160 kg./hour. The average catch/hour for the year was 166 kg. which compares favourably with 152 kg./hour in the previous year. But the total effort was less than 30% and a total catch a little less than 50% of 1959-60 figures. Details of catch taken from October 1960 to January 1961 are given below.

	Effort in hours	Total catch in kg.	Catch per hour	Percentage of major categories			
				Small fish	Sharks and rays	Cat- fish	Others
1. Alleppey area	391.6	1,10,734	282.6	71.6	14.6	6.0	1.0
2. Ponnani area	71.2	10,462	146.8	45.8	43.8	9.1	0.4
3. Calicut area	22.3	2,221	98.7	64.4	34.7	..	..

Small fish formed the major catch in all the areas; while cat-fish were taken in good quantities off Alleppey and Ponnani, sharks and rays were abundant in both Ponnani and Calicut areas—a feature observed in the previous years also. Prawns were negligible in all the 3 areas between 24 and 49 metres.

*M.F.V. Durgā, Samudra, and Tarpon.*—Shrimp trawling by these small vessels was mostly confined to areas off Cochin between 5 and 31 metres. Prawns were caught at 54.7 kg./hour in June, practically nil during September and October but varied between 12.2 and 35.26 kg. between November and January and 21.6–27.6 kg./hour during April and May. Small fish, however, formed 90% of the total catch. When the general catch declined in June the prawn catches showed double the yield per hour to the previous months. The total landings in the area amounted to 74,117 kg. of fish.

Two vessels worked off Tellicherry and Mangalore from November 1960 to January 1961 bringing 16,344 kg. and 65,225 kg. of fish respectively. Prawn catches were, however, poor in these areas.

The highest general catch return was obtained off Tellicherry (267.8 kg./hour) but fishing effort was limited only to the first half of November. Mangalore area gave 189.2 kg./hour in November–January as compared to Cochin area where 246.9 kg./hour were recorded for the same period. The relative abundance of the different areas cannot be determined properly unless proper sampling is made throughout the areas during the entire fishing season.

*Indo-Norwegian Project Vessels.*—Five boats (20 ton vessels) were operating mainly off Cochin for shrimp trawling. Out of a total fishing effort of 1,996.3 hours, 1,420.25 hours (about 70%) were spent south of Cochin and the rest north of Cochin. During March to early May fishing was confined to 6–8 fathom region, but later the boats shifted their activity towards 10–13 fathom depths. From September to October the boats worked in the 20 fathom line. The total landings for the year amounted to over 300 tons with an average yield of 151 kg./hour of trawling. Catches were better in shallower areas from March to May and December onwards. But at the commencement and termination of the monsoon the deeper regions were found more productive. This observation, however, cannot be generalised, at present, as effort is not evenly distributed over the entire region, though the tendency of commercial trawlers is to move towards areas of abundance of the species of fish they are after.

The boats were primarily fishing for prawns and about 90 tons of prawns (30% of total catch) were landed. 29% of annual prawn landings was taken in June 1960 around the 10-12 fathom line and consisted mainly of small prawns—*Metapenaeus dobsoni*. Details of prawn catch, effort and distribution are given below.

*Distribution of effort, catch and catch per unit of effort in space.—  
Areawise distribution of the effort and catch during the year 1960-61*

Area	North Cochin	South Cochin	Total
Total catch	85,868	215,293	301,161
Prawn	33,911	56,104	90,015
Total effort	576.05 (28.9%)	1,420.25 (71.1%)	1,996.3
C. fish/hour of trawling	149.1 kg.	151.6 kg.	150.9
Prawn c./hour of trawling	58.9	39.5	45.1

The fish were composed of a mixture of small fishes like *Nemipterus japonicus*, *Lactarius lactarius*, Sciaenids, ribbon fish, cat-fishes, *Upaeneus* sp., *Saurida* sp., Soles and juvenile *Serranus*.

*Other types of mechanised fishing: Purse seining.*—During September and part of October by one boat in 8-10 fathom area brought in 14,400 kg. of mackerel and 9,600 kg. of oil sardine. *Trolling line* was employed along with trawling when 2½ tons of seer fish majority of which (2 tons) were landed during September–November. *Hook and line* were chiefly used for Kalava fishing (*Serranus*) by R.V. KALAVA in the 48-50 fathom areas and is said to have given very good results. The data of the operations are not passed on to this substation.

*Biology and Fishery of Nemipterus japonicus and Lactarius lactarius.*—The biology of the two fishes is being studied as ancillary to the general study of the off-shore fisheries as no significant catches of prime fish are taken by trawling in these regions and these two species constitute the better varieties of fish taken in fair quantities. *N. japonicus* were caught off Cochin at 27-31 metres in good quantities but few in 37-50 metres. 11-14 cm. length groups occurred in April and May while in June younger fish were recorded. In September the modal size was 10 cm., in October 12 cm., and November/December 13 cm. Mature fish occurred during October-February with their peak during October–November. By March only immature fish were met with. Prawns and polychaetes formed the main food items in their diet. Occurrence of *Squilla* in large numbers in gut contents is an interesting feature.

*Lactarius lactarius*.—About 4,000 kg. were landed by Indo-Norwegian Project Boats during the year, the peak period of occurrence being March–April 1960. The length ranged from 11 to 28 cm. The growth rate between sexes were found to vary, the females having larger modal length than males. Juveniles appeared during January and March and ranged from 7 to 9 cm. The fish was found to be active piscivores with a marked favour for Anchovies. The juveniles of 7 cm. feed mostly on Mysids.

(d) *At Tuticorin*

During the year under report frequent trips were undertaken on board the vessels of the Offshore Fishing Station, Tuticorin, for collection of biological data and the catch data of the vessels were analysed and compiled. Four vessels, viz., M.L. *Sardinella*, *Meenakshi*, *Sagar Suhdari* and *Meenalochani*, were operating during the year. Bottom set gillnets, shrimp trawls, long-lines, drift-nets and R.C. hooks were used.

*Bottom-set gill nets*.—Bottom-set gill netting was done mostly off Tuticorin (Area 8-78/50) and on a few days near Cape Comorin (Area 8-77/10). The nets, usually 10–12 in number, were set in the evening and hauled up in the morning and hauled up in the evening. The latter sets consistently produced poorer catches, presumably due to the greater visibility of the nets during daylight hours. The details of catch, effort and catch-per-unit-effort of all the vessels operating bottom-nets are summarized below for each area separately.

*Area 8-78/5 B, Depth fished 3–8 fathoms*

	No. of sets	Total kg.	Catch/set kg.
April 1960	.. 28	1,454	51.9
May	.. 45	833	18.5
June	.. 34	835	24.6
July	.. 31	1,001	32.3
August	.. 39	1,601	41.1
September	.. 41	1,332	32.5
October	.. 66	2,929	44.4
November	.. 30	1,776	59.2
December	.. 17	1,428	84.0
January 1961	.. 34	1,884	55.4
February	.. 30	1,869	62.3
March	.. 25	1,296	51.8

It will be seen that bottom-setting yielded a fairly good catch throughout the year though the period November to April was more productive:

The percentage composition of the important fishes caught in the nets are given below for each quarter:

	April, May, June 1960	July, Aug., Sept. 1960	Oct., Nov., Dec. 1960	Jan., Feb., March 1961
Sharks ..	28.5	51.9	30.5	54.1
Skates ..	1.2	5.3	15.5	1.2
Rays ..	11.3	7.0	3.5	22.4
<i>Chorinemus</i> ..	17.3	5.4	2.5	0.98
<i>Arius</i> ..	18.4	0.4	17.9	16.1
Sciaenids ..	6.3	6.5	6.5	9.1
Perches ..	3.1	8.5	2.3	0.46
<i>Chirocentrus</i> ..	0.85	3.7	1.2	0.33
<i>Polynemus</i> ..	1.1	7.2	3.1	1.1

Elasmobranchs occurred throughout the year in good quantities and made up a large proportion of the catch. Chorinemids represented mainly by large specimens of *Chorinemus lysan* (10-13 lb.) occurred in good number only during the first quarter. Ariids, mostly large specimens of *Arius dussumieri* (5-8 lb.), occurred mainly during the first and last quarters and sporadically during the third quarter. *Polynemus indicus* occurred mainly during the second and third quarters.

Area 8-77/1-10, depth fished 7-11 fathoms. Bottom-setting was done only during February and March.

	No. of sets	Total catch kg.	Catch/set kg.
February ..	3	293	97.7
March ..	2	127	63.5

*Catch composition.*—Sharks 37.3%, *Arius* 20.5%, Rays, Sciaenids 8.7%, *Chorinemns* 3.5%, *Caranx* 2.4%, Miscellaneous 18.3%.

*Shrimp Trawls.*—Shrimp trawling was done mostly off Pinnakayal (Area 8-78/48) and Devil Point (Area 8-78/5-B) and occasionally off Overi (Area 8-77/2 F), Idinthakarai (Area 8-77/1 E) and Cape Comorin (Area 8-77/1 D) and Nallathanni thivu (Area 9-78/1 D).

For each area the total effort put in by all the vessels, the total catch and catch per trawling hour are summarized monthwise below: Shrimp trawling was done only during daytime.

*Area 8-78/4 B, Depth fished 7-12 fathoms*

	Trawling hours	Total catch kg.	Catch/hour kg.
June 1960	.. 90-50	3,855	42.0
July	.. 171-35	7,379	42.0
August	.. 210-30	15,729	74.7
September	.. 188-20	19,846	105.4
October	.. 145-40	16,196	111.7
November	.. 212-40	18,579	87.3
December	.. 77-10	4,381	56.8
January 1961	.. 12-20	295	23.9
February	.. 30-40	887	28.9
March	.. 82-25	2,509	30.4

It is seen that the second and third quarters were the most productive periods at Pinnakayal, the last quarter being the poorest.

Percentage composition of fishes caught in the shrimp trawl is given below for each quarter.

	April, May, June 1960	July, Aug., Sept. 1960	Oct., Nov., Dec. 1960	Jan., Feb., March 1961
Prawns ..	30.0%	22.0%	12.1%	18.5%
Sciaenids ..	21.3	26.4	32.9	30.4
Leiognathids ..	9.5	6.5	15.2	20.0
<i>Cynoglossus</i> ..	3.9	6.9	7.4	4.2
<i>Pomadourys</i> ..	15.7	5.6	5.5	5.2
<i>Polynemus</i> ..	Traces	8.4	8.9	Traces
Miscellaneous ..	19.6	24.2	18.2	21.6

Prawns occurred in good quantities during the first two quarters and then dwindled in number. *Metapenaeus dobsoni*, *M. affinis*, *Penaeus carinatus* and *P. indicus* were the important species arranged in the order of abundance. Small Sciaenids mainly *Pseudosciaena* since *Umbrina* formed the major component of the fish catches, all through the year. The Leiognathids came next in importance. The miscellaneous fraction was made up of Elasmobranchs (mostly skates and rays), clupeids (mainly *Opisthopterus* and *Thrissocles*), *Trichiurus* and *Therapon*. The common polynemid was *Polynemus heptadactylus*.

Area 8-78/5 B, Depth fished 3 fathoms

	Trawling hours	Total catch kg.	Catch/hour kg.
December 1960 ..	14-45	812	55.1
January 1961 ..	69-10	2,418	34.9
February 1961 ..	62-10	1,195	19.2
March 1961 ..	32-00	184	5.8

Catch composition.—Prawns 19.3%, Crabs 14.3%, Sciaenids 20.6%, *Cynoglossus* 8.1%, Clupeids 15.3%, *Leiognathus* 2.6%, Miscellaneous 10.6%.

*Metapenaeus dobsoni* and *M. affinis* were the important prawn species. The crabs were *Neptunus pelagicus*, *N. sanguinolentus* and *Scylla serrata*. The Sciaenids consisted of *Pseudosciaena sina*, *Umbrina russelli*, *U. macrop-tera*, *Sciaenoides microdon*. The important clupeids were *Opisthopterus*, *Coilia* and *Thrissocles*. The crabs, clupeids and *Cynoglossus* were relatively more important and the Leiognathids and *Pomadasys* less so in the Devil Point catches when compared to those of Pinnakayal.

*Area 8-77/2 F, Depth fished 5-7 fathoms*

	Trawling hours	Total catch kg.	Catch/hour kg.
December 1960 ..	3-05	39	12.6
February 1961 ..	10-55	444	40.0

*Catch composition.*—*Leiognathus* 48.5%, Sciaenids 29.1%, Clupeids 9.7%, Rays 3.0%, Miscellaneous 9.7%.

The catches in the Overi area were made up mostly of *Leiognathus* and Sciaenids. Among the latter *Pseudosciaena axillaris* was the most common species. Prawns formed a very small fraction of the catch.

*Area 8-77/1 E. Depth fished 5-31 fathoms*

	Trawling hours	Total catch kg.	Catch/hour kg.
February ..	4-05	286	70.0

*Catch composition.*—Prawns 9.0%, *Arius* 8.0%, Sciaenids 24.5%, Clupeids 32.6%, Miscellaneous 25.9%.

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*Area 8-77/10, Depth fished 5-13 fathoms*

		Trawling hours	Total catch kg.	Catch/hour kg.
February	..	5-50	29	5.0
March	..	6-10	5	0.8
<i>Area 9-78/10</i>				
December	..	1-30	2	1.3

The catches in the last two areas were very poor during the months fished.

*Long-lines.*—Long-lining was done off Tuticorin (Area 8-78/5 B) and Cape Comorin (Area 8-77/10). The details of catch, effort and catch-per-unit-effort are summarized below. Area 8-78/5 B. Depth fished 5-11 fathoms.

		No. of hooks operated	Total catch kg.	Catch/100 hooks
1st Quarter	..	3,495	343	9.9
2nd Quarter	..	1,625	138	8.5

*Catch composition for the two quarters.*—Sharks 30.2%, Rays 32.8%, Perches 6.8%, Carangids 3.6%, Miscellaneous 26.6%.

*Area 8-77/10, Depth fished 5-7 fathoms*

		No. of hooks operated	Total catch kg.	Catch/100 hooks kg.
February	..	200	60	30.0

*Catch composition.*—Sharks 10.5%, Rays 67.2%, Skates 22.3%.

*Drift-nets.*—Drift-netting was done in the night off Tuticorin (Area 8-78/5 B) only. The details are given below.

	No. of sets	Total catch kg.	Catch/set kg.
1st Quarter ..	39	383	9.9

*Catch composition.*—*Euthynnus* 33.3%, Sharks 22.4%, *Arius* 11.8%, *Chirocentrus* 8.8%, *Scomberomorus* 7.0%, miscellaneous 16.7%.

*R.C. Hooks.*—R.C. hooks were operated off Tuticorin only on three days. A large tiger shark (*Galeocerdo*) was the only fish caught.

	No. of hooks operated	Total catch kg.	Catch/100 hooks kg.
June ..	126	77	60.8

(e) *At Waltair*

During the year the vessels, six in number, made a total of 579 voyages, making a total of 1,027 hauls in 4161 hours. They caught an average of 231.5 kg./day; 143 kg./haul, and 33 kg./hour of fishing, a total of 1,46,354 kg. were taken in all, and this fetched Rs. 54,216.36 nP. in the market. Table VII gives details of this data, which is based on a series of *exploratory* hauls to ascertain the fishing grounds off the coasts of Orissa and Andhra Pradesh.

Although there are still several hundred square miles of sea area over the continental shelf to be explored satisfactorily between Kakinada in the south and False Point in the north, yet our investigations have indicated 4 chief trawling and gill netting grounds or areas, in depths chiefly between 15 and 80 metres off-shore. These are the sea areas boxed between :

- (a) 17° 40' N and 18° 10' N and 83° 30' E and 84° 20' E; off Vizagapatnam and Bimlipatnam. The bulk of the catches here consisted of *Upeneus*, *Saurida*, *Johnius* and other small fish. A few large sharks and prawns (specially at night) were taken here.

TABLE VII

Vessel	Areas fished	Depth (M)	Gear used	Number of				Average catch per			Total catch	Amount
				Voyages	Days	Hauls	Hours	Day	Haul	Hour		
<i>Ashok</i>	.. Vizag-Paradwip	22-120	Otter Trawl, Hoover, Grimsby, Murmansk	42	92	235	729	831.4	326	105	76,496	Rs. nP. 22,428 37
<i>Gudjon</i>	.. Vizag coast	22-80	Longline and Otter Trawl, Murmansk	75	75	127	233	314.4	186	101	23,582	11,968 12
<i>Sea House</i>	.. Vizag and Paradwip	14-80	Otter Trawl, Shrimp, Murmansk	85	88	229	292	172.3	66	52	15,162	4,453 12
<i>Sagar Kumari</i>	.. do.	14-80	Driftnets and Otter Trawl, Shrimp, Murmansk	150	150	282	537	119.1	63	33	17,864	7,675 25
<i>Dau Boat I</i>	.. Vizag	14-40	Bottomset Nylon, Gill nets	127	127	86	1270	59.7	88	6	7,585	4,299 50
<i>Dau Boat II</i>	.. do.	14-40	do.	100	100	68	1000	55.7	82	6	5,665	3,292 00
Total	.. ..	..	..	579	632	1027	4161	231.5	143	33	1,46,354	54,216 36

- (b) 18° 30' N and 19° N and 84° 30' E and 85° E; off Kalingapatnam and Baruva. This area is very prolific in large sciaenids, *Priacanthus* and carangids in day hauls; and in prawns during night time. Catches of 600 kg./hour and over were not uncommon.
- (c) 19° 20' N and 19° 50' N and 85° 30' E and 86° 20' E; off Chilka, Puri and River Devi. The catches here contained a greater proportion of pomfrets, sharks and prawns. The prawns occurred chiefly during night hauls.
- (d) 20° N and 20° 30' N and 86° 40' E and 87° 30' E; off the mouth of the river Mahanadi. This area is rich in medium and small size prawns, juvenile pomfrets, sciaenids, clupeids and carangids. The prawns appear to inhabit the shallows inshore.

All the grounds above yielded over 100 kg./hour of trawling. Chief species identified in the catches are shown in Table VIII with their individual contributions.

During the year under review M.T. *Ashok* undertook seven voyages for exploratory trawling in pursuance of F.A.O.'s programme, in the regions between Visakhapatnam and False Point and yielded on an average 96.78 kg. per hour of trawling. This area for convenience was divided broadly into four zones, viz., (1) Zone A: Visakhapatnam to Kalingapatnam; (2) Zone B: Kalingapatnam to Gopalpur; (3) Zone C: Gopalpur to Puri and (4) Zone D: Puri to False Point. The entire area was further subdivided into squares each square measuring 10×10 miles and numbered. Each zone was thus approximately made up of 15-17 squares. Although there were about 60 squares in the entire area between Visakhapatnam and False Point trawling operations were restricted to only 29 squares and they were square Nos. 19, 22, 23, 24, 27, 28, 36, 37, 39, 40, 42 A, 56, 57, 58, 59, 63, 68, 69, 69 A, 70, 71, 72, 72 A, 72 B, 73, 73 A, 74 and 75. Further major fishing was done in depths ranging from 0 to 30 fathoms. Fishing in depths beyond 30 fathoms was not uncommon though not as extensive as in lesser depths. The yield per hour of fishing in each square ranged from 13.33 to 606.55 kg., the maximum yield being in square No. 42 A and the minimum in square No. 24. While 7 squares, viz., square Nos. 24, 29, 40, 56, 57, 68 and 69 A yielded 0-50 kg. per hour; square Nos. 22, 23, 27, 59, 63, 71, 72, 72 B, 73 A and 74 yielded 50-100 kg. per hour, square Nos. 28, 36, 70, 73 and 75 yielded 100-150 kg. per hour, square Nos. 19, 72 A yielded 150-200 kg. per hour and the yield in square Nos. 37, 39, 42 A, 58 and 69 was above 200 kg. per hour. Accordingly zones A, B, C and D respectively yielded 75,

TABLE VIII

Species	Ashok	Gudjon	Sea Horse	Sagar Kumari	Dan Boat		
					I	II	Total
1. Crabs ( <i>Neptunus Charybdys</i> )	163	263	141	45	.	5	617
2. Prawns ( <i>Fenaeus, Metapenaeus</i> )	3,320	777	452	836	.	..	5,385
3. Skates	3,123	401	218	180	105	13	4,040
4. Rays	3,758	448	1,400	537	..	3	6,146
5. Sharks	.. 6,296	469	329	1,115	6,404	4,524	19,137
6. Saw fish	.. 3,643	86	460	280	573	410	5,452
7. Eels	.. 2,569	99	43	96	..	.	2,807
8. Cat-fish	.. 14,316	1,227	981	781	268	409	17,985
9. Podimeen (misc.)	34,163	15,178	10,590	11,354	10	28	71,323
10. Small sciaenids	..	1,242	..	430	..	.	1,672
11. <i>Chorinemus</i>	..	..	..	..	18	71	89
12. Seerfish	.. 7	.	..	..	65	69	141
13. <i>Chirocentrus</i>	.. 161	..	..	17	51	27	256
14. Karkara	.. 2,647	267	65	58	8	..	3,045
15. <i>Drepane</i>	.. 314	93	66	50	..	..	523
16. <i>Trichiurus</i>	.. 23	2,681	43	67	..	..	2,814
17. Pomfrets	.. 216	88	96	10	..	..	410
18. Soles	.. 137	35	4	36	..	..	212
19. Silver bellies (large)	..	.	85	..	..	..	85
20. <i>Lactarius</i>	.. 15	..	..	..	..	..	15
21. <i>Polynemus</i>	.. 4	.	.	..	..	..	4
22. <i>Upeneus</i>	.. 93	..	..	100	..	..	193
23. <i>Otolithus</i>	..	.	..	15	..	..	15
24. <i>Hilsa</i>	..	.	..	..	12	10	22
25. <i>Pellona</i>	..	..	.	..	15	6	21
26. Ghol	.. 387	85	60	39	56	67	694
27. <i>Caranx</i>	.. 1,170	18	129	..	..	..	1,317
28. <i>Lutjanus</i>	.. 71	..	..	..	..	13	84
29. Thom	..	20	..	..	..	..	20
30. Jewfish	..	..	..	1,820	..	.	1,820
TOTAL	.. 76,496	23,582	15,162	17,864	7,585	5,665	1,46,354

372, 48 and 96 kg. per hour. These exploratory trawling operations have shown that the grounds off Baruva support comparatively rich fisheries.

The yield per hour of fishing in depths ranging from 0 to 10 fathoms was comparatively higher than rise in depths up to 10-20 and 20-30 fathoms, the respective yield which was the maximum in depths ranging from 30 to 40 fathoms, because poorer in depths ranging either from 40 to 50 or from 80 to 90 fathoms, where the respective yields were 204.22, 198.34 and 22.67 kg. per hour. It may therefore be of interest to work here that maximum yields were met with once in depths ranging from 0 to 10 fathoms and a second time in 30 to 40 fathoms. The other regions so far fished were comparatively lesser in yield.

About 4,000 specimens of fish representing 68 samples and belonging to 77 families, 119 genera and 167 species were examined at the laboratory for recording the three lengths, the sex, the weight, the fulness of stomach and the stage of maturity of each specimen. Based on this data studies on length frequency, minimum size at first maturity with respect to sex and the feeding intensity in relation to size were completed for the following in relatively important species, *Upeneus sulphureus*, *Nemipterus japonicus*, *Saurida tumbil*, *Pseudarius jella*, *Euplatygaster indica*, *Uranoscopus juscomaculatus*, *Pomadasyus argyreus*, *Cynoglossus macrolepidotus*, *Scoliodon sorrakowah*, *Johnius aneus*, *Parastromateus argenteus* and *Anchoviella insularis*. The mean lengths of the above 12 species respectively were  $10.08 \pm 0.06$ ;  $10.07 \pm 0.29$ ;  $13.82 \pm 0.29$ ;  $25.08 \pm 0.65$ ;  $20.44 \pm 0.27$ ;  $9.99 \pm 0.14$ ;  $12.46 \pm 0.16$ ;  $16.15 \pm 0.39$ ;  $35.40 \pm 0.04$ ;  $15.44 \pm 0.13$ ;  $18.09 \pm 0.15$ ;  $5.92 \pm 0.04$  cm. Their sex ratio was also studied. The length-weight relationship of the following 5 species only was computed. *P. jella*, *J. aneus*, *U. sulphureus*, *U. juscomaculatus* and *S. tumbil*. Similar studies on the following species, which were also of equal importance by numbers in the catches, were taken up in the last quarter and are in progress: *Poly-nemus sextarius*, *Apogon septemstriatus*, *Grammolites scaber*, *Callionymus sagitta*, *Lactarius lactarius*, *Leiognathus hindus*, *Pentaprion longimathus*, *Secuter ruconius* and *Drepane punctata*.

(f) At Calcutta

Twenty-three voyages were made by the West Bengal fisheries trawlers during the period under report. Out of the five deep-sea fishing trawlers (Kalyani I-V), Kalyani I, had not undertaken any voyage due to major-engine trouble during this year. Kalyani II made only one voyage, Kalyani III performed seven voyages, Kalyani IV six voyages and Kalyani V nine voyages.

TABLE IX

Name of the fishes	Total weight in kg.
<b>"A" Class :</b>	
<i>Pampus argenteus</i>	7,611.83
<i>Penaeus</i> spp.	1,211.58
<i>Pomadasys hasta</i>	3,073.25
<i>Lutjanus</i> spp.	34.40
<i>Otolithus</i> spp.	24.00
<i>Pseudosciaena diacanthus</i>	31.70
<i>Scomberomorus</i> spp.	16.83
<i>Drepane punctata</i>	4.70
<b>TOTAL</b>	<b>12,008.29</b>
<b>"B" Class :</b>	
<i>Sciaenids</i>	59,735.34
<i>Leiognathus</i> spp.	34,837.05
<i>Kurtus indicus</i>	11,637.16
<i>Pellona</i> spp.	14,041.73
<i>Reconda russeliana</i>	1,222.09
<i>Opisthopterus tardoore</i>	314.90
<i>Engraulis</i> spp.	803.19
<i>Upeneus indicus</i>	3,010.46
<i>Polynemius sextarius</i>	469.88
<i>Lactarius lactarius</i>	998.47
Small perches ( <i>Pomadasys</i> , <i>Therapon</i> and <i>Nemipterus</i> )	1,160.07
<i>Caranx</i> spp.	2,359.40
Small prawns ( <i>Metapenaeus</i> )	227.00
<i>Acetes</i> sp. (Shrimps)	75.00
<i>Muraenesox</i>	2,315.35
<i>Arius</i> spp. (big)	723.80
<i>Drepane punctata</i> (small)	78.90
<i>Coilia</i> spp.	6.50
<i>Dussumieria acuta</i>	129.70
Miscellaneous	8,859.77
<b>TOTAL</b>	<b>143,003.76</b>
<b>"C" Class :</b>	
<i>Arius</i> spp.	1,215.50
Skates	294.00
Saw fish ( <i>Pristis</i> spp.)	118.00
Rays	3,423.08
Miscellaneous	590.26
<b>TOTAL</b>	<b>5,640.84</b>
<b>GRAND TOTAL</b>	<b>160,652.89</b>

Among the total catch of 1,60,652·89 kg., "A" class fish were represented by 12,008·29 kg., "B" class by 14,3003·76 kg. and "C" class by 5,640·84 kg. The details of the catch composition of the different species of fishes landed during this year under review are given below (Table IX).

The deep-sea fishing activities of the West Bengal fisheries trawlers Kalyani II-V started by the middle of September, May-August being the monsoon months. The fishing operations were confined to off Matla estuary Western Channel, Eastern Channel, Mahanadi River, Devi and Chilka at a depth ranging from 7 to 25 fathoms. The fishing was concentrated more towards off Mahanadi River mouth during the year. It is obvious from the catch analyses (*vide* Table X) of the different fishing regions that *Sciaena* spp., *Kurtus indicus*, *Harpodon nehereus* and *Upeneus indicus* occur in large quantities in Sand head off Devi and Prachi Rivers and off Mahanadi. *Pampus argenteus* appears in abundance at off Mahanadi and Black Pagoda. The major catches in False Bay are clupeoids.

TABLE X

S. No.	Name of fish	Total yield in kg.	Area of abundance
1	<i>Pampus argenteus</i>	7,611·83	Off Mahanadi, Black Pagoda
2	<i>Sciaena glaucus</i>	31062·00	Devi and Off Prachi and Off Mahanadi
3	<i>S. aneus</i>	8960·00	Sand Heads
4	<i>S. carutta</i>	11947·00	Off Mahanadi
5	<i>Sciaenoides microdon</i>	597·00	Black Pagoda
6	<i>Kurtus indicus</i>	11637·16	Devi and Prachi, S. Heads and Off Mahanadi
7	<i>Pellona indica</i>	14041·73	False Bay
8	<i>Harpodon nehereus</i>	..	Devi and Prachi
9	<i>Upeneus indicus</i>	3010·46	Devi and Prachi

The quantity of marine fish landed by the fisheries trawlers during this year was 1,60,652·89 kg. of which "A" class were represented by 12,008·29 kg., "B" class by 1,43,003·76 kg. and "C" class 5,640·84 kg.

*Pampus argenteus* formed the main bulk of the "A" class category. The other two varieties of pomfrets are *Parastromateus niger* and *Pampus chinensis* which formed negligible quantities.

A comparative analysis of the catch during this year and the previous one (*vide* Table XI) revealed that there is a considerable decrease in the total catch as well as the average catch during the year. It is also observed that there is a considerable increase in the catch of "A" class catch from 3% to 7.47% and decrease in "B" and "C" catches, from Table XI represents a comparative account of the catch, etc., during the year ending 31st March 1960 and 1961.

TABLE XI

Period	Total No. of voyages made	Catch by class in kg.			Total catch in kg.	Catch per voyage
		A	B	C		
Year ending 31-3-1960	25	7,218.70	2,22,921.75	7,578.85	2,37,719.30	9,708.77
Year ending 31-3-1961	23	12,008.29	1,43,003.76	5,640.84	1,60,652.89	6,984.91

Though there is a sudden decrease in the landings from 63 to 37.18% of "Bhola" fishery when compared with the previous year, the sciaenids continued to be the major fishery of the coast. A peak period in the abundance of sciaenid fishery is noted in the month of February. The dominant species in the catch were *Sciaena glaucus* and *S. aneus* contributed 48.4% and 22.8% respectively. A significant increase in the landing of Silver bellies was observed and formed 21.68% of the total catch. A failure in glass fish (*Kurtus indicus*) was noted which was represented by 7.24% as against in the previous year. Clupeoids constituted 8.74% and were dominated by *Pellona indica*, *Reconda russeliana* and *Opisihopterus tardoore*, Pomfrets, and prawns formed a negligible quantity of the catch and formed 4.74% and 0.75% respectively.

It is evident from Table XI that there was a progressive increase in the production of marine catch with the approach of winter season. December, January and February were the most productive periods with a peak in the month of February. During these three months 107,459.44 kg. were

obtained which formed 66·8% of the total catch of the year. It is also to be noted that of the total catch of 160,652·89 kg. for the year, 100,555·77 kg. were caught from off Mahanadi. Out of the above 100,555·79 kg. 9987·15 kg. were represented by "A" class category which indicates the quality fishing ground. It was also noted that between 8 and 20 fathoms the catch was more abundant.

Studies have been initiated on the biology of *Pampus argenteus*, *Kurtus indicus* and *Sciaena glaucus*.

Studies on the food and feeding habits of other sciaenids which occur in sufficient quantities in the West Bengal trawlers catches are receiving attention.

### C. Marine Fish Culture and Physiology

A tendency for a fall in fish production in the marine fish ponds, as compared to the previous years, was reported earlier. The results of experiments during 1960-61 confirm this experience. The maximum yield in the ponds this year has been only of the order of 100 pounds of fish per acre whereas previously the production has varied from 190 to 405 lb. per acre.

An experiment was tried by doubling the rate of stocking to 10,000 fingerlings per acre in some of the ponds. By regular weeding of the predators and safeguarding the sluices during water flow, a nearly 70% of survival of fish (unlike about 30% in previous years) has been possible. But such a high rate of stocking and increase in survival rate has apparently resulted in a poor growth of the fish over a ten months period. These fingerlings of 80 mm. in length at the time of stocking had grown over this period only to a length of 160-240 mm. whereas in previous experiments with only half the rate of stocking the growth had been nearly double, indicating thereby that these ponds may not be able to support such a high number of fish per unit surface, unless other measures for improving the fertility are taken.

Prolonging the growth of the fish for a period beyond one year in the present ponds under existing conditions also does not seem advantageous. Experiments carried out in this direction show that *Chanos* left over for the second year had not progressed significantly in their individual length or weight and it might appear more profitable to have the harvests from these ponds made at the end of every year and the ponds restocked. Perhaps the experiments should be attempted when more number of larger rearing ponds are constructed.

The various experiments and observations conducted during this year have helped to throw some light on the more probable causes for the continued reduction in fish yield year after year, and for the better management of the ponds in future. Added to the natural low productive potential of the area there is a depletion in the available fish food in these ponds during the successive years. The normal growth of microflora and other fish food is inadequate to cope with the continued deficiency. The standing crop of planktonic elements has been uniformly low in all the ponds throughout the year. The little improvement being brought about by repeated replenishment of water from the sea, addition of organic manures or even supplementary feeds such as oil-cake and rice bran has been found insufficient, especially for the growth of the larger fish. Thus the result at the end is a uniform retardation in the growth of the fish. Another problem that has arisen recently is the growth in certain ponds of a sea grass. Being the only vegetation in the pond and suspected to be beneficial, no attempt was made to eradicate this sea grass in its initial stages of growth. However, this weed has established itself well and has been growing luxuriantly at the expense of the little nutrients that are available in the ponds and this might be pointed out as another factor responsible for retarding the growth of the fish in such of those ponds where the weed has been present. It has since been observed that the milkfish does not make use of this sea grass which has a tough type of cellulose and as such has been found to be harmful in *Chanos* ponds. Means of eradicating this weed are now under contemplation.

For a proper understanding of the deficiencies and possible means of improving the conditions of the ponds for promoting better growth of fish, chemical analyses of the pond water and mud have just been started.

#### *Physiology*

The following projects were undertaken by the beginning of the year 1961.

- (1) A study on conditioned responses in the fingerlings of *Chanos chanos*,
- (2) Rate of filtration in *Meretrix meretrix*,
- (3) A study of the metabolism in *Mugil* spp.

Conditioned responses are being studied in the fingerlings of *Chanos chanos*. Several experiments were designed and carried out to study the intensity of olfaction and vision in locating food. Experiments are in progress for conditioning fishes to olfactory stimuli.

Cole's neutral red technique for the estimation of filtration rate is greatly modified to suit the work of *Meretrix meretrix*. The filtration rate is being studied in different size-groups of this clam.

Standardization of the methods for the study of oxygen consumption and metabolism is completed.

#### IV. MARINE BIOLOGY

##### A. Planktological Investigations

###### (a) At Kandla

Plankton studies in general confirm the previous year's results. Zooplankton constitute the bulk of collections, most common forms being *Acartia*, *Labidocera*, *Centropages*, *Eucalanus*, Pseudodiaptomids, *Rhinca-lanus*, *Euterpina*, *Oithona*, *Coryceus*, crustacean eggs and larvae, and bi-valves, gastropods, echinoderms and polychaet larvae. Fish eggs and larvae were observed in August to November and again from February to March. Chaetognaths appeared in moderate numbers during November to March.

###### (b) At Karwar

This year the maximum phytoplankton was recorded in the pre-monsoon months. Towards the south there was a secondary peak in the month of October. During January to March phytoplankton occurred in plenty. *Chaetoceros* spp. was the most common form present. *Thalassiothrix frauenfeldii* and *Nitzschia seriata* played the major role in some collections. *Fragilaria oceanica* appeared in fairly good numbers in the south. Monsoon blooms of diatoms were absent here this year also. *Coscinodiscus jonesianus* was present almost all through the year. *Coscinodiscus* sp., *C. asterom-phalus* and *C. gigas* were found in plenty during January to March. *Hemi-discus hardmannianus* was present in Karwar and Chendia in May-June. *Tricho-desmium* was found to occur all through the first quarter of the year and in some collections it dominated over the diatoms. It was abundant along this coast in the first half of June and at some places in the last quarter of the year also.

In April, May and June a good number of dinoflagellates occurred with *Ceratium trichoceros* as the dominant species. In October dinoflagellates attained the peak at all centres, with *Ceratium vultur* (forming colonies) as the important item. Chendia was exceptionally rich. *Ceratium furca*, *C. fusus* and *C. tripos* were abundant in some collections. From November onwards dinoflagellates were rare.

*Noctiluca miliaris* was more common in the post-monsoon period this year except in Kumta but was never found to discolour the water. Various planktonic larvae were abundant in October to March. They were comparatively rich this year. Copepod nauplii were common in October and crab larvae were numerous in January to March. Appendicularians which were abundant in the north were found decreasing towards the south. Cladocerans occurred in September to March with October as the peak. *Evadne tergestina* was more common up to September in Chendia and Kumta, and up to October at Karwar and Ankola. Later *Penilia avirostris* dominated. Copepods were abundant during September to December. *Acrocalanus longicornis* was abundant in the north. At Kumta *Acartia erythraea* dominated. *Oithona oculata*, *Schmackeria serricaudata* and *Temora turbinata* appeared in good numbers in the peak period. Chaetognaths when compared to that of the previous year were less. Fish eggs and larvae were generally few and they occurred at all places after the monsoon only. Carangid and clupeoid eggs and larvae were found frequently. Eggs and larvae of *Sardinella fimbriata* and Anchovy were found. Larvae of *Chirocentrus* occurred at Kumta in May to June. Larvae of *Cynoglossus* sp. were found at all places in the first quarter of the year. Leptocephalus and post-larva of eel were found in Kumta in the month of April.

(c) At Mangalore

Regular collections were interrupted during the south-west monsoon due to rough sea. Rest of the period regular weekly collections were made at the four fathom area at Ullal. The displacement volumes of plankton (surface hauls) were high in June due to phytoplankton bloom and in August due to swarming of *Noctiluca*. From October to March the plankton was fairly rich both in quantity and quality but during April and May it was poor.

In April a bloom of *Hemidiscus* sp. and *Trichodesmium* sp. was observed. *Trichodesmium* sp. continued to form the bulk of the plankton along with *Coscinodiscus*, *Chaetoceros*, *Rhizosolenia* and *Biddulphia* in the subsequent month also. In early June species of *Coscinodiscus* and *Thalassiothrix* were observed in good numbers, whereas *Schrodrella* sp., *Eucampia* sp., *Biddulphia*, and *Fragilaria oceanica* relatively few. In the last week of August a bloom of *Coscinodiscus* sp. and *Noctiluca* sp. was observed. Post-monsoon phytoplankton bloom was noticed in October, and the important diatoms were species of *Chaetoceros*, *Coscinodiscus*, and *Fragilaria oceanica*. In November, same species of diatoms were noticed but in lesser numbers. In December, there was a minor bloom of dinoflagellates, viz., *Ceratium trichoceros*,

*C. massiliensis* and *C. fusus*. In January and February, the phytoplanktonic elements were rather poorly represented. In the latter half of March, bloom of *Bellarochea malleus* and *Pleurosigma* sp., was observed at Ullal.

During June, July and August the plankton was composed mainly of phytoplankton elements. From September onwards, zooplankton showed increase in quantity. Cladocerans and copepods were dominant, the first group during September to October and the second from November to March. A swarm of fish eggs (clupeoid type) was observed in March. During May *Lucifer* were dominant. Larval bivalves and gastropods, larval polychaetes, penaeid and brachyuran zoea, hydromedusae, ctenophores, *Sagitta*, pteropods, *Oikopleura* and Cirriped nauplii occurred in small numbers in the plankton. No exclusive swarms of any group of animals was observed during the year. In the last week of August *Noctiluca* swarmed and the swarm persisted up to early September discolouring the water slightly.

(d) At Kozhikode

During the year, studies were conducted on the magnitude of the standing crop of phytoplankton by the net collections and on organic production by the 'dark' and 'clear' bottle experiments.

The standing crop in general was poorer than the preceding year both by volume and pigment and the poorest period was November to January. The seasonal cycle of phytoplankton was of the same pattern as the previous years, with a short bloom of moderate intensity during the south-west monsoon attaining its peak in June by pigment and August by volume and an almost negligible secondary peak during February to March. The occurrence of *Fragilaria oceanica* was not at all sustained one, although abounding in a few collections after the primary bloom. Swarms of *Trichodesmium* bundles were in plenty during the hotter months.

In the pre-monsoon period and again from October onwards copepods formed the most significant group of the zooplankton, the commonest available being species of *Labidocera*, *Paracalanus*, *Acrocalanus*, *Acartia*, *Eucalanus*, *Undinula*, *Centropages*, *Temora*, *Pseudodiaptomus* and *Corycaeus*. Both the cladocerans, *Evadne* and *Penilia* had their own periods of dominance, the former in August-September and the latter in October-November. By December both had dwindled and were no more than barely represented; but they continued to be available, though in sparse numbers all through the year. Siphonophores, medusae and salps were abundant in November-February. Medusae and salps in particular came in unusual abundance in

the inshore waters in November–December. Penaeid and Sergestid larvae showed their usual abundance in December–March. Others of good but restricted occurrence during the post-monsoon months were the pteropods ostracods, *Lucifer*, *Sagitta* and appendicularians. *Noctiluca miliaris* was represented throughout the monsoon season but not in such abundance as to discolour the water, which phenomena was only very rarely observed this year. A few *Noctiluca* swarms were seen to voraciously feed on plankton organisms and thus to multiply vigorously. Fish eggs and larvae were chiefly available in September–November.

During the year under report observations on bottom fauna and bottom plankton were carried out at Vellayil also in addition to West Hill.

Green mud, abundant with foraminiferan shells, was washed ashore during April–May. The mud-bank thus formed lay exposed to over a distance of half a mile into the sea during low tide, and was subsequently washed away from the shore by the south-west monsoon. Bottom plankton of the post-monsoonic season was abundant with planulae, viligers, trochophores, young *Prionospio pinnata* and Polynoid larvae, but the bottom mud was not successfully colonised by the adults of these (with the possible exception of actinarians which settled during November). Particularly conspicuous was *P. pinnata*, which was never found in abundance this year, whereas during the post-monsoonic months of 1959, the 2 and 4 fathom areas were dominated by young ones of these. Same size-groups, or even smaller size-groups, of *P. pinnata* have been observed in but small numbers in successive weekly samples this time, suggesting that the larvae have been trying to settle down from time to time, but not with much success. The removal of the mud-deposits by the monsoonic weather and the resultant depletion of the nutrient content of the bottom mud seem to have played a significant role in delaying the metamorphoses of the larvae invertebrates of this area. Owing, perhaps, to the non-availability of mud-living animals during the third quarter, *Cynoglossus semifasciatus*, Sciaenids and prawns were found to be feeding, not on animals that live in the mud, but on those forms that inhabit the bottom layers of water. The bottom fauna has been poor throughout the last quarter also. *Phyllochaetopterus socialis* was abundant on 28-3-1961 at 8 fathoms.

(e) *At Cannanore*

Studies on the seasonal fluctuation of the plankton of the Cannanore Bay from two stations (3 F and 6 F) were commenced from the post-monsoon season of the year under review. Such “edible” planktonic elements as

copepods, dinophysids, cladocerans and larval decapods reappeared in the latter half of the third quarter and continued to dominate the plankton till the end of the year. There was a minor peak of diatoms during December and January. *Noctiluca* reappeared in February, and continued to be dominant in March also, but the occurrence of "red water" due to swarming of pink *Noctiluca* was observed only in November. Towards the close of the year more and more off-shore planktonic elements, such as salps, certain medusae, doliolids, rare chaetognaths and pelagic molluscs started appearing. Prawn eggs and larvae were dominant during November and December. Eggs of *Sardinella fimbriata* appeared in November. The displacement volume increased steadily towards the close of the year due to occurrence in large numbers of macroplanktonic elements.

(f) At Tuticorin

The phytoplankton generally remained poor. However during the month of May 1960 phytoplankton was well represented in the hauls with species of *Coscinodiscus*, *Thalassiosira*, *Thalassiothrix*, *Ditylum*, *Chaetoceros* and *Rhizosolenia*. A rich bloom of *Rhizosolenia* sp. occurred during the first week of September and during the last week of November there was a rich bloom of *Thalassiothrix* sp.

Observations on the zooplankton showed that copepods dominated in most of the samples with occasional abundance of chaetognaths, pteropods and cladocerans especially during the months of April, May and August and October. Among the copepods, various species *Eucalanus*, *Paracalanus*, *Canthocalanus*, *Calanopia*, *Canadacia*, *Centropages*, *Acartia*, *Corycaeus* and *Oithona* were commonly represented. Other organisms that were regularly occurring were *Lucifer* spp., crustacean larvae and *Oikopleura*. *Noctiluca* swarmed during the second week of September and the second week of October.

(g) At Mandapam

Planktological investigations in the inshore waters of the Gulf of Mannar and Palk Bay showed that the summer bloom started in Palk Bay early in May with *Chaetoceros* spp. and *Thalassiothrix frauenfeldii* as dominant species. Later on *Bacteriastrum hyalinum* bloomed and continued to be the dominant species up the middle of June when species of *Chaetoceros* again dominated. Species of *Rhizosolenia* were common from the end of May to the end of June. In the Gulf of Mannar zooplanktonic elements dominated in April-May but by the end of May the summer started with *Coscinodiscus* spp. and *Chaetoceros* spp. The summer bloom continued practically up the third

week of October in Palk Bay, while it lasted only till the middle of August in the Gulf of Mannar. *Ceratium massiliense* appeared in appreciable numbers in the Gulf of Mannar towards the end of April and they bloomed in Palk Bay during the middle of July. During October–November and the third week of December phytoplankters showed a marked increase in the Gulf of Mannar. This increase in November–December is somewhat unusual for the period because in previous years phytoplankters were extremely low during these two months.

Studies on organic productivity by the oxygen method was continued from six stations in the Gulf of Mannar. More than three years' data from the original station and two years' data from the other five stations have been so far collected. A set of experiments was conducted off Tuticorin at 15 metres. With these data the total annual production of carbon for the in-shore waters of Gulf of Mannar from Cape Comorin to Dhanushkodi was estimated. An appraisal of fish landings of this zone in terms of carbon present yield is only 1/7 to 1/12 of a possible exploitable stock. Similar studies were extended to Palk Bay from May 1960 but only six months' data could so far be collected as observations could not be conducted during rough weather. Observations are being made from three stations at 2, 4, and 6 fathoms which besides oxygen experiments include pigments, phosphate and nitrate. In order to check the values of oxygen experiments, few  $^{14}\text{C}$  experiments also were conducted.

*(h) At Madras*

Plankton samples obtained by using different types of net were under study and all relevant data—pigment value, displacement volume, dry weight, etc.—have been recorded. The data show that in 1960–61 (April–March) the maxima for both phyto and zooplankton as well as macroplankton occurred in May, values showing a trend to rise from March and the period of minimum in December or January. From August to November the values did not show sharp fluctuations. Work is being continued.

*B. Hydrological Studies*

*(a) At Kandla*

Hydrological observations were made at Luni, Modhwa and Kandla. The fluctuations in pH, temperature, oxygen, phosphate, nitrite, silicate and salinity were as follows:

*Monthly average value :*

*Luni centre.*—At Luni centre the mean monthly values of pH ranged from 8.1 in January and February 1961 to 8.45 in December 1960. Temperature was lowest in January with 17.5° C. and highest in October with 26.5° C. The oxygen concentration for the same period varied from 4.962 c.c./l. in October 1960 to 6.198 c.c./l. in January 1961. The highest concentration of phosphates was noted in December with an average value of 0.689  $\mu\text{g.at./l.}$  while the lowest in January was 0.198  $\mu\text{g.at./l.}$  Nitrite values were at the minimum in November with a reading of 0.120  $\mu\text{g.at./l.}$  and the maximum in October with a reading of 0.485  $\mu\text{g.at./l.}$  Silicates too had the maximum in October with a concentration of 25.00  $\mu\text{g.at./l.}$  but the minimum was in January with a concentration of 13.16  $\mu\text{g.at./l.}$  The highest salinity was in February showing 42.54 ‰ and the lowest in October with 35.76‰.

*Modhwa centre.*—During the October 1960–January 1961 period pH ranged from 8.7 to 8.1, the highest being in January and the lowest in February. The surface temperature ranged from 19.4° C. to 19.8° C. during the latter three months whereas in October it was 27.0. The dissolved oxygen was lowest in October with a concentration of 3.882 c.c./l. and the highest in January with 6.503 c.c./l. Phosphates varied from 0.295  $\mu\text{g.at./l.}$  in November to 0.923  $\mu\text{g.at./l.}$  in January. Nitrite ranged from 0.050  $\mu\text{g.at./l.}$  in December to 0.400  $\mu\text{g.at./l.}$  in January. Silicate was highest in October with a concentration of 19.23  $\mu\text{g.at./l.}$  and the lowest in December with 6.20  $\mu\text{g.at./l.}$  The salinity ranged from 32.72‰ in November to 38.39‰ in January.

*Kandla centre.*—During the period of April 1960 to March 1961 the variations in pH were 8.10 in March to 8.50 in September. The lowest temperature of 17.72° C. was recorded in January and the highest 29.30° C. in July. Dissolved oxygen varied from 4.081 c.c./l. in August to 6.303 c.c./l. in January. Nitrite concentration was the lowest in September with 0.170  $\mu\text{g.at./l.}$  and the highest in January with 0.459  $\mu\text{g.at./l.}$  Silicate ranged from 26.73  $\mu\text{g.at./l.}$  in September to 16.54  $\mu\text{g.at./l.}$  in March. Phosphate concentration varied between 0.305  $\mu\text{g.at./l.}$  in October and November 1.089  $\mu\text{g.at./l.}$  in August. Salinity throughout was high ranging between 36.44‰ in May and 40.57‰ in June.

*(b) At Karwar*

As in the previous year surface temperature was generally high in the beginning of the year. During the rainy season it decreased to the minimum.

But the minimum values for this year were higher than that of the minimum for the year 1959-60. In the post-monsoon period the temperature rose and after a slight fall in December it rose again to fall once more in February. In Chendia the temperature rose after the monsoon and registered the fall in February only. As in the previous year lowest record of temperature at Karwar was in August. At Chendia, Ankola and Kumta it was in September. pH and salinity were also low in the south-west monsoon period. Dissolved oxygen content was high during August. Phosphates remained low throughout, whereas nitrite was much higher this year, the peak being in May-June. Concentration of silicates, as in the previous year, was high in the north and low towards the south. But this year the maximum values for the silicates were only 37.65%, 42.66% and 65.66% at Karwar, Chendia and Ankola respectively of the maximum record of the year 1959-60.

*(c) At Mangalore*

Sea-water samples were collected once a week at the 4 fathom area of Ullal. On a few occasions collections could not be made due to inclement weather conditions.

The average surface temperature of sea-water for April and first half of May was 30.6° C. being the highest value, and this dropped to 28.4° C. towards the end of May. The average value for June was 27.2° C. and for August it was 23.4° C. In September temperature showed a gradual increase to 27.5° C. In early October the temperature value was 26.2° C. and in the subsequent month it was fluctuating between 28.8 and 29.2° C. In early December the temperature dropped to 26.9° C. and it was still lower (26.9° C.) towards the end of the month. There was not much variation in the temperature value for January. From February onwards a gradual increase in the surface temperature of sea-water was noticed; and in March it was fluctuating between 29.0 and 30.0° C.

*(d) At Ernakulam*

During the year under review the research vessel *Kalava* made seven cruises in all.

The summer conditions during the year 1960 were as follows:

In the early part of summer, a good isothermal layer with a thickness of nearly 85 meters was observed with a temperature range of 28.0-28.5° C. Later in the period a considerable degree of heating was in evidence, the temperature having risen up to 29.5-30.5° C. and the thermocline was seen to be present at about 90 meters.

In regard to salinity, although a gross examination reveals a more or less uniform surface salinity in the entire area a more detailed examination shows a decrease seawards. Nearer the shore the salinity range was 34.4–34.5‰ while beyond the shelf the waters had salinity values between 34.0 and 34.2‰. The obvious explanation is the greater degree of evaporation in shallow near shore waters. A well-defined salinity maximum is seen at about 100 meters. Below 200 meters the isohalines are nearly vertical showing good mixing at these levels.

The density surfaces down to 200 meters are practically horizontal indicating clearly the presence of a stable water column. There is a slight sloping of the surface below 200 meters, but whether it is any indication of water movements at these levels it is not possible to state with any degree of certainty.

The temperature-salinity relationships show the presence of three distinct sub-surface water masses observed during the same period last year. The surface water characteristics appear to extend down to 30 metres thus indicating a thick surface water mass.

Uniform and a high degree of oxygenation appears to be one of the main characteristics of the entire shelf waters at this time of the year. In the deeper waters beyond the shelf the high oxygen layer was seen to extend down to 50 metres and even more. Decrease was observed from 75 metres downwards and the oxygen minimum was reached between 150 and 200 metres. Even at 1,500 metres the value was less than 1 ml. per litre.

From a cursory examination of the data collected in the more recent cruises it is seen that the usual sinking phenomena was observed in January, the sinking being more prominent at the edge of continental shelf and along the continental slope. The northerly coastal drift was seen to be fairly intense. By February both the intensity of sinking as well as of the coastal stream has become considerably reduced.

Studies on the diurnal variations in the temperature-salinity characteristics of these waters at two selected stations—off Cochin and Calicut—reveal certain interesting features. From surface down to 30 metres the variations do not appear to be quite significant but become prominent from 50 metre downwards, more so below 75 metres. From the existing data mean values for these two parameters were calculated for various times of the day and the deviations from these means were obtained for the stations off Calicut and Cochin. In general the deviations were found to be more off Cochin than off Calicut. The maximum diurnal variation was observed at the

thermocline. This points to the existence of internal waves which probably have an amplitude of nearly 40 metres off Cochin and 20 metres off Calicut.

*Hydrography of the Backwaters.*—The main hydrographical conditions of the Cochin backwaters in the neighbourhood of the Willingdon Island were: a well-marked stratification during whole of September and up the third week of October; cold and heavy bottom water containing very little oxygen and overlying layer of warm, light and well-oxygenated water. The stratification began to disappear by the end of October and by December typical mixed conditions were observed. With the onset of summer, there is a great deal of warming up in the entire area.

(e) *At Calicut*

Studies on the seasonal changes in the hydrological factors of the in-shore and off-shore waters of Calicut coast were continued. Off-shore collections were totally interrupted from May–November due to unfavourable weather conditions.

The temperature of the inshore and off-shore surface waters was highest in April with 30.7 and 30.4 while the lowest was 24.7 and 27.9° C. respectively. The lowest in inshore was in August and the off-shore in February.

The surface salinity in ‰ of the inshore area was highest in March (34.17) and lowest in June (29.15), while bottom salinity was highest in July (34.80) and the lowest in December (33.32). Surface and bottom salinities of the off-shore were highest in April (34.15 and 33.59) and the lowest in December (33.90 and 33.01) respectively. Oxygen of the inshore waters in c.c./l. at the surface and at the bottom was highest in February (4.68 and 4.82) and lowest in July (3.13 and 1.53). Surface oxygen of the off-shore waters was at a maximum in February (4.34) and minimum in April (3.88) while the bottom value was highest in March (5.02) and lowest in April (4.16).

Surface pH of the inshore region was maximum in April (8.7) and minimum in September (8.47), whereas at the bottom it was highest in February (8.6), and lowest in July (8.1). Surface pH of the off-shore waters was highest in April and December (8.7) and lowest in January (8.57) whereas the bottom pH was at maximum in February (8.65) and minimum in December (8.55).

Phosphates in  $\mu\text{g.at./l.}$  of the surface waters of the inshore area were highest in August (1.909) and lowest in December (0.276) while at the bottom phosphates were maximum in July (3.038) and minimum in February (0.431).

Surface phosphates of the off-shore area were highest in March (0.391) and lowest in April (0.308) while the bottom values were highest in March (0.721) and lowest in February (0.437).

Silicates in  $\mu\text{g.at./l.}$  of the inshore waters were highest in September (32.85) and lowest (4.00). Concentration at the bottom was at a maximum in August (35.65) and minimum in February (3.13). Surface silicates of the off-shore waters were at maximum in December (6.75) and minimum in January (5.08) whereas the bottom silicates were highest in December (9.13) and lowest in February (4.69).

Surface nitrites of the inshore area in  $\mu\text{g.at./l.}$  were highest in March (1.183) and lowest in April (0.033). Bottom values were at a maximum in December (1.763) and minimum in September (0.039). Surface nitrites of the off-shore area were highest in January (0.210) and lowest in April (0.028) and the bottom nitrites were at maximum in December (1.730) and minimum in February (0.318).

Surface total phosphorus of the inshore environment in  $\mu\text{g.at./l.}$  was having a peak value in September (7.093) and lowest in December (0.745). Total phosphorus at the bottom was at a maximum in September (8.307) and minimum in January (1.205). Surface total phosphorus of the off-shore waters was highest in April (1.952) and lowest in February (0.779) and the bottom phosphorus was at a maximum in April (1.852) and minimum in January (0.905).

(f) *At Cannanore*

Salinity and temperature reached higher values (30.2° C. and 36.1% respectively) during March, and except for a trough noticed during December, the values were steadily increasing from the second quarter of the period.

(g) *At Tuticorin*

During the months from May 1960 to August 1960 and from November 1960 to January 1961 the sea remained rough and turbid due to the activity of the monsoons.

The surface temperature fluctuated between 24.5 and 29.3° C. during this year. The low temperatures were noticed during November and December, whereas the maximum was in May.

The salinity varied from 34.05 to 36.6‰. Slight drop in the salinity was observed after heavy rains during the months of November 1960, and January 1961.

The pH ranged from 8.2 to 8.6.

The concentrations of inorganic phosphates were high during the months from May 1960 to September 1960 and comparatively low during the rest of the period. The range was from 10 to 33.3 mg. P./m.<sup>3</sup>

The values for silicates fluctuated between 6.25  $\mu$ g.at.Si/l. and 25  $\mu$ g.at.Si/l. during this year.

The dissolved oxygen content ranged from 4.05 c.c./l. to 5.6 c.c./l.

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March 31, 1961.

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#### V. LIST OF PUBLICATIONS DURING THE YEAR

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