

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

**ANNUAL REPORT OF THE CHIEF RESEARCH OFFICER  
FOR THE YEAR ENDING 31st MARCH 1959**

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## I. ADMINISTRATIVE AND GENERAL

Steady progress was maintained during the year 1958-59 in the implementation of the programmes of work both under the Normal and Second Five-Year Plan Schemes at the Headquarters Station and the various subordinate establishments. The construction of the permanent substation building at Calicut at a cost of over Rs. 2 lakhs was completed and it was formally inaugurated by the Deputy Minister for Agriculture, Shri M. V. Krishnappa, on the 1st October 1958. Prof. Joseph Mundassery, Minister for Education and Fisheries, Kerala Government, presided over the function and opened the Fisheries Exhibition conducted there. The Souvenir entitled *The Fisheries of the West Coast of India* issued to mark the occasion was well received by fishery workers both in India and abroad and the Exhibition proved to be a great success. Active efforts made for the collection of scientific data and material from the Minicoy-Laccadive area yielded very interesting results. For study of offshore fisheries the staff posted at Ernakulam was strengthened and new centres were opened at Tuticorin and Veraval. The Research Centres at Kandla and Tuticorin have been raised to the status of Research Units. New Survey/Field Centres were opened at Alibagh, Dahanu, Calingapatna and Colachel.

An aggregate budget allotment of Rs. 14.7 lakhs under the Normal and Second Five-Year Plan Schemes was sanctioned for the year. On the capital works side the completion of the Calicut Substation building as also the permanent staff quarters at Mandapam and the occupation during the year deserve special mention. Construction of the Guest House at Mandapam also made substantial progress. An additional overhead tank for circulating sea-water-supply to the Aquarium was also completed and put into commission.

With enhanced financial powers delegated by Government it has been possible to effect timely procurement and supply of essential scientific equipment required for the different sections. Scarcity of certain imported items of scientific equipments proved to be a handicap. But with the foreign exchange sanction, recently accorded by Government, it is hoped to procure from abroad some of these items during 1959-60. For experimental fishing and collection of data a  $7\frac{1}{2}$  H.P. westbend outboard motor was purchased. The Pablo Boat from Ernakulam has been transferred to the Headquarters Station. A 75/100 B.H.P. motor boat for use for fisheries research work on the west coast has been received at Ernakulam. The Dan Boat at the Headquarters Station has been temporarily transferred for use at the Tuticorin

Research Unit. A lathe ordered during the previous year has been received and installed in the workshop. The jeep temporarily transferred to the Ernakulam Substation has again been brought back to Headquarters Station.

Substantial increase in the accessions to the Library took place besides continuing existing subscriptions to existing periodicals. Library facilities at the subordinate establishments were also augmented by regular circulation of selected number of journals as also by the loan publications and by the transfer of duplicate copies from the Headquarters Library.

Vol. V, No. 2 of the *Indian Journal of Fisheries* was published and Vol. VI, No. 1 is in press. Over 130 copies of each issue of the Journal are mailed free to various institutions interested in fisheries work and in addition about 50 copies are sent out in exchange for publication received in the Library of the Research Station. Demand for copies of the *Indian Journal of Fisheries* on regular subscription basis is also steadily on the increase. Copies of the Souvenir *The Fisheries of the West Coast of India* were also distributed to various departments and organisations. Certain number of publications were sent on permanent transfer to the Central Fisheries Technological Research Station. Facilities of the Library were also made available to visiting workers and specialists working at other institutions.

For the implementation of the programme of work under the Second Five-Year Plan, the following posts were created during the year:

Assistant Research Officers (Pelagic Fisheries)	..	2 posts
Assistant Research Officers (Mackerel), (Sardine) and (Offshore Fisheries)	3	..
Research Assistants	.. .. .	3 ..
Field Investigators	.. .. .	4 ..
Senior Caretaker	.. .. .	1 post
Motor Boat Driver-cum-Serang	.. .. .	1 ..
Field Assistants	.. .. .	4 posts
Lower Division Clerks	.. .. .	2 ..

The following appointments and promotions had taken place during the year:

<i>Name of Officer</i>	<i>New Post</i>	<i>Previous post held</i>
Dr. G. Seshappa	.. Research Officer (Fishery Biology)	Assistant Research Officer (Marine Zoo- logy)
Shri K. H. Mohamed	.. Research Officer (Offshore Fisheries)	Research Officer (Sardine)
Dr. V. Balakrishnan	.. Assistant Research Officer (Offshore Fisheries)	..
Shri M. Rajendranathan Nair	.. Assistant Research Officer (Fish Curing)	Research Assistant
Shri V. Balan	.. Assistant Research Officer (Sardines)	Do.
Shri S. Ramamurthy	.. Assistant Research Officer (Prawns)	Research Assistant
Dr. P. Vijayaraghavan	.. Assistant Research Officer (Mackerel)	Do.
Shri N. Radhakrishnan	.. Assistant Research Officer (Sardines)	Do.
Shri K. Venkatanarayana Rao	.. Assistant Research Officer (Mackerel)	Do.
Shri M. S. Muthu	.. Assistant Research Officer (Offshore Fisheries)	Do.
Shri B. T. Antonyraja	.. Assistant Research Officer (Pelagic Fisheries)	Do.
Shri M. Mydeen Kunju	.. Assistant Research Officer (Prawns)	Assistant Research Officer at CIFRS
Dr. M. D. K. Kuthalingam	Assistant Research Officer (Offshore Fisheries)	..

Dr. N. K. Panikkar, who held the post of Chief Research Officer of this Station in a permanent capacity, was confirmed in the post of Fisheries

Development Adviser at the Ministry of Food and Agriculture, New Delhi, with effect from 26-4-1957. Dr. H. L. Arora who was holding the post of Research Officer (Fishery Survey) (Class I, Junior) was relieved from the post at his own request. Dr. A. Anantharama Sastry and Shri A. S. R. Sarma who were holding the posts of Assistant Research Officers (Physical Oceanography) and (Statistics) respectively were also relieved from this Department to take up appointment in higher posts elsewhere.

The formation of the Processing Wing of the Central Fisheries Technological Research Station at Ernakulam took place in December 1958 by the transfer of the following staff members along with the posts held by them:

1. Dr. V. Krishna Pillai, Assistant Research Officer (Bacteriology).
2. Shri P. V. Kamasastri, Assistant Research Officer (By-products Utilization).
3. Shri M. Rajendranathan Nair, Assistant Research Officer (Fish Curing).
4. Shri T. K. Govindan, Research Assistant.
5. Shri A. P. Valsan, Extension Assistant.
6. Shri M. Abdul Sathar, Laboratory Attender.

Sarvashri M. J. George, B. Krishnamurthy, K. V. Sekharan, K. Nagappan Nair and T. Tholasilingam were confirmed as Research Assistants while Shri V. Balan and Shri V. Somanathan were confirmed as Survey Assistant and Typist Clerk respectively. Sarvashri S. V. Suryanarayana Rao, S. Ramamurthy, V. Krishna Pillai, N. Radhakrishnan, P. V. Kamasastri, C. Mukundan, M. Rajendranathan Nair, Miss P. D. Nayak and R. Prasanna Varma were declared quasi-permanent in the post of Research Assistants; while Miss H. Kamala, Shri M. P. Laskhmanan and Shri S. PL. Sethu were made quasi-permanent in the posts of Librarian, Typist Clerk and Despatch and File Clerk respectively.

A second post of Superintendent was filled by the promotion of Shri S. Rajagopalan, permanent incumbent of the post of Accountant. Recruitment to a number of vacant Class III posts was made during the year. Confirmation of certain members of Class IV staff in vacant permanent posts and quasi-permanent appointment of others eligible for the same also took place during the year.

The Chief Research Officer participated in the meeting held at Bombay on 13-6-1958 for co-ordination of fisheries research there; the Fishery

Research Committee meeting held at Srinagar in July 1958, and the Indian Science Congress Session held at New Delhi in January 1959.

Shri K. H. Mohamed, Research Officer, completed a course of 6 months' training in Japan, Shri M. S. Prabhu, Assistant Research Officer, returned to India in November 1958 after completion of a 6 months' training in Canada in bottom fisheries. Shri N. K. Velankar, Research Officer, who went to Canada for advanced training, had to return to India owing to ill-health before the completion of the training. Dr. P. Vijayaraghavan and Shri K. Venkatanarayana Rao, Research Assistants, participated as trainees in the F.A.O. International Training Centre for methodology and techniques of research on mackerel held at Bangkok in October-December 1958. A similar refresher course in Marine Biology held at Bombay was attended by Shri C. Mukundan, Research Assistant. Sarvashri P. C. George, Assistant Research Officer and K. Krishna Rao, Research Assistant, were deputed to attend as trainees in the Indo-Pacific Training Centre in Fisheries Statistics conducted at Bombay under the auspices of the F.A.O. Shri S. K. Banerji, Research Officer, also took part in this course as a Lecturer. Dr. R. Viswanathan, Assistant Research Officer (Oceanography), who was in Germany on study leave, was awarded *Dr. rer. nat.* degree of the Kiel University. He returned to India in December 1958 to take charge of his post. Sarvashri K. Nagappan Nair, M. S. Prabhu and B. T. Antonyraja, Assistant Research Officers were given training in the use of aqua-lung at Tuticorin under Dr. Baschieri Salvadori, F.A.O. Expert for Underwater Exploration.

Regular classes were conducted for teaching Hindi to the gazetted and non-gazetted staff. Sixteen members of the staff appeared for the Prabodh examination conducted by the Ajmir Board of Secondary Education of whom more than 50% came out successful.

Dr. F. Morawa, who worked at this Institute as a Research Fellow under the Indo-German Industrial Co-operation Scheme, completed his work and left India in October 1958. Dr. Karl Banse, the second German Research Fellow, is continuing his investigations here.

Sarvashri K. K. Tandon and M. Subrahmaniam, Senior Research Scholars, actively pursued their studies at this Institute. Sarvashri P. S. B. R. James, A. N. P. Ummer Kutty and C. Sankaran Kutty have joined as Senior Research Scholars during the year. Sarvashri S. Malhotra and K. Krishna-murthy, who were working earlier as Research Scholars, have been relieved from their assignments as requested by them. Shri P. K. Eappen, who was an Honorary Research Worker, was appointed as Assistant Director in the

Deep-Sea Fishing Station, Bombay. Shri K. Ramalingam was awarded the Ph.D. of the Madras University on the basis of the thesis submitted by him embodying the results of the research work carried out at this Institute as Senior Research Scholar.

Shri Bishnuram Medhi, Governor of Madras and Mrs. Medhi, visited the Research Station on 25-2-1959. The distinguished visitors were taken round by the Chief Research Officer and the work in the different sections were explained to them. The Fishery Education Committee of the Government of India with Dr. N. K. Panikkar as Chairman and Dr. B. N. Chopra and Prof. G. M. Gerhardson as members visited the Research Station on 4-2-1959. Among other distinguished visitors could be mentioned Shrimati Lourdammal Simon, Minister for Local Administration and Fisheries, Madras Government, who visited this Research Station on 3rd and 4th January 1959 in connection with the Madras Fisheries Advisory Board meeting and the State Fisheries Officers Conference when Shri P. P. I. Vaidyanatham, I.C.S., Secretary, Food and Agriculture, Department of the Madras Government, Shri C. P. Kelu Erady, I.A.S., Director of Fisheries, Madras and a large number of Officers of the Madras Fisheries Department and other delegates were present. Other notable visitors were Prof. N. G. Ranga, M.P., Chairman of the Public Accounts Committee and Mrs. Bharati Devi Ranga, M.L.C., Dr. Bachieri Salvadori and Mrs. Salvadori, Mr. J. A. Gulland of the Lowestoft Fisheries Laboratory, England, Mr. R. O. Smith, T.C.M. Fish Marketing Expert, Mr. Peter Gurtner, F.A.O. Naval Architect, Mr. M. R. Khan, Assistant Regional Officer of the F.A.O., Bangkok, Messrs. T. Lashin and Abdel Khalek El-Sayed Imam of Egypt, Shri L. R. S. Singh, Chief Commissioner of Pondicherry Administration, Dr. N. K. Gupta of the Punjab University, Shrimati Grace Tucker, Deputy Minister for Education, Mysore State and Shri G. M. Muthusamy Pillai, Collector of Ramanathapuram at Maduari. Shri E. M. Sankaran Namboodiripad, Chief Minister of Kerala and Shri A. M. Thomas, Union Deputy Minister for Food visited the Kozhikode Substation.

There has been an increase in the numbers of different categories of visitors to the Research Station. Numerous enquiries received from diverse sources have been answered when information and details requested for by various departments, organizations and parties were supplied. The research programme, carried out in collaboration with the Indo-Norwegian Project authorities in Kerala, made steady progress and a number of cruises were carried out by the research staff of this Station on board their research vessel "Kalava" in different areas of the Arabian Sea. The scheme on the

collection and analysis of sea-water samples and other data and their study sanctioned by the Ministry of Scientific Research and Cultural Affairs was effectively continued. Cotton and nylon twines required for collaborated work with the Gear Wing of the Central Fisheries Technological Research Station at Cochin were also indented for supply. Many of the scientific apparatus and equipment required to start work in the Processing Wing of the Central Fisheries Technological Research Station were also permanently transferred to that institute. In addition, some of the films received under the T.C.M. Programme were also transferred to them and a few others to the Deep Sea Fishing Station, Bombay. Some of the other films received under the T.C.M. Programme were made available on loan for use by the Fisheries Extension Units at Mandapam Camp, Bangalore and Hyderabad. Facilities were given to the Central Electro-Chemical Research Institute, Karaikudi, for continuing their experimental observations here relating to corrosion of metals under tropical marine conditions.

The Marine Biological Association of India was inaugurated at this Research Station on the 3rd January 1959 by Shrimathi Lourdhammal Simon, Minister for Local Administration and Fisheries, Madras State. The Local Branch of the Zoological Society of India functioned effectively and several distinguished visitors addressed the members on different occasions. The Canteen and Stores, Recreation Club, Welfare Club and Ladies Club and the Nursery School, all organised and run by the staff of the Institute for the benefit of the residents of the Research Station Campus, were in active operation. The Lady Medical Officer posted at the Mandapam Local Fund Dispensary, as per special arrangements made by the Ministry of Food and Agriculture with the Madras Government had started visiting this Research Station for giving medical aid to the staff of this Institute. A list of scientific papers published by the staff during the year is appended at the end of the report.

## II. FISHERY SURVEY

The analysis of data collected in 1958 was completed during the year and the total landings of marine fish during 1958 was estimated at 7,55,774 m. tons, as compared to 8,75,516 m. tons in 1957, thus showing a decrease of about 14 per cent. below the fish landings in 1957. The production in the west coast portion of Madras particularly showed appreciable increase whereas the landings on both the east and west coast showed a general decline; while, the yield in Kerala and Mysore did not show any significant



variation. The State-wise break-up of the total landings for 1957 and 1958 are given in Table I below:

TABLE I

States	Fish landings in m. tons	
	1958	1957
1. W. Bengal and N. Orissa	3,593	4,509
2. S. Orissa ..	2,674	3,757
3. Andhra ..	28,846	40,462
4. (i) Madras (East coast)	55,265	48,592
(ii) Madras (West coast)	62,791	31,092
5. Kerala ..	2,94,655	3,09,926
6. Mysore ..	80,242	76,090
7. Bombay (excluding Kutch)	2,20,906	3,56,660
8. Kutch ..	1,980	Not available
9. South Andamans ..	92	96
10. Mechanised vessels ..	4,730	4,332
	<u>7,55,774</u>	<u>8,75,516</u>

The landings in West Bengal and Orissa were lower than those of 1957 mainly due to the decline in the catches of *Harpodon nehereus*. The landings of prawns and other crustaceans, *Trichiurus savala* and sciaenids, also showed a slight decrease while those of *Polynemus tetradactylus*, *Sardinella fimbriata* and other clupeids registered moderate increase.

Low catches of *Leiognathus* spp., *Anchoviella*, *Sardinella fimbriata* and *Trichiurus* were mainly responsible for the decline in the catches of Andhra. Appreciable decrease in the landings of *Upeneoides*, mackerel, *Otolithus*, *Gerres*, *Gazza*, *Hilsa ilisha*, *Sciæna* and *Ilisha* was also noticed in this State. The increase in the landings of sardines including *Dussumieria* and *Kowala coval*, *Neptunus*, prawns and other crustaceans, other *Hilsa*, elasmobranchs, pomfrets and *Chirocentrus dorab* could not balance the deficiency in the total production.

Madras State showed some increase in the landings during 1958, in spite of low catches of *Sardinella fimbriata*, *Sardinella sirm*, *Chirocentrus dorab*, *Rastrelliger*, *Thrissocles*, *Cypsilurus*, *Arius*, *Ilisha* and other miscellaneous fishes. This increase was chiefly due to good landings of *Trichiurus*, *Anchoviella*, *Leiognathus*, *Caranx*, prawns and other crustaceans. The catches of *Sciæna*, rays, *Lactarius*, *Anodontostoma*, *Upeneoides*, *Polynemus*, tunnies, oil-sardine and other sardines were also moderately good in Madras State during the year.

The slight decline in the landings in Kerala was due mainly to the low contribution of prawns and shrimps, oil-sardine, other sardines, catfishes and *Upeneoides*. Good catches of mackerel along with sharks, *Sciæna*, *Nemipterus*, *Leiognathus* and *Cynoglossus semifasciatus* were observed in these zones. Malabar coast, however, maintained steadiness in the fish production though significant decrease was found in the landings of *Sardinella longiceps*, *Trichiurus*, *Rastrelliger canagurta*, *Cynoglossus semifasciatus* and prawns and shrimps. The decline in the landings of oil-sardine and ribbon-fish was balanced by the good catches of mackerel, soles, catfishes, prawns and shrimps. The landings of *Sardinella fimbriata*, *Kowala coval*, *Anchoviella*, *Thrissocles*, pomfret, *Caranx*, *Ambassis* and sharks showed an increase while those of mullets and seer-fish showed a general decline.

The landings in Mysore during the year were slightly better than those of 1957. The heavy catches of mackerel balanced the decrease in the landings of oil-sardine, silver-bellies and jew fishes. Slight increase was also seen in the landings of soles, seer-fish, elasmobranchs, catfish, *Lactarius* and tunnies. A general decline in the landings of prawns, *Sardinella fimbriata*, *Opisthopterus tardoore* and *Anodontostoma chacunda* was also witnessed in the State during the year.

The landings in Bombay during the year were only about two-thirds of those of 1957. This was mainly due to unfavourable weather conditions which existed over a long period resulting in relatively low catches of prawns and shrimps, Bombay duck *Coilia*, *Polynemus* and oil-sardine and also to some extent decreased landings of elasmobranchs, mackerel, jew fishes, ribbon-fish and clupeids. Slight increase in the landings of eels, *Bregmaceros maccllellandi*, *Upeneus*, *Leiognathus* and *Hilsa* was also found in these zones.

The fish production of Kutch region was estimated for the first time during 1958 and the catches consisted mainly of prawns. Bombay duck, *Hilsa*, *Polynemus*, *Cybium*, *Mugil*, *Sciæna*, *Arius* were also found in the catches in moderate quantities.

The salient features of 1958 were:

(a) The *Rastrelliger* fishery was highly successful during 1958. The total catch of *Rastrelliger* exceeded even that of 1957 and in fact was the highest since 1951. The success of the mackerel fishery was mainly due to the heavy landings of the fish in Malabar and Mysore. The fishery was also significantly good in Central Kerala.

(b) The landings of oil-sardine during 1958 were less than those of 1957 and this was due to the general decline in the landings in Kerala and Mysore. Some decrease was evident in the landings of other clupeoid also. The good fishery of *Anchoviella* in West Madras and the significantly increased catches of the whitebaits in South and Central Kerala are noteworthy. Some improvements were also noticed in the landings of perches, soles, eels, ribbon fish, *Caranx*, *Lactarius* and *Leiognathus*.

(c) The landings of Bombay duck in 1958 were only a little over half those of 1957 and this decline was due to the poor fishery in Bombay owing to unfavourable weather conditions. The fishery of prawns and other crustaceans also showed a significant decline in Bombay.

The flying-fish fishery in Madras was not satisfactory during the year.

The good catches of *Nemipterus* spp. in South Kerala increased the landings of perches. The landings of *Bregmaceros maclellandi* during 1958 were nearly three times those of 1957, and this is due to a highly successful fishery in Bombay.

Table II shows the overall composition of the total fish landings in India during 1958 and 1957.

Composition of fish landings

TABLE II

Name of fish	Quantity landed in metric tons	
	1958	1957
1. Elasmobranchs .. .. .	24,286	23,081
2. Eels .. .. .	9,159	6,397
3. Catfishes .. .. .	29,872	27,379
4. <i>Chirocentrus dorab</i> .. .. .	5,549	5,816

TABLE II (Contd.)

Name of fish	Quantity landed in metric tons	
	1958	1957
5. (a) <i>Sardinella longiceps</i> .. .. .	1,23,731	1,91,469
(b) Other sardines .. .. .	39,958	45,720
(c) <i>Hilsa ilisha</i> .. .. .	991	902
(d) Other Hilsa .. .. .	2,660	1,245
(e) <i>Anchoviella</i> .. .. .	29,346	12,700
(f) <i>Thrissocles</i> .. .. .	3,960	4,509
(g) Other clupeoids .. .. .	15,525	30,663
6. (a) Bombay duck .. .. .	67,188	1,19,500
(b) <i>Saurida</i> and <i>Saurus</i> .. .. .	238	212
7. <i>Belone</i> and <i>Hemirhamphus</i> .. .. .	348	379
8. Flying-fish .. .. .	388	984
9. Perches .. .. .	11,959	6,787
10. Red Mulletts .. .. .	2,166	3,055
11. Polynemids .. .. .	5,974	14,846
12. Sciænids .. .. .	25,565	29,972
13. Ribbon-fish .. .. .	41,918	38,427
14. (a) <i>Caranx</i> .. .. .	18,133	10,767
(b) <i>Chorinemus</i> .. .. .	3,014	3,238
(c) <i>Trachinotus</i> .. .. .	59	5
(d) <i>Coryphæna</i> and <i>Elacate</i> .. .. .	820	423
15. (a) <i>Leiognathus</i> .. .. .	12,865	16,909
(b) <i>Gazza</i> .. .. .	343	958
16. <i>Lactarius</i> .. .. .	16,363	8,101
17. Pomfrets .. .. .	16,587	16,205

TABLE II (Contd.)

Name of fish	Quantity landed in metric tons	
	1958	1957
18. Mackerel .. .. .	1,23,282	89,010
19. Seer-fish .. .. .	7,889	8,921
20. Tunnies .. .. .	3,239	3,014
21. <i>Sphyræna</i> .. .. .	830	523
22. Mullet ( <i>Mugil</i> ) .. .. .	729	1,051
23. <i>Bregmaceros</i> .. .. .	3,884	1,138
24. Soles .. .. .	12,856	3,687
25. (a) Penæid prawns .. .. .	29,204	74,648
(b) Non-penæid prawns .. .. .	55,987	61,374
(c) Other crustaceans .. .. .	1,508	791
26. Miscellaneous .. .. .	7,401	10,710
TOTAL ..	7,55,774	8,75,516

*Catch per unit effort.*—Table III shows the total effort in man-hours expended in each State and also the catch in kg. per man-hour during 1958-57.

The improvement in catch-per-unit effort in West Madras and Mysore even in spite of lower effort points towards greater abundance of fish. The lower return per unit effort in Bombay was probably due to lesser availability of fish resulting from unfavourable weather conditions.

### III. FISHERY BIOLOGY

#### A. Inshore Fisheries Investigations

##### (1) *Oil-sardine*—*Sardinella longiceps*, and other *chupeoids*

(a) *At Karwar.*—The oil-sardine fishery showed considerable improvement during the year under review (1958-59), and the total quantity landed

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

	Effort in 1000 man-hours		Catch in kg. per man-hour	
	1957	1958	1957	1958
1. W. Bengal and N. Orissa	4,283	5,976	1.05	0.60
2. South Orissa ..	4,688	3,757	0.80	0.71
3. Andhra ..	47,110	50,628	0.86	0.57
4. Madras (East Coast)	46,440	46,117	1.05	1.20
5. Madras (West Coast)	27,415	20,032	1.13	3.13
6. Kerala ..	93,351	95,391	3.30	3.09
7. Mysore ..	11,495	10,809	6.62	7.42
8. Bombay (excluding Kutch)	82,864	79,997	4.30	2.76
9. Kutch ..	..	548	..	3.61
	3,18,147	3,13,255	2.47	2.40

was 90,706 kg. as against 37,483.2 kg. for 1957-58. However, there were frequent breaks in the fishing activity during the season which started from the third week of November 1958 and lasted up to March 1959. Oil-sardine was encountered in the *Rampan* hauls during the current season. The range in length of fish caught was 145-99 mm. with the 160-70 mm. size group dominating. Almost all the specimens examined were in the I and II stages of maturity. Studies on the length-weight relationship, sex-ratio and fecundity were continued.

The *pedi* (*S. fimbriata*) fishery commenced by the end of September and heavy landings were recorded in October, with a total catch of 11,398.9 kg. for the season. From September-November 90-99 mm. size group dominated whereas for the latter half of the season (January-March) 100-19 mm. group formed the majority of the catches.

(b) *At Mangalore*.—The oil-sardine fishery was a complete failure during this year in this zone and it might be significant to mention that the produc-

tion of diatoms was also extremely poor during this year. During October a small catch of oil-sardine was made at Kadike (10 miles North of Mangalore). The total length of the fish ranged from 170-80 mm. in this catch, and it is interesting to note that these fish had their gonads in stage I of maturity, giving rise to some suspicion that they might possibly belong to a second spawning generation.

(c) *At Kozhikode.*—The oil-sardine fishery of the 1958-59 season in the Calicut area was poorer than that of the previous season. At Vellayil, the total catch was 4,063 m. tons, while at the same place 7,700 m. tons of oil-sardine was landed from July 1957 to March 1958. As far as could be judged from the present conditions of the fishery and the size composition of the catches in the Calicut area, it would appear that there was a much lower level of recruitment in 1958-59, than in 1957-58. It may be mentioned, however, that in December 1958 and January 1959, though oil-sardine was very abundant in the fishing grounds, it was not fully exploited by the fishermen owing to fear of a possible glut in the market. From April-October, the landings were supported mostly by a single age group. This age group, along with another year-class newly recruited into the fishery, gave the catches of the November-March period. This was the year-class which was responsible for the record catches of the 1957-59 season and whose progression through the fishery was being studied from October 1957 onwards.

About 99% of the total catch at Vellayil was accounted for by *mathikolli*, *pattenkolli* and *mathichala vala* (gill-net). The share of the first two (boat-seines) alone amounted to about 95%. *Mathikolli* and *pattenkolli* were also the most used nets. With regard to the annual catch-per-unit of effort at Vellayil, these two nets ranked first and second respectively. All types of fishing units except *mathichalla vala* registered their highest catch-per-unit of effort during the October-December period and it would appear that the abundance of sardine in the fishing grounds off Vellayil during this period was roughly double of what it was in April-June. Of the two age groups in the fishing grounds, the *mathichala vala* fished almost exclusively the older one, and hence its catch-per-unit of effort was lower in October-December than in April-June. Oil-sardine of the commercial catch varied in standard length from 105-64 mm. (128-94 mm. in total length).

Work on the general biology of oil-sardine with special reference to the food-habits, growth and reproduction was continued at Calicut. Growth appears to be quicker during the period July-November than in other periods. The fish were mostly in maturity stages III-V in April-June and in stage V

in July-September. The samples of the October-December period contained sardines mainly in stages I and II as also some specimens in the spent and recovering spent conditions. In January and February also, sardines were mostly immature (stages I and II). Mature fish in stages IV-V were observed only between mid-May and August. The gonad-weight reached a maximum in mid-July. On 9-9-1958 a fully ripe ovary with transparent ova 0.75 mm. in diameter was recorded. Spent individuals formed the bulk of the catches in December 1958 to January 1959. Unlike last year no young fish (50-80 mm.) were observed since August 1958. But juvenile sardines (130-40 mm. in total length) were observed in December-January on certain days. The ova diameter measurements appear to show that the sardine spawns only once a year and that the spawning season is not protracted. A tendency for the females to outnumber the males was noted in the maturing shoals in May. Later the sex-ratio became more or less equal. No marked difference was found in the food habits of the smaller and bigger sardines examined. Gorged stomachs were observed whenever there was a phytoplankton bloom in the sea. This was especially noted during the monsoon months. When the zooplankton was dominant in the sea the stomachs were only half full. The fish do not appear to abstain from feeding during the breeding season.

(d) *At Cochin.*—Large quantities of oil-sardine (130-40 mm.) were landed in May and June. The 1957-58 season appeared to have ended with the small and irregular fishery for 140-60 mm. groups in July. The entry of juveniles (130 mm.) in August indicated the starting of the 1958-59 season. The appearance of another immature but large-sized group (170 mm.) contributing significantly to the fishery from September-December is of great interest from the point of population studies. Maturity studies revealed the occurrence of a good number of specimens in stage III and of some in stage IV from May-July. A few recovering spent fishes (stage I) were met with in the third quarter, especially in October. Sex-ratio studies have shown the female to exceed the males in number, the former constituting about 60%. Oil-sardine eggs were collected for the first time from this area (76° 09' 8" E., 09° 58' N.).

A method has been developed to distinguish the sex of the oil-sardine externally. In the males a prominent muscular urinogenital papilla is present whereas in the female fish the genital and urinary openings are situated on a thin-walled protuberance. On the basis of this external difference sexes can be easily distinguished in the field so as to help in handling large samples of oil-sardine for sex ratio studies.



(e) *At Neendakara*.—Biological studies on oil-sardines were started at this centre. Preliminary observations indicated that the fish obtained in the local catches belonged to the first and second stages of maturity. The gut contents of a few specimens from each sample have been analysed.

(f) *At Mandapam*.—The *choodat* fishery commenced in Palk Bay in June and lasted till October. The fishery started in the Gulf of Mannar from November onwards. *Sardinella albella* predominated the catches from Palk Bay while in the Gulf of Mannar *S. gibbosa* was the dominant species. Appreciable landings of *S. gibbosa* were observed in January and February from the Gulf of Mannar. Data were collected on various meristic and morphometric characters and on the intestinal length, for detailed taxonomic studies.

(g) *At Waltair*.—A fall in the landings of sardines was noticed at Lawson's Bay during the period from April 1958 to March 1959 as only 34.28 m. tons were landed compared to 87.50 m. tons of the corresponding period in 1957-58. The sardine fishery of 1958-59 season started in October. Shore-seines were operated from December onwards. A total of 33.16 m. tons of sardines were landed during October-March of which 93.46% were landed by gill-nets, 6.4% by shore-seines and the rest by boat-seines. A gradual increase in the fishery was observed from October-December. There was a decrease in the landings in January and February and a rise in the month of March. The highest catch of 21.56 m. tons was recorded in March. *Sardinella fimbriata* was the dominant species of sardines in the catches throughout the season and the fishery was mainly contributed by juveniles. *Sardinella gibbosa* was caught in small quantities in April and from October-February.

Studies on the biology of sardines started in 1957 were continued during this year. A detailed analysis of the gut-contents of *Sardinella gibbosa* was made. *S. gibbosa* obtained in April and May ranged in size from 57-117 mm. and they were all juveniles. From October-January the size-range was 124-59 mm. and the fish were in stage I of maturity while in February 1959, 138-62 mm. fish occurred in the catches which were in stages I-IV. Gut-contents of 210 specimens of *Sardinella fimbriata* in different size-groups were analysed. Most of the specimens examined during October-March were juveniles. Specimens in stage I of maturity were recorded during December-March. The size-frequency distribution of the catches showed two peaks in each of the three months of October, November and December. In October they were at 55 and 90 mm., whereas in November they were around 65 and 115 mm. while in December they were at 75 and 120 mm.

The dominant size-groups recorded for January, February and March were 95, 105 and 120 mm. respectively. Certain morphometric and meristic characters were studied in some of the samples of *S. fimbriata*.

(2) *Mackerel*—*Rastrelliger canagurta*

(a) *At Karwar*.—Length frequency studies of the Indian mackerel showed that the fishery in October and early November was composed of the 190 and 200 mm. groups. From the second week of November to the third week of March, the mode remained constantly at 210 mm. During the last week of March the 220 mm. group was dominant. Thus from October–March there was a shift in the mode from 190–220 mm. The ratio of females to males varied slightly from month to month, although the overall ratio for the year was 50:50. The fishery was composed of immature fish. Observations appear to indicate that the mackerel has only one spawning period lasting from May or June–January or February, with a rather short time interval in the ripening of successive batches of ova. Whether this spawning occurs with a regular and continuous shedding of ova or whether there is any interval between the release of successive batches, in view of the long duration, needs further investigation.

(b) *At Mangalore*.—Fishery for mackerel along the coast started somewhat late this year as against the previous years when the fishery was evenly spread out during the season. This year there were spurts of very active fishery followed by long periods of lull. However, the fish caught even in the beginning of the fishing season belonged to the larger size-group (210–19 mm.). Mackerel caught during the active fishing seasons were all juveniles and immature. The volume of the stomach contents was relatively high during November, when it consisted mostly of copepods.

(c) *At Kozhikode*.—This year's mackerel landings at Calicut were 1,449.78 m. tons out of the total fish catch of 7,437.38 m. tons, thus contributing 19.49% to the annual catch. The fishery was contributed by one dominant class (215 mm.) which persisted throughout the season. Mackerel caught in April–September months were in maturity stages III–V and those from October–March in stages I–III. The juvenile mackerel up to 160 mm. encountered in September were in stage I.

(d) *At Cochin*.—Mackerel fishery at Cochin was of small magnitude. With moderate landings of 200–20 mm. group in April the 1957–58 season ended. The 1958–59 season started in September and continued till January when it showed decline. The 190–210 mm. group mainly supported the fishery. Landings were mostly by gill-nets. At the end of the previous

season in April and May specimens in maturity stages II and III were encountered whereas still advanced stages were rare. Ova diameter studies of stage III ovaries showed a unimodal curve.

Active feeding occurred more or less during the entire period except during the first quarter when it was only moderate.

Cursory examination of the otoliths showed only a very small percentage of the fish above 210 mm. which possessed demarcations like growth-zones.

(e) *At Vizhingam.*—There was no exclusive fishery for mackerel along the Vizhingam coast, during the year. However, mackerel were caught in small numbers throughout the year along with other fish, in shore-seines, boat-seines and drift nets. The total landings of mackerel at Vizhingam for the year were estimated at 15,500 kg. The size composition of the fish in these catches showed four different size-groups during the first quarter of the year (within a wide size-range from 40–240 mm.) while towards the last quarter adults of 225–45 mm. in total length dominated.

The bulk of the catches consisted of either indeterminate or immature fish. A few specimens obtained in August–October showed their gonadal maturity in stages ranging from I–VII. Detailed studies on the spawning of the species are being made. Analyses of plankton collections of the previous two years have been made with special reference to the eggs and larvæ of mackerel.

(f) *At Mandapam.*—The mackerel fishery of the Mandapam area was poor during the year and there were no landings at Vedalai fish landing place. Occasional samples were, however, available from other neighbouring villages during the months of April, May and November–February. There was no fishery during the period June–October after which the fishery in the area started in the last week of November. The size-range during the different months was as follows:

Month	Size-range (total length in mm.)	Remarks
April	207–312	Largest sizes were few and unusual. Ripe and spent individuals were frequent.
May	220–236*	*Five specimens only. Mostly in stage I or II of maturity.
November	201–235	
December	192–230	
January	191–235	
February	202–244	

Studies which were initiated at Karwar on the scale-rings in the Indian mackerel were continued. The analysis of the data relating to 369 specimens from North Kanara indicated that these rings were spawning marks occurring as a rule in the older individuals and that they might prove useful not only in age and maturity studies but also in raciation studies in view of the reported variation in the size-distribution and spawning period of the species in different parts of the Indian coast. In continuation of these observations scale studies on mackerel from the Indian coast were carried out. Sufficient numbers of the larger sizes of fish were, however, not available.

Of the morphometric data collected in the past, certain selected characters were utilized for the analysis of co-variance in order to test the distinctness or otherwise of the populations from different centres. Of the meristic characters the positions of certain vertebral characters were studied. The data taken related to samples drawn from Ratnagiri, Karwar, Malpe, Kozhikode and Mandapam.

Several samples of *Rastrelliger* were received from abroad during the year. Observations on these samples have been in progress and certain morphometric and other data have been collected on most of these samples for comparative study with the Indian material.

(g) *At Porto Novo*.—Mackerel formed only 9% of the total fish landings at this observation centre. *Rastrelliger* ranked second to *Lactarius* in importance. Mackerel fishing on the coast is restricted to two very short seasons, namely, August–September and January–March. The size composition of the fish caught in the first season varied between 140 and 170 mm. and in January–March between 200 and 240 mm. During both seasons, a slight preponderance of the females over the males was noticed with a ratio of 6:5. Studies on the sexual maturity of the fish indicate a possibility of the fish attaining first maturity at about 200 mm. in length. This seems to be in agreement with observations made on the west coast. Similarly, gonadial studies indicate that the first spawning takes place in April or May. Efforts to identify mackerel eggs in the plankton or to fertilize the eggs artificially were not so far successful.

### (3) *Biology and fishery of prawns*

(a) *At Bombay*.—This year a total of 79 samples was taken from Bombay out of which 36 were collected from Versova, 23 from the vessels belonging to Deep-Sea Fishing Station, Bombay, and 20 from the trawlers belonging to New India Fishing Co. The principal species of prawns in Versova landings were *Metapenæus affinis*, *M. brevicornis*, *Parapeneopsis sculptilis*

and *Solenocera indicus*; whereas in the previous year they were *M. affinis*, *M. brevicornis*, *Parapeneopsis stylifera*, *P. sculptilis* and *S. indicus*. *P. stylifera* has disappeared from the catches both at Versova and Sassoon Docks; a species of the genus *Trachypenæus* has been recorded for the first time. They were encountered in comparatively large numbers. Studies of year-class strength, rate of growth, sex ratio and sexual development of the prawns (from Bombay) are being carried out through sampling the commercial catches. The size composition of the Versova samples was more or less similar to those of the Sassoon Docks (Area 43 A). However, there was a remarkable difference on the species comprising the catch and the size composition of the catches landed by New India Trawlers. It is evident from the present study that the sex-ratio tends to vary with age and the species, with the season, and probably with the ground also. It varies from slight predominant male population to a complete female population. However, it appears that more information relating to the problem is required before further analysis is given. In general, immature prawns formed a large proportion of the commercial catch at all the three centres.

(b) At Mangalore.—Prawn fishery by the indigenous craft was poor this year as in the previous year. October–November period was the peak season. Cast-net was the chief gear used and the catches consisted mainly of *Metapenæus dobsoni*. Kanthabale operated from January–March landed poor quantities of *Penæus indicus*. A good number of berried females were observed during October and this coincided with the occurrence of large number of prawn larvæ in the plankton.

The mechanized vessels of the State Fisheries Department started operations from the last week of September. From September–January there were no prawn catches but from February, the catches were fairly good and comprised of *Metapenæus dobsoni*, *M. monoceros*, *M. affinis*, *Penæus indicus*, *Parapeneopsis stylifera*. Mostly *M. dobsoni* dominated and the most abundant size groups for females ranged from 86–90 mm. and 91–95 mm., while for males they were 76–80 mm. and 81–85 mm. Males outnumbered the females in most of the catches. Data on percentage composition of the catches, length-frequency, sex-ratio and maturity conditions were recorded. Juveniles of *M. dobsoni*, *M. monoceros*, *P. indicus* and *P. canaliculatus* were caught in appreciable quantities in the Netravati estuary.

(c) At Kozhikode.—Along the Calicut coast prawn fishery showed marked fluctuations during the period under report. The fishery was absent in June, October, December of 1958 and January and February of 1959 due

to the existence of more lucrative sardine and mackerel fisheries. During monsoon months fishing was totally abandoned on several days but whenever there was fishing the return was substantial. *Paithuvala*, *pattenkolli vala*, *arakolli vala*, cast-net and otter trawl at Beypore were employed during this period. The first three are boat-seines operated in waters up to 20 metres deep. Cast-nets were employed when the fishery was at its minimum. The fishery was at its peak during the monsoon period when the landings amounted to 193 m. tons for three months at Calicut and 493 m. tons for the same period at Quilandy. Moderate fishing existed from April-June when 14.31 m. tons at Calicut and 5 m. tons at Quilandy were landed. The October-December period witnessed a fall in the fishery when sardine and mackerel fisheries were flourishing and the landing figures were 5 m. tons at Calicut and 11.9 m. tons at Quilandy. The fishery was a failure during January and February 1959.

*M. dobsoni* was the most important species in the catches, especially in the monsoon period. During the other months, April and May, this species accounted for 50-90% of the catches. *Parapenaeopsis stylifera* was the next in importance, the peak for this species being in May and July and it reappeared in February. *Penaeus indicus* occurred only in small quantities throughout and a slight increase in quantity was noticed towards the end. *M. affinis* was noted for its demarcated seasonal occurrence. A slight increase in their numbers was noticed towards the end of the year under report.

Eggs and larvæ belonging to the species *M. dobsoni* were observed from November-December. Some attempts were made to rear the protozoa and z a stages in the laboratory.

(d) *At Cochin.*—The fishery was quite poor on the Cochin coast and catch samples for routine study were not available in some months. At Alleppey, excepting for the failure of the fishery of *Parapenaeopsis stylifera*, the same trend as has been noted last year is seen this year also. *M. dobsoni* contributed to the major portion of the catches in all the months. In the months of the peak season the percentage of the species increased considerably, the size of the prominent length group also reached the maximum, and males were represented in the catches more than females. Although *P. stylifera* comes next in abundance, its percentage was much lower than that of last year. *M. affinis* was the next predominant species and it showed an increased percentage in some months, especially in November.

At Chellanam, in the case of the dominant species *M. dobsoni*, the same trends are noted as at Alleppey, the percentage and the prominent length

groups being at the maximum during July-September. In these months the males are in excess of females. *M. affinis* and *P. indicus* are next in abundance. The prominent length group of *M. affinis* increased regularly from 81-85 mm. to 131-35 mm. At Narakkal, although sufficient samples were not available in all the months, in the case of *M. dobsoni* the same trend of maximum percentage and prominent length group in September is noted.

In the country craft catches of Alleppey and Narakkal *M. dobsoni* is predominant and *P. stylifera* next in abundance, whereas in the trawler catches *M. dobsoni* is dominant and the species next in abundance is *M. affinis*. The latter is the case in the country craft catches of Chellanam also, which is slightly in variation from data obtained last year. In regard to the recruitment of post-larvæ to the backwaters, in comparison with last year, a marked increase in the species *M. dobsoni* and *M. monoceros* and decrease in *P. indicus* has been observed this year.

In the trawler catches also *M. dobsoni* is the major species in most of the months and bigger size groups were represented in the catches, as has been noted last year. In repetition of the observation of last year *M. affinis* is the species next in abundance this year also. This is more prominent this year since in November and December this is the dominant species. The prominent length group of this species increases from 81-85 mm. to 131-35 mm. by the end of the year. A slight difference between the catches of the shrimp trawlers and that of M.T. 'Ashok' and 'Pratap' is noted in that in the former *M. dobsoni* is dominant and in the latter *M. affinis* or *P. indicus*.

The quantitative observations that were being made on the catches of two stake nets, one at Azhikal near the harbour mouth and the other at Thevara about 5 miles to the south were stopped at the close of October after collecting data for two years. They are being analysed in order to show the fluctuations in the total catch of prawns from month to month as well as the variations in the proportion of the species represented and their size-range. The catches were generally much less in 1958 when compared to those of 1957 at both places.

The statistically designed experiment on paddy field prawn fishery with a view to ascertain, if any, the effect of area of the field and size of sluice on the annual yield came to a close in April. When the catches from the various sections of the field were compared it was found that, (i) two sluices did not affect any substantial improvement in the yield over only one, the area of the field remaining the same, and (ii) the yield from the larger field is larger irrespective of the number of sluices provided and is roughly pro-

portional to the area of the field. The experiment is being repeated during this season also in order to verify last year's results.

Last year's experiments on *Tilapia* plus prawn culture showed that the fish does not usually feed on prawn fry and young ones. The experiment is repeated this year to verify this and also to establish, if any, the effect of the presence of prawns on the growth of the fish. Observations made so far seem to indicate that growth is slightly retarded.

(4) *Half-beaks*—*Hemirhamphus spp.*

There were good landings of Hemirhamphids in the Mandapam area during the period under report. The fishing operations at Theedai commenced in the first week of March, slightly earlier than the previous year. Morphometric measurements and meristic counts were taken of all the samples received from the various survey centres. The morphometric data have been completely analysed while the meristic characters remain to be studied. Samples of *H. georgii* from the Gulf of Mannar and Palk Bay are being compared for detection of possible differences. The data for the males and females from one locality (Rameswaram) have been analysed separately and no statistically significant difference has been noticed between sexes for the four characters chosen. The seasonal variation in the diet of *H. georgii* seems to have some physiological relation with the maturation cycle. It has been observed that there is no complete cessation of feeding in any species of *Hemirhamphus* during its spawning period in this area. Maturity studies are in progress. Large samples were sexed on various occasions in the field in the case of both *H. georgii* and *H. marginatus* in order to get a clear picture of the sex-ratio of the spawning population of the two species. The spawning ground of *H. marginatus* in the Gulf of Mannar has been located. Attempts to rear the eggs in the laboratory were a failure.

(5) *Seer-fish*—*Scomberomorus guttatus*

Studies on the biology of *Scomberomorus guttatus* were continued at Waltair. The total landings of the fish for the period at Lawson's Bay were estimated at 59.0 m. tons. The fishery reached its maximum in June, with a sudden decline thereafter. In December again it reached another peak. Teleosts, crustaceans and molluscs which formed the main food of the fish constituted 18%, 21.5% and 0.84% respectively the stomach contents on an average for the year. Among crustaceans squilla larvæ were the most important item while larval and young prawns were also present. Cephalopods and gastropods were observed rarely. The percentage of females was



always higher than that of males. Length-frequency analysis showed that 320-60 mm., 360-400 mm., 400-40 mm. and 440-80 mm. size-groups were dominant in different periods. From February-October, fish of 600 mm. size and above were recorded. Juveniles of 30-110 mm. size were observed in March.

(6) *Mullet*s—*Mugil spp.*

The following observations were made on *Mugil cephalus* and *Liza macrolepis* of the "Pullamadam" backwater area (near Palk Bay) which had been taken up for detailed biological study. Two distinct size-groups of *Mugil cephalus* (100 mm. and 260 mm. in furcal length) occur in the lagoon catches in January. The larger group dwindle in numbers since February, and disappear completely by the end of March while the smaller size groups continue to show steady progress in growth and are regularly caught in the nets. None of the specimens examined had any well-formed gonads excepting two fish in September (at 229 mm. and 243 mm. furcal length) and one in November (at 233 mm. furcal length) which had gonad in stage II of maturity. Nematode parasites were observed in the body cavity of this species.

The size-range observed in the catches of *Liza macrolepis* was between 69 and 320 mm. furcal length. The smaller sizes occurred in the catches in June, July, September, December and January. Mature (about stage IV) and spent fish were observed during early June, middle of August and December, but these were more commonly seen in the cast-net catches from the Palk Bay. Studies on food, maturity, time and duration of spawning (by the availability of the fry) and rate of growth of the two species are in progress.

(7) *Tunny*—*Katsuwonus pelamis*

Investigations on the biology of the tuna, *Katsuwonus pelamis*, which forms the more important species of tunnies (the other being *Neothunnus macropterus*) around Minicoy Island, were started during this year. The fishing season commences early in November and lasts till about April and the fishing activity is usually within a range of 6-7 miles around the island. The export of dried tuna in 1958 amounted to about 173 m. tons as against 281 m. tons in 1957.

The commercial catches are usually composed of fish ranging in size from 350-650 mm. in standard length and with an individual weight varying from about 1-6 kg. Nevertheless, specimens of a minimum length of

290 mm. and those as large as 1,239 mm. were recorded in this region. Adult fish which are mostly mature or spent constitute the fishery. Preliminary observations indicate that spawning commences in February. There is generally a preponderance of males in the catches at the beginning of the spawning season. Fecundity and ova diameter studies are in progress. A general survey of the tuna live-bait fishery was carried out because of its importance in the tuna fisheries programme.

(8) *Spiny lobsters*—*Panulirus spp.*

Because of the growing economic importance of the spiny lobster fishery along the coast of Kerala biological observations on the fishery was started towards the end of the third quarter of the year under report. The fishery of the Kanyakumari District is richer than in other regions. The total catches in numbers at Colachel and Muttam during the 3 months December-February have been estimated as follows:

	Colachel	Muttam
December .. (15th-31st)	19,958	53,645
January ..	19,292	36,661
February ..	9,306	9,200

Three types of gear were in use in the Muttam area, *viz.*, the anchor hook, the trap and the gill-net. Except in February anchor hooks were not used at Colachel. In this place the major part of the catch has been obtained by the trap while at Muttam, the catch by the anchor hooks were much higher, except in February, as the following figures will show.

	Trap	Net	Anchor hook
<i>At Colachel—</i>			
December ..	16,398	3,560	Nil
January ..	16,228	1,064	Nil
February ..	9,306	50	50
<i>At Muttam—</i>			
December ..	7,359	Nil	46,286
January ..	14,672	Nil	21,989
February ..	6,932	58	2,210

Although four species were represented in the catches one of them predominated and in all the months had contributed practically the entire catch, the other species accounting for only 1-2%. The estimates of total catches given above therefore relate only to this species which is provisionally identified as *Panulirus dasyopus*.

Length-frequencies have been determined separately for each sex of this species for each centre; the sex proportions have also been determined. At Colachel the proportion of males was 63.7% in December and 53.3% in January. At Muttam the percentage varied from 61% in December to 46.4% in February.

#### (9) *Molluscs*

Investigations on the effect of transferring seed clams, *Meretrix casta*, from the Adyar estuary to the Cooum estuary have shown that the depleted clam beds could be reclaimed by transplanting young clams during the October-November period when the hydrological conditions in both the estuaries are identical. The polluted nature of the Cooum estuary during the rest of the months appear to affect the transferred seed clams adversely. The large-scale occurrence of young ones of *M. casta* measuring 1-5 mm. with a mode at 3 mm. during the months of April indicated that these clams probably spawn sometime towards the end of March. Studies on the rate of growth of these clams in relation to the variations in the environmental factors, such as pH, salinity, phosphates, silicates and nitrites, were continued.

Training in the modern methods of diving with aqualung, etc., was undergone during the survey of the chank beds and pearl oyster paars off Tuticorin conducted by the Madras Fisheries Department in collaboration with Dr. F. B. Salvadori, F.A.O. Underwater Expert. So far, three paars, viz., Davi paar, Fernando paar and Velangu Karuwal paar, have been surveyed in detail and the survey of the Tholayiram paar is in progress.

#### *B. Offshore Fisheries Investigations*

##### (a) *Mechanised fishing at Bombay*

During the year under review the analysis of the catch data from the trawlers of Government of India and New India Fisheries was continued. In addition, the fishery and biology of *Dara*, *Ghol*, *Koth*, *Karkara*, *Shende*, Bombay duck and prawns were studied.

The two sets of bull-trawlers Arnalla and Paj and Satpati and Pilotan of the New India Fisheries Ltd., Bombay, have taken 3,529 hauls and landed

36,15,648 kg. of fish and shellfish from January–December 1958. There has been an increase of 12.64% in the total quantity of fish taken in the areas fished and increase of 20.53% in catch per haul, when compared with that of last year. The increase in catch per haul, in the areas fished, has been during the months of January, March, April, July, August, September, October, November and December and was of the order of 13.74, 11.11, 14.30, 5.34, 9.95, 53.83, 67.01, 85.80 and 28.17% respectively. The decrease in catch per haul during February, May and June was of the order of 11.57, 3.95 and 20.29% respectively. The major groups of fish landed in their order of abundance together with their percentage composition in the total bull-trawler takings has been—*Sciæna* and *Otolithus* spp. (21.283%), *Muraenesox talabonoides* (15.081%), sharks (10.300%), *Arius* spp. (8.453%), *Pellona* spp. (5.558%), *Pristipoma* spp. (5.413%), *Lactarius delicatulus* (5.190%), *Sciæna diacanthus* (4.838%), *Polynemus heptadactylus* (4.500%), *Polynemus indicus* (2.295%), skates and rays (1.936%), *Pagrus spinifer* (1.916%), miscellaneous (1.805%), *Sciænoidea* spp. (1.740%), and other nineteen minor groups which together constitute 9.692%. There were eight mechanised vessels of the Deep-Sea Fishing Station operating from Bombay. In the month of October 1958 three boats were transferred to Cochin. From November, two boats have started working off Veraval. Totally 492 voyages were undertaken and 1,542 hauls made involving 2,804 hours and 20 minutes of actual fishing effort. The total landings were 3,00,576 kg. and an average catch of 107.182 kg. has been obtained. The major groups have been *Sciænids* (32.688%), skates and rays (27.760%) and catfishes (6.775%).

(1) *Biology and fishery of Dara*—*Polydactylus indicus*.—The preliminary study of *Dara* from the landings of the bull-trawlers indicates that areas around Lashington Shoals off the Gulf of Cutch, abound mostly in juvenile fish while adults are found only in small numbers. However, as the season advances an extensive gill-net fishery for these occurs off the coast of Jamnagar and Satpathi. Investigation started at these two centres are expected to throw some light on the movements of the juveniles and adults. The peak period of *Dara* fishery is January–March. From April–August there is a decline followed by a gap in our observations in September due to the stoppage of operations by the trawlers in this area on account of unfavourable weather conditions. From December onwards there is a recovery in *Dara* fishery. The bulk of the landings from the bull-trawlers consists of *Chelna* or juvenile *Dara*. The size-range vary from 290–975 mm. during April–June and specimens from 700–800 mm. were immature (stages I and II). One *Dara* of 975 mm. was found to be at stage IV of maturity

in June but two specimens of 980 and 1,020 mm. taken in December were found to be at stage III of the spent recovering phase.

(2) *Biology and fishery of Shende*—*Polynemus heptadactylus*.—Locally *P. heptadactylus* is landed by dol or bag-net and it consisted mostly of individuals less than 900 mm. in length. They were all immature and in many cases even the sexes could not be differentiated. Only in October and November slightly larger specimens in the stages I and II of maturation were observed. The smallest size-group with the mid-point at 200 mm. entered the fishery twice in the year, in September and March. The New India Fisheries Trawlers landed fishes of above 950 mm. size. Spent individuals were observed nearly for 8 months. Spawning individuals were noticed twice in the year, July and March. This fishery formed 4.7% of total trawler landings in the offshore areas of Cambay, Porbandar and Dwaraka.

(3) *Biology and fishery of Ghol*—*Pseudosciaena diacanthus*.—This fishery formed 4.38% of the landings of the New India Trawlers which operated mainly in Dwaraka, Porbandar, Veraval and Cambay regions. The trawler catches consisted of fishes of length range 200–1,060 mm. though the dominant size-groups during the months fluctuated between 325 and 975 mm. In the inshore catches of dol-net at Versova, however, juveniles of 320 mm. were available in large numbers especially from October–March, though a few larger fish (1,110 mm.) than those occurring in trawlers were also recorded. The length at first maturity appears to be between 800 and 850 mm. spent and spent recovering fish were found during October–March in large numbers. From April onwards mature specimens (stage IV) were recorded, reaching stage V in June as seen from examination of the few available specimens. Scale and otolith studies are inconclusive, as the growth checks are not distinct, though some indications of zonation can be seen in the scales and up to seven rings could be made out in fish of 1,000 mm. Further work is in progress. Examination of stomachs shows that 60–70% are empty due to extroversion of the stomachs while landing the fish, especially of the large ones. In the stomachs, which were not affected, prawns, shrimps and small fishes were found, the crustaceans being found in greater quantity in the young *Ghols*, and fishes dominating the gut contents of the larger fish.

(4) *Biology and fishery of Koth*—*Sciænoides brunneus*.—The bull-trawler landings of *Koth* became reduced from 2.71% of total catch in 1958 to 1.74% in 1959. They were mainly caught in the offshore region off Dwaraka. The fishery is formed mainly of juveniles above 250 mm. length. In the dol-net catches of the inshore waters, however, the size-range from 750–1,250 mm. do not appear at all. Prawns and fishes form the major

food items of the fish. They seem to prefer *Acetes*, *Bregmaceros* and *Coilia* during monsoons. In winter months feeding activity is at the minimum whereas it is maximum in May-October. The fish attains first maturity at 1,200 mm. Spawning takes place probably from January. Fecundity was found to be around 6.8 million eggs per female. Scale and otolith studies show 3-4 growth checks on the former tallying with the length-frequency modes in monthly samples of fishes within 1,000 mm. range. 10-11 rings were found on scales of specimens 1,450-1,500 mm.

(5) *Biology and fishery of Karkara—Pomadasys hasta.*—Biological study on *Pomadasys hasta* locally known as *Karkara* was continued. The fish is mainly landed by trawlers constituting 5.41% of the total catch. November-December seems to be the good months for this fishery especially in the Porbandar and Dwaraka regions. The fishery gradually declined from the month of March-September and started recovering in October. Juveniles of *P. hasta* ranging from 54-125 mm. in length were collected in January. They are caught by a type of gill-net locally called 'peri' which is operated near the shore. Otoliths of 200-320 mm. size-group fish show two rings, 330-440 mm. three rings, 450-560 mm. four rings and 570 mm. and onwards five rings. Scales also show some rings on them but their interpretation has not been possible. Stomach analysis reveals that it feeds on squilla, crabs, prawns, sipunculids, polychæte worms, lamellibranchs and gastropods. From the above it seems that *P. hasta* is a bottom-feeder. Juveniles are plankton feeders mainly feeding on amphipods. For maturation study nearly 250 specimens were examined. Females constituted 48.13% and the rest by males. In the month of June ovary shows IV stage of maturity. Occurrence of spent specimens started from October-December. From this it appears that spawning may be taking place from September-November which is again supported by the occurrence of juveniles in January.

(6) *Biology and fishery of Bombil—Harpodon nehereus.*—Length-frequency studies at two fish landing centres at Bombay have shown that the recruitment to the stocks takes place during November-December. The rate of growth appears to be 12-15 mm. per month in the earlier life of the fish. The rate of growth progressively decreases in the later life and is about 4 mm. per month in specimens beyond 250 mm. The commercial catches mainly comprises of fish measuring between 190 and 250 mm. Spawning season of *Harpodon nehereus* appears to commence in December and lasts till the end of February. With the available data on hand the minimum size at maturity is 217 mm. The number of eggs that can be produced by a single individual has been estimated to vary between 14,606 and 81,205,

Ova diameter measurements have shown that the development of ova in all the regions of the ovary is uniform and that a single individual spawns only once a year. Considerable volume of data for raciation studies has been collected and is being processed statistically.

(b) *Mechanised fishing at Cochin*

“*Ashok*” and “*Pratap*”.—In April 1958 the cutters ‘Ashok’ and ‘Pratap’ in the course of bull-trawling in area 108 in depths ranging from 24 to 44 m. close to Cochin, obtained a total catch of 76,965 kg. over a trawling time of 52.63 hours, the catch per trawling hour being 1,462.38 kg. Both the total catch and the catch-per-unit effort were the highest recorded for any one month during 1957–58 season. In May 1958 also the fishing operations were mostly confined to area 108 at depths ranging from 18 to 46 m. and the total catch amounted to 75,972 kg. over a trawling time of 55.7 hours, the catch per trawling hour being 1,363.93 kg. During both the months small fish formed major part of the catch (73.31%) while the other important fishes in the landings were rays (11.93%), sharks (8.89%), catfish (2.33%) and *Pristipoma* (1.79%). The high catch rates obtained in April and May 1958 show that area 108 is a rich fishing ground, though the bulk of the catches belonging to small fish category. In June the total landings declined to 25,416 kg. due to adverse weather.

In January 1959 the cutters resumed bull-trawling operations after the monsoon break in areas 108, 110, 111 and 112 lying between Quilon and Cochin at depths ranging from 24 to 47 m. The total catch for the month was 54,737 kg. over a total trawling time of 89.62 hours, the catch per trawling hour being 610.77 kg. The highest return per unit of effort, 722.02 kg. per trawling hour, was from area 111. In February 1959 the trawling operations were mostly confined to area 108 and the total catch obtained was 29,743 kg. over a trawling time of 55.50 hours, the catch per trawling hour being 535.9 kg. In both the months small fish constituted the biggest catch (42.09%), while rays (24.76%), sharks (15.89%), *Pristipoma* (6.97%), moon-fish (3.64%) and prawns (2.99%) were the other important categories in the landings.

‘*Durga*’.—During the year this trawler carried out shrimp trawling mainly in areas 106 A and 108 close to Cochin. In April and May 1958 the total catch amounted to 18,587 kg. over a trawling time of 172.58 hours, the catch per trawling hour being 107.70 kg. Small fish (47.66%) and prawns (38.81%) formed the major catches. All the vessels suspended fishing operations during June–November period for the duration of the monsoon and carried out annual repairs. The total landings during

December 1958 to February 1959 came to 34,054 kg., the highest catch of 14,019 kg. being recorded in the month of February. Prawns formed the dominant catch (47.44%) while small fish (37.33%) was the next major category in the landings.

'*Samudra*'.—This trawler which commenced fishing operations off Cochin in April 1958 operated shrimp trawl, mainly in area 108, at depth ranging from 7.27 m. The total catch in April and May 1958 was 5,982 kg. the catch per trawling hour being 41.98 kg. Small fish formed the largest portion of the catch (57.07%) while prawns formed the next large category in the landings (36.79%). In June the total catch was 3,037 kg., prawns constituting the dominant catch (67.88%). The total landings during November 1958 to February 1959 were 40,240 kg., the catch per trawling hour being 111.78 kg. Small fish (55.45%) and prawns (32.79%) constituted the main catches.

'*Tarpon*'.—This vessel started fishing operations off Cochin in May 1958 and like the other small vessels, she operated shrimp trawl mainly in area 108 at depths ranging from 11 to 27 m. The total landing in May 1958 was 8,427 kg., the catch per trawling hour being 82.62 kg. Small fish (47.95%) and prawns (39.93%) formed the main catches. During October 1958 to February 1959 the total landing amounted to 41,335 kg. (the highest among smaller vessels), the catch per trawling hour being 110.70 kg. Small fish (59.92%) and prawns (30.49%) were the main catches. In all the above vessels the maximum landing of prawns was in January 1959.

'*Sagarkumari*'.—This vessel commenced fishing operations in area 103 off Cochin in October 1958 and during October 1958 and February 1959 a total catch of 19,272 kg. was obtained. As observed in the other vessels, here also small fish (43.48%) and prawns (41.83%) were the main categories caught.

### (c) *Mechanised fishing at Calcutta*

The details of catches by the Government of West Bengal's trawlers for the year under report was collected entirely from the landing place. Out of five trawlers, Kalyani II was inactive throughout the year, Kalyani I had 7 fishing voyages and in one voyage there was no fishing. The total catch by this trawler was 81,643 kg. for only six trips and thus worked a better average catch per voyage than Kalyani III which in its eight voyages could



Name of vessel	No. of voyages	A in kg.	B in kg.	C in kg.	Total
Kalyani I ..	7	323.02	81,096.01	224.08	81,643.11
Kalyani III	8	1,400.26	84,326.03	2,156.86	87,883.15
Kalyani IV	6	1,150.31	53,410.02	2,873.08	57,433.41
Kalyani V ..	11	2,419.43	57,966.36	3,254.60	63,640.39
TOTAL..	32	5,293.02	2,76,793.42	8,508.62	2,90,600.06

take 87,883.15 kg. The lowest total of 57,433.41 kg. was obtained by Kalyani IV. Though the number of voyages made by Kalyani V was more, the total catch of 63,640.39 kg. worked out a comparatively low average catch per voyage. There was no fishing during the months of May-July, and only one voyage was possible in August and September. Improvement in the catches was noticed from October onwards with the maximum returns in January, confirming the observations made in previous years regarding fishing trends. In the absence of master's log reports the exact fishing grounds where particular types were taken could not be ascertained. It was in a general way information gathered about fishing grounds visited, from the masters after the arrival of the vessel. The change in the method of catch disposal where transference from fish holds to shore cold-storage immediately after the vessels berthing did not allow a more detailed appraisal of the catch composition. The increased types in various classes listed here may indicate improvement of the fishery in a general way though actually there was fall in the total quantity landed over previous year. Presence of seer-fish, mackerel and better valued perches may be taken as an encouraging sign for further activity. Especially when commercial exploitation is the main object, attempts for greater effort may prove more profitable. Presence of smaller quantities of better class and B class perches, seer-fish, horse mackerel and an increase in clupeid and eel catches are the special features of the catch composition of this year's landings. The last two voyages in March, when fishing was confined to nearer fishing grounds, produced good quantities of eels. A decrease in the taking of sciænid (Bhola) and glass fish (*Kurtus indicus*) was noticed, though they continued as in previous years to be the main varieties. It was gathered that fishing was mainly concentrated near Black Pagoda, Devi and Prachi river-mouth up to False point and during rough weather limited operations were con-

ducted near Hoogly point and Sand heads. Total landings of individual types compiled at landing place are given below:

	kg.	kg.
<b>A. Prawns and shrimps:</b>		
<i>Metapenæus</i> .. .. .	152.02	
<i>Penæus</i> .. .. .	1,105.88	
<i>Acetes</i> .. .. .	96.16	
		1,354.06
Pomfrets .. .. .		1,302.32
<b>Perches:</b>		
<i>Pristipoma</i> sp. .. .. .	2,400.33	
<i>Ephinephelus</i> sp. .. .. .	28.58	
<i>Nemipterus</i> sp. .. .. .	12.70	
<i>Lates calcarifer</i> .. .. .	111.58	
Indian salmon .. .. .	37.20	
<i>Otolithus</i> sp. .. .. .	1.81	
		2,592.20
Mackerel .. .. .		7.25
Seer-fish .. .. .		37.19
		5,293.02
<b>B. Sciænids</b> .. .. .		
Glass fish ( <i>Kurtus indicus</i> ) .. .. .		1,09,034.90
		84,318.92
<b>Clupeids:</b>		
<i>Pellona</i> sp. .. .. .	20,527.43	
<i>Setipinna</i> sp. .. .. .	2,250.75	
Engraulids .. .. .	5,388.27	
Other clupeids .. .. .	5,388.27	
		28,783.91
Silver belly .. .. .		14,329.81
Smaller prawns .. .. .		1,379.84
Bombay duck .. .. .		1,418.86
Carangids .. .. .		2,047.55
<b>Perches:</b>		
Miscellaneous .. .. .	19.05	
Goat fish .. .. .	2,291.09	
<i>Nemipterus</i> .. .. .	575.62	
		2,795.76
<i>Lactarius lactarius</i> .. .. .		209.55
Catfish .. .. .		133.80
<i>Sphyræna</i> sp. .. .. .		6.35
Miscellaneous .. .. .		20,193.58
Unspecified .. .. .		12,145.59
		2,76,798.42

C. Eels	..	..	..	..	4,555.06
Rays	..	..	..	..	991.10
Skates	..	..	..	..	1,698.73
Saw-fish	..	..	..	..	446.34
Catfish	..	..	..	..	743.90
Miscellaneous	..	..	..	..	73.49
					8,508.62
TOTAL LANDED ..					2,90,600.06

Fish catches in general showed a downward trend during the year. In spite of the more voyages total landing was less than in 1957-58. Kalyani I, the Danish trawler, showed greater catch efficiency and proved to be more suitable for these waters. There was an increase in fish types and decrease of sciaenids and glass fish which formed the main stay of this fishery.

#### C. Physiology and Marine Fish Farming

In order to find out whether by reducing the osmotic load on fish the metabolic ( $O_2$  uptake) rate could be lowered and the fish made to last longer in a restricted volume of water as in fish fry transport, and to analyse the factors which restrict the adults of some marine fish but not their fry from penetrating the lagoons and tidal creeks, some experiments were performed on *Plotosus anguillaris*. It was found out that with reference to the former condition, salinity of 12.5‰ reduced the standard metabolic rate and the lethal level of oxygen by nearly 80% over those of fish normally in sea-water. With reference to the latter aspect, the relatively wider range of metabolic adjustment and probably the osmotically unspecialized nature of the fry are indicated as reasons for their ability to enter into highly fluctuating situations. Further work on similar lines but with greater detail was partially completed on *Tilapia mossambica* where fish of all sizes were acclimated to low salinity and 30° C. and their metabolism measured in temperatures ranging from 15-40° C. As an essential adjunct to the work an apparatus was devised for measuring the release or uptake of chloride by the fish over a prolonged period in different media.

Analysis of figures obtained after the fish harvest of 1957-58 showed that the marine fish-ponds yielded a maximum of 220 kg. of fish per hectare during the year. *Chanos* constituted nearly half the total weight of fish

caught. In this first attempt at rearing fish in the experimental ponds since their construction, supplementary feeds for the fish during the last phase of their growth were found essential in order to maintain them in healthy condition. Owing to the poor fertility of the ponds in the initial stages, organic manures in the form of seaweeds and cow-dung compost and also green manure were helpful in enriching the ponds. During the 1958 fry season some of the ponds were stocked with *Chanos* fingerlings. Length measurements at intervals revealed that the fish with an initial length of 80 mm. maintained a steady increase in length in the order of 120 mm. and 300 mm. at the end of the first and third month respectively. Methods to improve the growth rate and the ultimate yield of fish in ponds are being tried.

A survey of the ecological characteristics and the fishery resources of the lagoon around the experimental marine fish-ponds was completed during the year. This furnishes an important basic background while considering the scope for expansion of salt-water fish culture in this area.

#### IV. MARINE BIOLOGY

##### A. Planktological Investigations

(a) *At Karwar.*—Diatom blooms were never noticed although there were indications of increase in diatom population during the monsoon. Dinoflagellates were common during September. *Noctiluca* was abundant during August–September. *Sagitta erflata* was generally observed to be common at Karwar and Chendia and this form was replaced by *S. bedotei* at places farther south and this observation confirms the previous year's findings regarding the chaetognath distribution in the North Kanara Coast. Copepods were abundant during August–September and cladocerans in September.

(b) *At Mangalore.*—Planktological conditions along the Mangalore Coast during this year, while showing many similarities to those of last year, showed also significant differences. The general trend during the two years were diatom bloom in June, copepod maximum during October–January which coincides with the active fishing season, *Noctiluca* bloom in October which was not of such a magnitude as to affect fishery, dinophysid maximum in September–October, progressive increase of fish eggs and larvæ in the plankton from October–February, maximum of prawn eggs and larvæ during September and October which coincides with the active inshore prawn fishery, maximum of chaetognath eggs during December–January, and summer bloom of *Hemidiscus* sp., and swarming of *Lucifer* sp. after March.

The significant differences were: the monsoon bloom of diatoms was of a shorter duration and lesser magnitude. The post-monsoon bloom of diatoms which occurred in January last year was absent this year. The post-monsoon dinophysid bloom was exceptionally good and exclusive swarms of *Ceratium* sp. occurred in the inshore waters during this year. An exclusive swarm of *Temora turbinata* occurred in the first week of November and this coincided with the bumper mackerel fishery all along the zone. An almost exclusive radiolarian swarm occurred in December. The bearing of these facts on the fishery condition in this zone is under active investigation.

(c) *At Kozhikode.*—The seasonal cycle of the plankton was more or less of the same pattern as in the previous year. Phytoplankton was at its maximum during the south-west monsoon attaining the peak in July-August, and the usual secondary bloom was conspicuous by its absence. Zooplankton formed the bulk during the north-east monsoon season. The standing crop was generally poor when compared to the corresponding periods last year. The poorest months for the plankton were December and January. Spectrophotometric studies on the chlorophyll content was made while an assessment of the biomass is under investigation. *Fragilaria oceanica* occurred occasionally during the south-west monsoon as usual, but never in abundance at any time. This year its bloom was not a sustained one and this has been partly reflected in the poor oil-sardine fishery during the season. During the monsoon *Hornellia marina* also was seen in good quantities, for a short period but never in abundance as to discolour the water. Minor blooms of *Trichodesmium* spp. were seen during the hottest months. Data on the fluctuations in the magnitude of standing crop of phytoplankton in terms of Harvey Units and production of carbon per unit area were collected. Values up to 12.83 gm. of carbon per metre square of sea-surface for the area were obtained, indicating a high productive potential of the waters.

The pattern of abundance of zooplankton showed but slight variations this year. The copepods were abundant till the outbreak of the monsoon in late June and thereafter revived by August-September and continued, without appreciable dwindling, for the rest. Though swarms of *Evadne* and *Penilia* appeared in September-November they had not their usual abundance. They, however, were present throughout the year, though often scarce. The chætognaths, usually dominant in post-monsoon months, were moderate this year. Medusæ came in large numbers from November-March, mainly *Obelia* and *Aequorea* in the earlier part and *Liriope* and *Nausithæ* later. Swarms of polychæte larvæ occurred in July; they were

erratic for the rest. Penæid eggs and larvæ were abundant, particularly in December, while sergestid and crab larvæ were numerous in February–March. *Noctiluca* swarms appeared in July–August, salps in February–March and appendicularians and pteropods were numerous in December–March. The main period of availability of fish eggs and larvæ were October–December, though appreciable number of carangid eggs were collected in mid-July.

(d) *At Mandapam*.—Investigations on the organic production in the seas around Mandapam were continued. In order to check the values of organic production computed from the “dark and clear bottle” experiments, concurrent experiments were carried out using  $^{14}\text{C}$ . The collection of data has been extended to five other stations covering a distance of about 20 miles. The changes of total nitrogen and particulate and dissolved phosphorus are being studied.

The study of the characteristics of plankton at various centres in the Gulf of Mannar and Palk Bay revealed the following interesting features during the year: (i) Swarms of *Noctiluca*, which used to occur in the Gulf of Mannar and Palk Bay particularly during the summer months, were completely absent during the year under report. (ii) As in the previous two years *Evadne tergestina* appeared rather late this year also. They occurred during the end of January in the Gulf of Mannar only. (iii) *E. tergestina* was soon followed by a small population of *Penilia avirostris*. (iv) During the end of March there was a sudden appearance of large numbers of *Creseis acicula* in Palk Bay. (v) The standing crop of plankton in Palk Bay during the period January–March was comparatively lower than that of the Gulf of Mannar. (vi) The following blooms were recorded during the year: *Rhizosolenia* spp. and *Chatoceros* spp. in Palk Bay during September, and *Asterionella japonica* during February; *Chatoceros* spp., *Rhizosolenia styliformis*, *Concinodiscus gigas*, *Thalassiothrix frauenfeldii*, *Hemidiscus hardmannianus* and *Thalassionema nitzschioides* in the Gulf of Mannar during November–December.

Chætognaths seemed less abundant this year both in the Gulf of Mannar and the Palk Bay. Among the 8 or 9 species occurring in these waters, *Sagitta enflata* were the most abundant and an unusual swarm of the species was noted in the Gulf of Mannar in November 1958. Observations on the biology and fluctuations in populations of the copepod *Acartia erythræa* were made. Attempts to rear the species in the laboratory were not successful. A detailed comparative study of the copepod nauplii of the Gulf of Mannar and the Palk Bay based on the material collected during 1952–55

was also completed. A critical study of the spawning of copepods in this area seems to suggest a relation of their spawning with the phytoplankton cycle.

### *B. Oceanographic Studies*

#### *(a) At Bombay*

*April-June.*—The temperature of the waters varied between 31.8° C. and 26.5° C. The salinity remained more or less steady at 35.6‰ except for an increase to 36.8‰ in the first week of May. With the onset of the monsoon towards the end of June, the salinity dropped down to 22.0‰. The oxygen content of these waters ranged between 3.66 and 6.90 ml./l. and both the highest and lowest values were obtained in the month of May. The inorganic phosphate varied between 0.37 and 0.83 µg.-at. P/l. The dissolved organic phosphate was high, being nearly 60% of the total phosphorous content.

*July-September.*—The mean temperature values in this period ranged between 27.5° and 28.8° C. The salinity of the surface waters varied from 24.31 to 30.91‰, while the subsurface waters had higher salinity and the highest value recorded was 34.99‰ at a depth of 20 meters in late September. The mean oxygen content of the waters was between 4.5 and 4.8 ml./l. Inorganic phosphate was high in August and in the middle of September and low for the rest of the period; the concentrations ranged between 0.51 and 1.38 µg.-at. P/l. The integrated mean concentration of inorganic phosphate in the entire column down to 20 meters varied from 0.89 to 0.92 µg.-at. P/l. Unlike in the previous quarter the dissolved organic phosphorus was only 15% of the total phosphorous content. The chlorophyll 'a' values were rather low in early August and early September and increased in the rest of the period. The highest value of 3.32 mg./m.<sup>3</sup> was in late September.

*October-December.*—Temperature varied from 26.0 to 30.0° C. and 26.0–28.4° C. in the inshore and off-shore waters respectively. The drop in the temperature was fairly sudden in late November and the discontinuity layer was seen at 25 m. early in November and by the end of the month it had crept up to 13 m. By December the temperature became practically uniform throughout the entire water column. Salinity which had shown an increase to 34.99‰ towards the end of September rose further to 35.35‰ by the end of October and 36.27‰ by the last week of November followed by a decrease to 35.62‰ in December. The salinity distribution at subsurface levels followed the same pattern as the distribution of temperature. The oxygen content was low in October and in early

November and showed an increase in late November, the values being 2.9 ml./l. and 5.2 ml./l. in the respective periods. In December, the values have come down to 4.35–4.10 ml./l. During the October–November stratification in the water column an oxygen-minimum layer was seen to be present more or less at the discontinuity layer which disappeared completely by December when turbulent conditions had set in. The inorganic phosphates in the surface waters varied between 0.40 and 1.36  $\mu\text{g.}-\text{at. P/l.}$  The values were low in October and November and high in December. In the entire water column the values were 0.63  $\mu\text{g.}-\text{at. P/l.}$  in October, 0.89  $\mu\text{g.}-\text{at. P/l.}$  in November and 1.12  $\mu\text{g.}-\text{at. P/l.}$  in December. The mean chlorophyll content decreased from 4.36  $\text{mg./m.}^3$  in October to 1.18  $\text{mg./m.}^3$  in December. Maximum variations within the same month were seen in October while the minimum was in December.

*January–March.*—The turbulent conditions commenced in December and continued till the end of February. The water temperature showed a further decrease to 24.2° C., while the salinity remained more or less steady, except for slight fall in late January, the range being 35.71–35.28‰. There was no appreciable difference between the surface and subsurface salinity. Little change in salinity was observed in the succeeding months. The oxygen content of waters also remained steady at  $4.3 \pm 0.1$  ml./l. The inorganic phosphate showed a slight decrease from 0.79  $\mu\text{g.}-\text{at. P/l.}$  in January to 0.69  $\mu\text{g.}-\text{at. P/l.}$  in February. The integrated mean concentration of phosphates in the entire water column from surface down to 20 metres increased from 0.74  $\mu\text{g.}-\text{at. P/l.}$  in early January to 1.09  $\mu\text{g.}-\text{at. P/l.}$  towards the end of the month and this was followed by a sudden decrease to 0.67  $\mu\text{g.}-\text{at. P/l.}$  in February. Dissolved organic phosphorus amounted to nearly 15–20% of the total. The chlorophyll content showed a slight increase over the December value of 1.18  $\text{mg./m.}^3$ , the value in January being 1.54  $\text{mg./m.}^3$  and that in February being 1.72  $\text{mg./m.}^3$

(b) *At Karwar*

At Karwar, the water temperature, pH and salinity declined during monsoon. Dissolved oxygen content increased. Phosphates remained low throughout but nitrites increased during June–July and silicates were high during monsoon.

(c) *At Mangalore*

The year under review showed similar hydrological conditions off Mangalore as those of last year. The influx of freshwaters into the sea during the monsoon period lowered the salinity to a great extent. During the post-monsoon months the salinity as well as temperature gradually increased.



The temperature fluctuated between 27.5° C. and 29.5° C. during the post-monsoon months (October–January).

*(d) At Kozhikode*

Studies on the seasonal variations in the hydrological conditions of the inshore and off-shore waters of the Calicut coast were continued. However, off-shore collections were totally interrupted from July–August due to bad weather. In general, the temperature of the inshore waters was higher in April, May and September than that of off-shore waters, and lower in October, November and February. Surface salinity of the inshore waters was higher than of off-shore waters in April, May and October and lower during the rest of the period. Except in April, the bottom salinity of the inshore waters was lower than that of off-shore waters. The surface phosphates and nitrites of the inshore waters were generally higher than those of off-shore waters and in the case of bottom waters it was *vice versa*. Silicate content of the inshore waters was also higher than of off-shore waters. Except in March, the total phosphorus content of the inshore surface waters was higher than that of off-shore and in the case of bottom waters it was lower in the inshore area in May and December and higher during the rest of the period than in the off-shore area. pH of the inshore and off-shore waters remained more or less the same. Surface oxygen of the inshore region was higher than that of off-shore area in September, December and January and lower during the rest of the period. Bottom oxygen of the off-shore waters were generally higher than that of inshore waters.

*(e) At Cochin*

Preliminary analysis of the data on physical oceanography collected so far has been completed and the results may be summarised as follows:

Oceanographic conditions after south-west monsoon between Cape Comorin and Cochin: (a) There is a south to south-easterly flow along the coast up to 30 m. depth. (b) Eddy circulations are prominent between Alleppey and Quilon. (c) The divergence at lower levels accompanied by upwelling and tendency towards convergence and steady flow at the surface layers afford a clue towards understanding the dynamics of the formation of mud banks between Cochin and Quilon. (d) From 75–100 m. there is a steady countercurrent flowing either north or north-westwards. (e) In a layer at a mean depth of 50 m. the flow is indicated to be eastwards. Probably any exchange of water between the Arabian Sea and the Bay of Bengal takes place in deeper layers only. (f) The circulation derived from the distribution of salinity is somewhat different from the one derived either

from temperature or density and, as such, there appears to be no direct correlation between temperature and salinity. (g) The distribution of temperature should be taken into consideration while deriving the circulation along the west coast of India as the temperature seems to be a more conservative property. (h) The last two inferences are in contrast with the conditions in the Bay of Bengal where there is a direct relationship between temperature and salinity.

Summer conditions are as follows: (a) The temperature of the surface layer has increased and the surface temperature is generally 31° C. (b) The thermocline forms at about 80 m. depth. (c) At 500 m. depth, no appreciable change in temperature is noticed as compared to the observation of the previous season. (d) Though the conditions are unsettled in the mixed layer, good stability is found in the thermocline region. (e) The space variation of salinity is from 33.5-35.5‰. (f) Consequent on the rise in temperature the density of surface layers has undergone reduction and the density layers corresponding to  $\sigma_t = 25$  now occur at 140 m. whereas it was 80 m. during September-October. (g) Lighter waters are present along the coast-line, indicating a northerly current.

#### C. • Algology

During the year under review satisfactory progress had been maintained on the studies of ecology of marine algæ in the intertidal zone in Palk Bay and Gulf of Mannar. It was observed that seasonal cyclic changes in the floral pattern was more constant in Palk Bay than in the Gulf of Mannar. Further, towards a survey of the harvestable grounds of economic seaweeds, a beginning has been made in the Gulf of Mannar area. In this preliminary survey covering the zone from Dhanushkodi to Hare Island it has been observed that Turbinarias and Sargassums are most abundant and more uniformly represented in all the stations than the red algæ. A detailed study of the genus *Hypnea* has been undertaken on account of the wide range in morphological variations within the genus and lack of earlier work on these from Indian waters. It was also possible to make some studies on the distribution of algæ in the Pearl beds off Tuticorin based on samples collected from the Paars. Besides being able to make observations on the colonization of the substratum and growth of the algæ, a number of interesting species also have been recorded on which studies are being made.

Agar prepared from *Gelidium micropterum* has been found to be highly suitable for mycological work in laboratories.

V. CHEMISTRY AND BACTERIOLOGY OF FISH; FISH CURING AND BY-PRODUCTS

The report covers the period from April up to December 8, 1958, after which date this work, together with the related staff, was transferred to the Central Fisheries Technological Station at Ernakulam. During this period, several objective tests for assessing the quality of preserved prawns in ice were conducted. In the case of one batch of prawns (mainly *Penaeus indicus*), preserved in ice, it was observed that leaching in contact with melting ice affected all the water-soluble compounds in the muscle. After 11 days of storage the prawns lost by leaching 40.38% of the total proteins, 63.32% of the water-soluble proteins, 88.73% of the soluble non-protein compounds and 88.16% of the free L-amino-acids. Such information is important from the commercial point of view because it indicates that the storage of fish in ice before processing (which is necessary in most cases) should be reduced to the shortest possible period so that maximum nutrients are retained. This also explains why some of the more common chemical tests for spoilage, such as for trimethylamine and volatile basic nitrogen, do not give any reliable information in the case of ice-stored fish.

Experimental studies on the possible use of shellac as a fish preservative gave encouraging results only in the case of very small fish such as *choodai* (*Sardinella* spp.). Analyses of *Scomberomorus* samples treated with alginate jelly and kept at 14° F. for three months showed that apart from the better physical appearance of the flesh, the development of rancidity was considerably less in the coated sample than in the control. The percentage of salt-soluble nitrogen on the total nitrogen was 34.8 in the coated sample and 31.5 in the control as against 36.1 in the beginning of the experiment, indicating thereby that denaturation of the muscle protein is retarded to a great extent in the treated samples. In the study of the bacteriological and biochemical changes taking place in the fermentation method a series of experiments was conducted with shark flesh. The effect of increasing the fermentation period on the rate of multiplication of lactic acid bacteria was studied. The 4-hour and 8-hour counts were approximately 6 and 8 times the count at 0 hours showing their increased growth during fermentation. Along with this the effect of adding small quantities of free sugars to the fermenting mass in the form of dextrose was studied. Although the rate of multiplication of lactic bacteria was enhanced several-fold, the final product was found to assume a brownish appearance. There was no significant change in the amount of urea removed from the shark flesh as a result of addition of sugar.

Analysis was made of the data obtained in the experiments to study the different aspects of mackerel curing, viz., (i) effect of different methods of dressing the fish prior to salting, (ii) washing the gutted fish in different solutions prior to salting, (iii) optimum salt proportions required, (iv) influence of various chemical preservatives on the keeping quality of the finished product, (v) optimum humidity conditions for storing and (vi) maximum permissible delay between catching and actual processing.

With a view to studying the changes occurring in the fat of *Hemirhamphus* owing to hydrolysis and oxidation while processing, different types of cured products, such as dry-cured, wet-cured and tamarind-cured, were prepared. In all these series separate lots were also prepared after pre-treatment with preservative to improve the shelf-life. Experiments were also conducted to study the beneficial effects of treating cured products with prescribed quantity of propionic acid to prevent attack by red halophiles and fungi. Preliminary studies on the digestibility of dry-cured *Lactarius* by enzymatic hydrolysis with pepsin and trypsin were attempted.

Sardine oil sample prepared during the last season was periodically examined for any change in quality during storage. There was little change in the iodine value, acid or free fatty acid content during its storage in the past one year, while in the commercial samples the acid value and the free fatty acids had increased. Possibilities of preparing enzymes from the pyloric caeca of mackerel were also explored.

CENTRAL MARINE FISHERIES  
RESEARCH STATION,  
Marine Fisheries P.O., S. India,  
June 1, 1959.

(Sd.) S. JONES,  
Chief Research Officer.

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