

**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 1958**

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I. ADMINISTRATIVE AND GENERAL

The activities of the Central Marine Fisheries Research Station received added impetus during the year 1957-58. The programmes of work at the Headquarters Station at Mandapam and the various subordinate establishments at different centres were actively pursued. Additional Research/Survey/Field Centres were opened at Kandla (Cutch), Bedi (Jamnagar), Malwan, Ganguli (Mysore State), Cape Comorin, Porto Novo, Adirampatnam, Masulipatnam and Balasore, and the Survey Centre at Kakinada was revived. Arrangements have been finalized for opening two Field Centres at Dahanu and Alibagh on the Bombay Coast. The substation at Bombay has been shifted to the Botawala Chambers, Sir Pherozeshah Mehta Road, Bombay. The staff at the Ernakulam Substation has been further augmented and an additional building has been rented there to meet the increased demand for laboratory accommodation. A co-operative research programme has been launched in close collaboration with the Indo-Norwegian Project authorities at Cochin and it has been possible to organize a number of cruises on their schooners for the collection of oceanographical and marine biological data in different parts of the Arabian Sea. Advantage has been taken of the opportunities for the collection and study of data on marine fish catches provided by the increased fishing activities at Bombay by power fishing vessels belonging to the New India Fisheries, Ltd., at Cochin by the Government of India Power Fishing Vessels and at Calcutta by the West Bengal Government Mechanized Fishing Craft.

The fishery survey programme was considerably expanded and the number of zones was increased from 12-20 covering the entire coastline of the country. The total marine fish landed in India during 1957 was estimated at 875,420 metric tons recording an increase of over 1.5 lakhs metric tons (22%) over the 1956 figures. The landings on the east coast showed a general decline which was more than offset by the increased catches on the west coast, especially due to the remarkable recovery of the sardine and mackerel fisheries. The landings of the oil-sardine in 1957 were the highest recorded so far.

In a twenty acre plot at Vaikom (Kerala State) large-scale field experiments on paddy field prawn fishery have been initiated. Field experiments were also started there to ascertain whether *Tilapia* would feed on prawn fry and the extent of tolerance of the fish to salinity changes. An important line of marine biological work, the estimation of organic production, has been initiated at Mandapam and the data so far obtained are interesting and informative. On the basis of detailed proposals submitted to the

Government, a sum of Rs. 1 lakh has been sanctioned for 1958-59 for the initiation of research schemes on Pelagic Fisheries and the Laccadive Fisheries. Dr. S. Jones, Chief Research Officer, visited the Minicoy and Laccadive Islands in February-March 1958 for making preliminary arrangements for opening a Research Unit there.

The scheme for the collection of sea-water samples and their analysis by special Chemical Assistants at Bombay, Calcutta and Madras sanctioned by the Ministry of Natural Resources and Scientific Research was continued during the year. Though a drift-card scheme for studying the ocean currents in the Bay of Bengal and the Arabian Sea in areas near the Indian coast-line, which would be helpful in connection with marine fisheries investigations, was also sanctioned by the same Ministry it could not be implemented during the year owing to paucity of funds provided for the purpose and non-availability of a research vessel.

Publication of the *Indian Journal of Fisheries* was continued under the Managing Editorship of Dr. S. Jones, Chief Research Officer. Volume IV, No. 2 and Volume V, No. 1 of the Journal were published.

Budget allotments of Rs. 11 lakhs for non-recurring expenditure and Rs. 8.87 lakhs for recurring expenditure were sanctioned by Government for 1957-58. Substantial progress has been made in the capital works programmes. The permanent residential quarters are expected to be made available for occupation shortly. The construction of a Guest House at a cost of Rs. 1.38 lakhs has also made substantial progress. An overhead tank for the supply of circulating sea-water for the Aquarium and a Cold Storage Plant for keeping specimens and other materials for scientific studies have been completed.

Substantial progress has been made on the construction of a permanent building for housing the substation at Kozhikode. A private building at Karwar in which the Research Unit there has been accommodated for the past few years, has been permanently acquired at a cost of Rs. 38,000. The question of acquiring a suitable site at Bombay for the construction of a building for the substation there is also under active consideration.

Essential scientific requirements for continuing the normal activities and the projects under the Second Five-Year Plan were procured and made available. Twenty-four 16 mm. films indented under the T.C.M. Programme were also received during the year. A 29 ft. motor launch and a pablo boat for use in connection with prawn studies in the backwaters at Cochin were received. An aluminium dinghy was also acquired during the year. Owing

to foreign exchange difficulties it has not been possible to procure many essential oceanographic equipment from abroad. A lathe ordered for the Workshop is expected to be received shortly. All the other Workshop equipment like arc-welder, shaping machine, band-saw machine, hydraulic jack, electric blower and spray-painting machine have been received. A Carpentry Section has been added on to the Workshop with the appointment of a carpenter during the year.

The year under review recorded an increase in the activities of the Library service in the circulation of journals to subordinate establishments and in building up nucleus libraries at some of the outstation centres. Library facilities were also extended by way of loan of books for short periods to research workers in university research laboratories and other institutions. Also several non-departmental persons were permitted to consult publications in the Research Station Library. A considerable number of books and monographs of fisheries interests, back numbers of journals and periodicals and microfilm copies of rare publications have been procured for the library.

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

<i>Name of post</i>	<i>Number of posts</i>
Research Officer (Offshore Fisheries) Class I, Senior ..	.. 1
Fish-farm Engineer—Class I, Junior .. ..	.. 1
Assistant Research Officers—Class II (for Sardines, Mackerel, Prawns and Offshore Fisheries investigations) .. ..	.. 7
Research Assistants .. .. .	.. 7
Computer .. .. .	.. 1
Field Assistants .. .. .	.. 6
Superintendent (not filled) .. .. .	.. 1
Upper Division Clerk .. .. .	.. 1
Lower Division Clerks .. .. .	.. 2
Serang .. .. .	.. 1
Lascar .. .. .	.. 1
Oilman .. .. .	.. 1

	<i>Name of post</i>					<i>Number of posts</i>
Laboratory Boys	3
Watchmen	2
Hindi Instructor	1
Hindi Translator	1

Dr. S. Jones, assumed charge as Chief Research Officer on the 18th April 1957 on the appointment of Dr. N. K. Panikkar as Fisheries Development Adviser to the Government of India. Dr. Jones participated in the meetings of the Fisheries Research Committee and the Committee for standardization of names of fishes at Hyderabad in October 1957 as a member of these committees.

The following postings and appointments were made:

<i>Name</i>	<i>Post held</i>	<i>Present post</i>
R. Velappan Nair	Research Officer (Fishery Survey) till May 1957, Fishery Naturalist till November 1957, Research Officer (Sardine) - till January 1958	Research Officer (Fishery Survey) Class I Senior, from January 1958
L. B. Pradhan	Assistant Research Officer (Mackerel)	Research Officer (Mackerel) from October 1957
T. Tholasilingam	Research Assistant	Research Officer (Offshore) from January 1958
A. Sri Ram Sarma	..	Assistant Research Officer (Statistics)
P. T. Meenakshi-Sundaram	Survey Assistant	Special Survey Assistant

<i>Name</i>	<i>Post held</i>	<i>Present post</i>
S. J. Rajan	Do.	Assistant Fisheries Extension Officer (Ministry of Food and Agriculture)
T. A. Mammen	Research Assistant	Do.
A. V. Natarajan	Research Scholar	Assistant Research Officer (Ecology) at the Central Inland Fisheries Research Station.
M. V. Pai	Do.	Assistant Research Officer (Off-shore Fisheries)
K. V. Sekharan	Research Assistant	Assistant Research Officer (Sardine)

Shri R. Jayaraman, Assistant Research Officer (Biochemistry), who was on deputation for training in Oceanography in the United Kingdom, returned to India in December 1957; Shri K. V. Sekharan, who was deputed to Japan for training in Sardine Fisheries returned to India in July 1957 and Shri P. R. Sadasivan Tampi, Assistant Research Officer (Fish-Farm) who was away in the U.S.A. on special leave for training, rejoined his post here on the 3rd August 1957. Shri S. V. Suryanarayana Rao, Assistant Research Officer (Fish Curing), was granted leave for two years' training at the University of Hamburg, West Germany. Shri R. Viswanathan, Assistant Research Officer (Oceanography), continued his studies in Oceanography at the Kiel University (West Germany).

Shri V. Sadasivan who has been officiating in the post of Assistant Research Officer has been confirmed in the post with effect from the 27th November 1957. Shri V. Balan has been declared quasi-permanent in the post of Research Assistant with effect from 1st July 1956. Recruitment to most of the vacant Class III and IV posts have been made.

It is recorded with great regret that Sarvashri S. A. Mukarram, Survey Assistant and M. Abdul Majid, Fieldman, died from illness during the year.

Shri K. Ramalingam, Senior Research Scholar, completed his investigations in July 1957 and submitted a thesis for the Ph.D. Degree of the Madras University.

Under the Indo-German Industrial Co-operation Scheme, the Government of India awarded two Fellowships to two German Scientists, Dr. F. Morawa and Dr. Karl Banse, for Research Work at this Institution. They started work here in August 1957 and March 1958 respectively. Sarvashri M. Subrahmanyam, K. K. Tandon, K. Krishnamurthy and S. Malhotra have joined here as Senior Research Scholars during the year. Shri K. P. Eapen was also admitted as an Honorary Research Worker in January 1958.

The first Fisheries Research Workers Conference was held at the Central Marine Fisheries Research Station in January 1958, in which besides the Chief Research Officers of the Marine and Inland Fisheries Research Stations and several research workers from the two Fisheries Research Stations, representatives from the States and from Universities in India also participated actively. The Conference was inaugurated and presided over by Dr. N. K. Panikkar, Fisheries Development Adviser to the Government of India. Dr. G. L. Kesteven of the F.A.O. and Mr. Charles B. Wade of the T.C.M. also took part in the proceedings. A number of contributions were presented at the Conference on problems relating to fishery biology with special emphasis on methodology by different research workers based on their critical studies on the marine and inland fisheries of India. Following the discussions at the Conference, various recommendations were made for the improvement of methodology used in fishery biological investigations.

A scientific meeting presided over by the Chief Research Officer and attended by all mackerel and sardine workers of this Research Station was held at Ernakulam in the first week of March 1958. At this meeting detailed discussions were held and programmes of investigations on these two fisheries have been drawn up.

Shri N. K. Velankar, Research Officer (Chemistry), and Dr. V. Krishna Pillai, Assistant Research Officer (Bacteriology), attended the Indian Standards Convention held at Madras from the 22nd to the 28th December 1957 and the delegates of the Convention evinced keen interest in the papers presented by the above officers.

Among the distinguished foreign visitors to the Headquarters Station could be mentioned Prof. Gerhardsen, Fisheries Expert under Norwegian aid, Prof. Myrland, Physical Oceanographer and Research Adviser of the Indo-Norwegian Project in Kerala, Charles B. Wade, T.C.M. Fisheries Extension Adviser, Dr. E. Hess, Chief Technologist, F.A.O., Rome, Madame Y. Khouvine, Director of Higher Studies at the Rothschild Institute, Biological Physics-Chemistry, Paris and delegate to the Indian Science Congress Session, held at Madras, Dr. G. L. Kesteven of F.A.O., Rome, Mr. Joh

Martone of the T.C.M., American Embassy, New Delhi, and Mr. T. Yamamoto, Deputy Chief of the Japanese Fisheries Statistical Branch who was receiving training under F.A.O. Fellowship at the Indian Council of Agricultural Research, Statistical Wing.

Other distinguished visitors to the Headquarters Station include Shri R. A. Baig, Controller-General of Emigration and Joint Secretary to the Ministry of External Affairs, New Delhi, Dr. P. M. N. Naidu, Deputy Animal Husbandry Commissioner, Indian Council of Agricultural Research, New Delhi, His Holiness Jagatguru Shri Sankaracharya Swami of Sringeri Mutt and Shri Kelu Eradi, I.A.S., Additional Director of the Industries and Commerce Department, Madras.

Among the distinguished visitors who visited the subordinate establishments could be mentioned Dr. Miyamoto, F.A.O. Gear Technologist who visited the Kozhikode Substation; Mr. Nils Lyso, Minister for Fisheries, Norway and Dr. E. Hess, Chief Technologist, F.A.O., Rome, who visited the Substation at Ernakulam; Prof. Hiyama, Fisheries Scientist from Japan, Mr. Lyso, Norwegian Minister for Fisheries, Dr. G. L. Clarke and Dr. Ryther of the Woods Hole Oceanographic Laboratory who visited the Bombay Substation. Shri M. V. Krishnappa, Deputy Minister for Agriculture, Government of India, visited the building under construction for the Substation at Kozhikode.

The large number of visitors to the Headquarters Station, about 2,800 in number, included several research workers, trainees, parties of University, College and School students and the lay public. The Museum and the Aquarium continued to be centres of attraction for the generality of visitors. In addition, an Exhibition with special emphasis on fisheries which was organized in co-operation with the Fisheries Extension Unit here, was largely attended by visitors from the neighbouring areas. The State Agriculture, Co-operative and Animal Husbandry Departments and the Schools at Ramanathapuram and at Mandapam Camp also participated in this Exhibition. This Institution also took part in the All-India Cattle and Poultry Show at New Delhi where the occasion was availed of for explaining and popularizing various modern methods of fish processing and preservation, production of quality fish meal, seaweed utilization, etc.

Consequent on the appointment of a Hindi Instructor, regular classes for teaching Hindi to the members of the Class I, II and III staff at the Headquarters Station have been started from March 1958.

In accordance with the directive received from the Ministry, two Staff Councils, one for staff other than Class IV staff and the other for Class IV staff were set up and these have been functioning effectively.

The Canteen and Stores, to which Government had granted an interest-free loan of Rs. 1,500, the Recreation and Welfare Clubs, which are run solely with subscriptions raised from the staff, the Nursery School and Ladies Club, both maintained by private contributions and the branch of the Zoological Society of India located at this Research Station, have all been functioning effectively and contributing towards providing some of the very essential amenities for life and work in an out-of-the-way place like Mandapam. These organizations actively co-operated in celebrating the Independence Day and Republic Day functions at this Research Station in a befitting manner, helping to organize exhibitions, film shows and dramas which attracted large numbers of visitors from the neighbouring areas.

The Research Station answered numerous enquiries received from various Government agencies, manufacturers, industrialists, traders and private individuals on subjects handled at this Institution. Very close collaboration was maintained with other scientific organizations. Particular mention in this connection could be made of the facilities offered to the Central Electro-chemical Research Institute, Karaikudi, for carrying out experiments relating to corrosion of metals under tropical marine conditions such as those prevailing at Mandapam. A large number of original scientific papers contributed by the staff of the Research Station was published in the *Indian Journal of Fisheries* and other scientific periodicals (list attached).

II. FISHERY SURVEY

Survey programme expansion.—As per the recommendations of the *ad hoc* Fisheries Committee (1954) the fishery survey programme was expanded considerably in 1957-58 and the number of zones in the coast-line of India was increased from 12-20. This made each zone more compact with a more or less homogeneous fisheries represented in it. The number of villages selected in the sample was increased to 185 by bringing in another 50 fish landing centres consisting of 92 fishing villages under observation during the year. This has helped to fulfil the target of covering 10% of fishing villages in the survey programme.

The jurisdiction of the survey was extended for the first time to Kutch (zone 20) from the month of September 1957. As only preliminary surveys could be made in the region and as data for the whole year were not available, no estimate of landings for this zone is included in the present report.

Statistics of landings.—The analysis of the data collected in 1957 was completed during the year under review. Further increase in the total landings of marine fish was witnessed during the year and the total of landings was estimated at 875,420 metric tons in 1957, as compared to 718,702 metric tons in 1956, thus showing an increase of about 22% over the fish landings in 1956. The regional analysis of the total landings for 1956 and 1957 is shown in Table I.

TABLE I
Regional distribution of total landings of marine fish

Zone	Fish landings in metric tons	
	1957	1956
1. West Bengal and North Orissa	4,509	15,882
2. South Orissa	3,757	
3. North Andhra	29,673	52,476
4. Central Andhra	5,499	
5. South Andhra	5,290	
6. North Madras	20,521	55,208
7. Central Madras (Palk Bay)	13,974	
8. South Madras (Gulf of Mannar)	14,097	
9. West Madras and South Kerala	51,820	133,736
10. Central Kerala	112,278	
11. North Kerala (Malabar)	176,920	78,405
12. Mysore	76,090	25,901
13. South Bombay I (up to Ratnagiri)	11,945	
14. South Bombay II	51,078	324,127
15. Central Bombay	258,467	
16. North Bombay	2,763	
17. South-East Saurashtra	24,448	29,792
18. South-West Saurashtra	5,451	
19. North Saurashtra	2,508	
20. Kutch	Figures not complete	
Mechanized Vessels	4,332	3,175
TOTAL ..	875,420	718,702

From Table I, it will be seen that while the fish landings had declined in all the zones of the east coast, they had improved in all the zones of the west coast, excepting in Bombay zone, where there had been a slight decline. The noteworthy feature was the phenomenal increase in landings in Malabar which was more than twice that of 1956.

The decline in fish landings in West Bengal and Orissa was mainly due to decreased landings of prawns, sardine, *Harpodon nehereus*, Polynemids and *Hilsa*. In Andhra, there was some improvement in the landings of *Trichiurus*, *Leiognathus*, *Anchoviella* and perches, but decreased landings of sciaenids, *Caranx*, red mullets, *Lactarius*, prawns, *Thrissoctes* and clupeids like *Sardinella fimbriata*, *Dussumieria*, *Kowala*, *Ilisha*, *Coilia* and *Anodontostoma* were responsible for the decline of the total landings in the region. Even though slight improvement in the catches of *Rastrelliger* and Elasmobranchs, was noticed in the Madras State, the total catch in the State declined because of diminished landings of several fishes, especially *Trichiurus*, *Caranx*, Sciaenids, *Cypsilurus*, perches, *Ilisha*, *Anodontostoma*, *Leiognathus* and prawns.

Though the heavy increase in the landings of *Sardinella longiceps*, together with some increase in the landings of *S. fimbriata*, *Rastrelliger* and *Trichiurus* improved the total catch quantitatively in the South and Central Kerala, several other fishes showed decreased landings. In particular there was considerable decline in the landings of *Caranx kurra*, Sciaenids, *Anchoviella* and *Dussumieria*. In Malabar, a bumper catch of *Sardinella longiceps* together with somewhat improved catches of *Rastrelliger*, *S. fimbriata*, *Trichiurus* and prawns increased the total landings to more than twice that of 1956 in spite of considerable decrease in the landings of *Caranx kurra*, and smaller decline in the catches of several other fishes like *Cynoglossus*, *Anchoviella*, *Leiognathus*, *Sciæna*, catfishes, pomfrets and Elasmobranchs. In Mysore, the landings in 1957 were more than thrice that of 1956. This was principally due to the remarkable increase in the landings of *Rastrelliger*. While some improvement in the landings of *Arius*, *Sardinella longiceps*, *Leiognathus* and prawns was also noticed, there was some decline in the catches of *Scomberomorus*, *Chorinemus*, *Cynoglossus* and Elasmobranchs. There has been a slight fall in the total catch in Bombay in 1957. This was mainly due to poor fishing in the last two months in the year, which resulted in decreased landings of prawns, *Harpodon* and Sciaenids. Some improvement was noticed in the landings of *Polynemus*, Elasmobranchs, Pomfrets and *Muranesox talabonoides*. Another significant feature was the landing of a substantial quantity of oil-sardine for a short period in Bombay II (*i.e.*, in the region between Ratnagiri and Bombay). A slight increase was noticed in the total

landings in Saurashtra. No outstanding variation in the catches of any fish was noticed, excepting that there was some improvement in the landings of pomfrets in 1957.

Composition of fish landings.—The salient features of 1957 fisheries were as follows:

(a) Both oil-sardine and the mackerel fisheries were highly successful. The landings of oil-sardine in 1957 were the highest recorded so far. The total catch of mackerel was also the highest since 1951. The catch of these two fishes in 1957 exceeded that of 1956 by 256,637 metric tons, *i.e.*, about 35% increase in terms of total catch of all fishes in 1956.

(b) Some improvement was also noticed in the landings of *Sardinella fimbriata*, Polynemids, ribbonfish, eels, catfishes and pomfrets.

(c) As against these improvements, there was decline in several fisheries, so that the net increase in the total catch was to the extent of 22% of the 1956 catch only. The most significant fall has been in the landings of *Caranx*, Sciaenids, prawns, red mullets, *Anchoviella*, flyingfish and soles.

The bumper catch of oil-sardine was mainly due to the successful fishery of oil-sardine in Kerala, although there were some landings in Mysore and South and Central Bombay. Another interesting phenomenon was that oil-sardine was landed in North and Central Madras (Zones 6 and 7) and in North Andhra (Zone 3). Mackerel was landed in all States, but the heavy catches in Malabar and Mysore were mainly responsible for the great improvement in the total catch of this fish. Similarly the improvement in the total landings of *S. fimbriata* was mainly due to increased landings in Malabar, Mysore and to some extent in South Bombay. The improvement in the total catch of Polynemids and eels was due mainly to increased landings in Central Bombay (Zone 15). The rise in the catches of catfishes and pomfrets was essentially due to increased landings in Bombay and Saurashtra. Similarly, improved landings of *Trichiurus* in Kerala accounted for the rise in the total catch of this fish.

The significant fall in the landings of *Caranx* was due to decreased landings of the fish in Kerala. It may be mentioned here that there was exceptionally good catch of *Caranx kurra* in Kerala in 1956, when both the oil-sardine and mackerel fisheries failed in the area. Similarly, decline in the catches of *Anchoviella*, red mullets and soles had been due mainly to decreased landings of these fishes in Kerala. The fall in the prawn catch in 1957 was due mainly to reduced landings in Bombay and Andhra. Reduced landings of jewfishes in Bombay, Kerala and Andhra were responsible for the fall in the total catch of jewfishes in 1957.

Table II shows the overall composition of the total fish landings in India in 1957. For comparison, the corresponding figures of 1956 are also given.

TABLE II
Composition of fish landings

Name of fish	Quantity landed in metric tons	
	1957	1956
1. Elasmobranchs	23,080	21,856
2. Eels	6,397	3,293
3. Catfishes	27,378	23,307
4. <i>Chirocentrus</i>	5,816	6,922
5. (a) Oil-sardine	191,469	7,412
(b) Other sardines	45,703	36,444
(c) <i>Hilsa ilisha</i>	902	1,885
(d) Other <i>Hilsa</i>	1,245	
(e) <i>Anchoviella</i>	12,694	26,995
(f) <i>Thrissocles</i>	4,509	
(g) Other clupeoids	30,661	34,357
6. (a) Bombay-duck	119,500	128,880
(b) <i>Saurida</i> and <i>Saurus</i>	212	
7. <i>Belone</i> and <i>Hemirhamphus</i>	377	625
8. Flying-fish	984	2,512
9. Perches	6,759	8,250
10. Red Mulletts	3,055	10,578
11. Polynemids	14,846	8,998
12. Sciænids	29,972	57,437
13. Ribbonfish	38,427	24,481
14. (a) <i>Caranx</i>	10,758	56,619
(b) <i>Chorinemus</i>	3,238	
(c) <i>Trachinotus</i>	5	
(d) <i>Coryphæna</i> and <i>Elacate</i>	423	775
15. (a) <i>Leiognathus</i>	16,903	17,353
(b) <i>Gazza</i>	958	
16. <i>Lactarius</i>	8,101	10,168

TABLE II—Contd.

Name of fish	Quantity landed in metric tons	
	1957	1956
17. Pomfret	16,205	12,701
18. Mackerel	89,006	16,426
19. Seerfish	8,910	12,254
20. Tunnies	3,013	3,670
21. <i>Sphyrana</i>	522	3,358
22. Mulletts (<i>Mugil</i>)	1,048	255
23. <i>Bregmaceros</i>	1,138	1,308
24. Soles	3,687	9,122
25. (a) Penæid prawns	74,647	66,909
(b) Non-penæid prawns	61,374	92,372
(c) Other crustaceans	791	271
26. Miscellaneous	10,706	10,909
TOTAL	875,420	718,702

Catch per unit effort.—Table III shows the total effort in man-hours expended in each zone and also the catch in kgm. per man-hour. The corresponding figures for 1956 are also shown.

It will be seen that the total fishing effort had declined a little in 1957, even though there was increase in the total catch as well as in catch-per-unit-effort. The decline in effort mainly occurred in Andhra and to some extent in Madras. The exact reason for the decline in fishing effort in Andhra is not known, but there is no doubt that it brought about a fall in the total catch. The fact that decreased effort and higher return per unit-effort occurred together, suggests that the decline in effort in Andhra has nothing to do with decrease in availability of fishes but is probably related to unfavourable fishing conditions. In Madras, the effort, the catch and the index for catch-per-unit-effort, all show simultaneous fall. This may indicate lesser availability in the area during the year. In Kerala and Mysore, the total effort increased along with total catch and catch-per-unit-effort. This shows that the availability in these zones was greater than in 1957. When compared with figures of previous years, no substantial change is

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

	Effort in 1000/ man-hours		Catch in kgm./ man-hours	
	1956	1957	1956	1957
1. West Bengal and North Orissa .. .. .	..	4,283	..	1.05
2. South Orissa .. .. .	..	4,688	..	0.80
Sub-Total ..	5,489	8,971	2.89	0.92
3. North Andhra .. .. .	..	34,898	..	0.85
4. Central Andhra .. .. .	..	8,723	..	0.63
5. South Andhra .. .. .	..	3,489	..	1.52
Sub-Total ..	78,855	47,110	0.67	0.86
6. North Madras .. .. .	..	20,195	..	1.02
7. Central Madras .. .. .	..	13,033	..	1.07
8. South Madras .. .. .	..	13,212	..	1.07
Sub-Total ..	49,605	46,440	1.11	1.05
9. West Madras and South Kerala .. .. .	..	45,691	..	1.13
10. Central Kerala .. .. .	..	37,924	..	2.96
11. North Kerala (Malabar) .. .. .	..	37,651	..	4.70
Sub-Total ..	117,462	121,266	1.77	2.90
12. Mysore .. .. .	..	11,495	..	6.62
13. South Bombay I .. .. .	..	6,028	..	1.98
Sub-Total ..	14,201	17,523	1.82	5.02
14. South Bombay II .. .. .	..	18,625	..	2.74
15. Central Bombay .. .. .	..	46,631	..	5.54
16. North Bombay .. .. .	..	1,517	..	1.82
Sub-Total ..	62,685	66,773	5.17	4.67
17. South-East Saurashtra .. .. .	..	3,626	..	6.74
18. South-West Saurashtra .. .. .	..	4,552	..	1.20
19. North Saurashtra .. .. .	..	1,885	..	1.33
Sub-Total ..	6,589	10,063	4.51	3.22
TOTAL ..	334,887	318,147	2.14	2.74

indicated in Bombay. In Saurashtra, more effort was put in which resulted in increased landings; there was some decline in the catch-per-unit-effort which appears to be in accordance with the law of diminishing returns.

III. FISHERY BIOLOGY

(I) AT MANDAPAM

Mackerel.—Samples of mackerel were received from various centres and the morphometric study of the samples was continued. The data collected so far on this aspect were examined and further work was planned. Work was started on the scales of the mackerel as possible age-indicators. A total of 414 specimens (including 369 collected during the season from the Kanara Coast) was examined. The material from the Kanara Coast has revealed clear growth checks or rings in the scales of the largest specimens, in the form of breaks in the sculpturing parallel to and near the margins. In all the cases except three there was only one ring in the scale. In three specimens measuring 25.0, 25.4 and 25.7 cm. in total length two rings were found and such cases are under further examination. The ring was at the margin in a few specimens; in some the upper sculptured layer stopped short of the lower unsculptured layer, the edge of the former marking the ring; but in a large majority of individuals there was a well-marked upper (sculptured) layer also outside the ring, often with a change of pattern. Rings were completely absent in the scales of all individuals below 22.0 cm. in total length in all the three months, while all individuals above 23.0 cm. showed clear rings. In the size-group 22.1–23.0 cm., twelve specimens were examined; only two of these had clear rings in the scales. On the basis of the data available so far, it seems probable that the rings mentioned above are spawning marks.

Sardine.—The *choodai* fishery of Mandapam was a failure in 1957. The total catches amounted to about 748 tons,* whereas in 1954, one of the best seasons so far recorded, the total landings amounted to about 2,083 tons. In 1957, the fishery began in April, but owing to poor catches, some of the boats stopped operation midway through the season. There was a slight revival in August, but thereafter, the catches again declined. As noted during previous years, the bulk of the *choodai* catches was supported by the 0-year-class of *Sardinella albella* and *S. gibbosa*. Both species were in maturity stages II, III and IV in February 1958.

Hemirhamphus.—The fishery season of this fish during the present year was good and the total landings in the Mandapam area came to approximately

* Metric tons are used throughout the report.

285 tons for the two species, *H. georgii* and *H. marginatus*. Samples from commercial catches were obtained periodically and studied with a view to elucidating various aspects of the biology of the fish, such as systematics, type of feeding, growth checks as seen in otoliths, maturity stages, spawning, development, etc. Several egg-masses were collected; with one of them attempts were made to hatch the eggs in laboratory tanks and to rear the larvæ. The species was determined to be probably *H. marginatus*. Special attention is being paid to the study of the dynamics of the spawning population under the conditions of exploitation by man.

Light-fishing.—In addition to the standing dip-net on the Gulf of Mannar side, another one was constructed on the Palk Bay side and experimental fishing operations were continued at both stations using an electric lamp at the former and a 500 c.p. petromax lamp at the latter. Analysis of light-fishing catches in the Gulf of Mannar up to May 1957 was completed. This showed that out of 50 species of fish caught the species listed below in order of abundance were of economic important: *Plotosus arab*, *Ilisha indica*, *Atherina forskali*, *Hemirhamphus marginatus*, *Gazza minuta*, *Leio-gnathus brevirostris*, *Anchoviella tri*, *Sphyræna jello*, *Caranx sexfasciatus*. The "Kellong" operations continue to attract the attention of the local fishermen who evince great interest in this novel method of fish capture.

(2) AT KOZHIKODE

Oil-sardine.—The 1957–58 season was one of record catches in the oil-sardine fishery. At the Vellayil landing place, the total landings from July 1957 to March 1958 amounted to 7,814 tons. The catches in February and March 1958 amounted to about 737 tons and 1,048 tons respectively. The lack of a proper marketing system was amply demonstrated during this season. A good proportion of the catches was used as manure. As the catches were unmanageable, the price of sardine declined to a very low level, and so the fishermen themselves tried to restrict the catches. There is therefore reason to believe that the actual catch was less than the potential catch. The major length-groups represented in the oil-sardine catches at Vellayil in February and March 1958 were 130–34 mm. and 135–38 mm. respectively.

Work on the scales and otoliths of the oil-sardine as well as observations on its shoaling behaviour have been continued.

Mackerel.—The mackerel fishery of the present year showed a very marked improvement over the preceding year, the landings being 492 tons in 1956–57 and 3,655 tons in 1957–58. The landings by different types of

gear were as follows: *ayila kolli vala*—421 tons; *patten kolli vala*—2,813 tons; *mathi kolli vala*—297 tons; *nethal vala*—0.45 tons; *thattum vala*—14.83 tons; *ayila chala vala*—101.91 tons; *odam vala*—6.61 tons. The mackerel season commenced this year in August when two size-groups, 6.5–17.5 cm. and 16–17 cm. entered the fishery. The fishery improved considerably in the next month, September, when the highest figure of 2,728.79 tons was registered. The range of size was 13.5–21.5 cm. with the modal size of 18 cm. There was a set-back in the fishery in the two succeeding months of October and November, when the lowest landings were recorded, 80.46 tons in October and 74.99 tons in November. The fishery revived considerably in December, the increased output reaching the high figure of 395.47 tons. There was gradual decline towards the end of the season, the mackerel landings falling as low as 14.37 tons. The dominant size-group in November was 21.5 cm. and in December, January and February 20.5 cm. It is significant to note that mackerel landings formed only 4.83% of the total landings of fish (75,518.89 tons) by the various fishing units mentioned above.

Fishing intensity in the inshore waters of Kozhikode.—Work on this problem has been continued. The data collected were analysed from time to time and the catch-per-unit-of-effort (man-hour) was calculated in respect of the total catch and also in respect of each of the nine selected species, viz., *Pseudosciaena sina*, *Parastromateus niger*, *Thrissocles mystax*, *Caranx kalla*, *C. kurra*, *Leiognathus bindus*, *L. splendens*, *Lactarius lactarius* and *Parapenaopsis stylifera*. The fishing gear of Calicut are of diverse nature and hence the data had to be maintained separately for each type of gear. In the year 1957, a total of 95,64,935 kgm. of fish was landed at Calicut for an expenditure of 17,41,188 man-hours using five different types of nets. It is seen from the data that overall return per unit-effort in 1957 (5.49 kgm./m.h.) was more than two times that of 1956 (2.39 kgm./m.h.). Although the pooling of all the data to draw up an overall catch-per-unit-of-effort is not free from objection, because of the diversity of the catching capacity of the different nets, these figures definitely indicate that the trend of the catches was upward. With the exception of *paithu vala* all nets considered here registered better catches in 1957. In the case of *kolli vala* and *odam vala* this increase was very pronounced.

Prawn.—Prawn fishery was rather poor during the year under review. The condition was satisfactory in the months of July and September, but from October–December the fishery was a failure. In the months of January, February and March the condition improved slightly. *Paithu vala* was the chief gear used. Occasionally *thattum vala* was used at Calicut.

Castnets were operated on several days at Quilandy. *Nethal vala* and *ara kolli vala* were used rarely at Calicut. Whereas during the period from June–September *Metapenaeus dobsoni* formed 75% of the catches, *Parapenaeopsis stylifera* formed 60–70% of the catches from January–March. *Penaeus indicus*, *P. stylifera* and *M. affinis* occurred in fair numbers during the period from June–September. Large sized *P. indicus* and *M. affinis* appeared in good numbers from January–March. Total landings for all the months, dominant size-groups in males and females of various species for each month, and sex-ratio for all the months were computed. Mature males of *M. dobsoni* were observed in all the months. Ripe females were also noticed, mostly in December. Mature males and ripe and impregnated females of *P. stylifera* occurred throughout. Mature males and ripe females of *P. indicus* and *M. affinis* were noticed in the months of January, February and March. Impregnated females were also observed. Plankton samples were examined with a view to collecting prawn larvæ and piecing together consecutive stages in the life-history of some of the species. Attempts were also made to rear the larvæ in the laboratory.

(3) AT BOMBAY

Offshore fishing by mechanized vessels.—During the year 1957 the total quantity of fish landed by the mechanized fishing vessels of the Deep Sea Fishing Station and the New India Fisheries Limited, Bombay, was 33,64,330 kgm. The mechanized vessels of the Deep Sea Fishing Station landed 1,54,543, kgm., whereas the vessels of the New India Fisheries Limited, Bombay, landed 32,09,787 kgm. M. T. Ashok and Pratap have been operating at Cochin from February 1957 onwards. The vessels of the Deep Sea Fishing Station did not operate for the major part of the year as will be evident from the following table:

Name of vessel	Number of months of operation during the year	Total landings kgm.
M. T. Ashok and Pratap	.. 1 (January)	38,042
M. F. V. Champa	.. 7 (January to June, December)	32,490
M. F. V. Bumili	.. 7 Do.	31,647
M. F. V. Bangada	.. 4 (January to March, December)	25,712
M. L. Meera	.. 9 (January to June; October to December)	23,444
M. L. Meenalochani	.. 1 (December)	3,049
		1,54,384

The New India Fisheries Limited operated two sets of bull-trawlers, namely, Satpati Pilotan and Arnala & Paj. The operations yielded 32,09,790 kgm. of fish in 3,773 hauls. Thus the average catch per haul was 850.73 kgm. These vessels operated throughout the year.

The vessels of the Deep Sea Fishing Station operated both north and south of Bombay. The vessels of the New India Fisheries Limited, have operated mostly north of Bombay and more particularly around the Saurashtra Coast. The areas fished by the New India Fisheries vessels during the year were A, D, E, K, L, M, N, 3, 9, 10, 11, 12, 17, 18, 24, 25, 31, 38, 42 A and 43 A.

Analysis showed that the following categories constituted catch, in order of their abundance. *Muranesox talabonoides*; *Pseudo sciæna* spp. and *Otolithus* spp.; sharks; *Pristipoma* spp.; *Arius* spp.; *Polydactylus indicus*; *Sciæna diacanthus*; *Polydactylus heptadactylus*; *Lactarius lactarius*; miscellaneous; *Sciænooides* spp.; *Lutjanus* spp.; *Pellona* spp.; rays; *Synagris* spp.; pomfrets; *Engraulis* spp.; prawns and lobsters; *Chirocentrus dorab*; *Psettodes erumei*; skates; *Trichiurus* spp.; *Drepane punctata* and *Ephippus orbis*; *Caranx* spp.; other Polynemids; *Scomberomorus* spp.; *Harpodon nehereus*; squids and cuttle fish; *Saurida tumbil*; *Cynoglossus* spp.; *Neothynnus macropterus*.

Harpodon nehereus.—The study of the biology and fishery of *Harpodon nehereus* was taken up from January this year. The length frequency distribution showed two modes in all the three months, viz., at 105 and 145 mm. in January, 135 and 185 mm. in February, and 135 and 205 mm. in March 1958. The gonads were in III and IV stages of development. Otoliths and scales are being collected for age determination studies. From information gathered from fishermen, it would seem that the Bombay-duck fishery was a failure this year.

Polynemids.—*Polydactylus indicus* (Dara)—Samples for biological studies were collected from the New India Fisheries Trawlers, Government of India vessels M.F.V. Bangada and fish-landings at Satpati fishing village. The fishes landed at Satpati, which were already gutted, ranged in size from 82–102 cm. The New India Trawler landings, taken mostly from area M of Dwarka region, ranged from 23–96.5 cm. and were all immature. Those of the Government of India vessel Bangada varied from 23–54.6 cm. *P. heptadactylus* (Shende)—A detailed study of this species was carried out from landings at Sassoon Docks, Versova and the catches of the trawlers and mechanized vessels. Nearly 90% of specimens from the former two places were immature and mostly below 9 cm. in length. Specimens from

the Government of India trawlers ranging from 4–15 cm. in size were mostly immature, from 10–24 cm. in length were mostly mature. Biometric studies, initiated during the year are under progress.

Pristipoma hasta (Karkara).—The study of the biology of *P. hasta* was continued. The size ranged from 30–62 cm., the size at maturity being 35 cm. when stages III and IV had been reached. A specimen measuring 57.5 cm. in length contained transparent ova with oil globules. Most of the fish examined were found to have empty stomachs and a few contained crabs and fishes in semidigested state.

Pseudosciæna diacanthus (Ghol).—From the length frequency data collected during the last two months, it may be said that the size-range was from 20.5–107.0 cm. The stomachs of most of the specimens examined were empty and a few contained *Lactarius*, young sciænids, prawns, crabs and remains of *Sepia*. Of the specimens examined for maturity stages the females were immature (stages I and II).

Sciænides brunneus (Koth).—317 specimens were measured, out of which 209 measurements were made haulwise while on board M.F.V. Bangada and 30 on board M.F.V. Champa. The size ranged from 32.6–74.8 cm. 47 specimens were studied for their stomach contents. Both prawns and fishes occurred frequently as food items. Among prawns *Solenocera* sp. and *Metapenæus* sp. and *Acetes* sp. were met with. Among fishes *Coilia dussumieri* occurred more frequently than any other fish. All the specimens studied were juveniles.

Pomfrets.—Studies on pomfrets with special reference to the size frequency distribution aspect were made, the data being collected at the fish landing places at Versova and Sassoon Docks. Though the fishery was constituted of all three species, *Pampus argenteus*, *P. chinensis* and *Parastromateus niger*, *Pampus argenteus* (silver pomfret) was found to form the bulk of the landings. Large-scale occurrence of juvenile pomfrets commenced from September 1957 as was found in the previous year. All specimens of *Pampus argenteus* measuring less than 18–20 cm. were found to be immature. Those above 20–22 cm. were found to be in maturing condition. *P. chinensis* ranging from 6.4–17.7 cm. were found to be immature. *Parastromateus niger* above 24–25 cm. were found to be maturing. Examination of scales showed that three or more growth zones occur in the scales of only *Parastromateus niger* measuring above 18 cm. Gill-net operations of the vessels of the Deep Sea Fishing Station brought better catches of *P. niger* in surface waters. Operations of bottom gill-net brought only *P. argenteus* and *P. chinensis*.

Occurrence of post-larvæ in commercial catches.—Work was initiated in January 1958 with a view to studying the abundance of post-larvæ, (which form an important item of fishery in this area) and the effects of their exploitation on different fisheries. The following post-larvæ (in order of their abundance) appeared in the commercial catches during January–March 1958.

- | | |
|------------------------------------|--------------------------------------|
| 1. <i>Bregmaceros macclellandi</i> | 5. <i>Polydactylus heptadactylus</i> |
| 2. <i>Anchoviella commersonii</i> | 6. <i>Chirocentrus dorab</i> |
| 3. <i>Stolephorus malabaricus</i> | 7. <i>Dussumieria</i> sp. |
| 4. <i>Coilia dussumieri</i> | 8. <i>Sciæna</i> sp. |

Biology and fishery of prawns.—This study has now been extended to include the catches of the mechanized vessels also. The small mechanized boats of Versova landed prawns throughout the year from area 38 (7–18 fathoms) forming 30–40 per cent. of the total fish landings. They reached a peak of 60–70 per cent. during March–April. The catches consisted of prawns of poor quality such as *Solenocera indicus*, *Parapenæopsis stylifera*, *P. sculptilis*, *Leander tenuipes*, *L. stylifera* and at times *Hippolysmata ensirostris*. The bull-trawlers, however, landed appreciable quantities from January–October in the areas L, N, D, E, 11, 18, 25, 30, etc., at depths varying between 25–60 meters. Though the total quantity taken by these vessels was much less as compared to prawn landings of Versova, the species constituting trawler catches, i.e., *Metapenæus monoceros*, *M. affinis*, *Penæus carinatus* and *P. indicus*, were of greater commercial value because of their large size. The Government of India mechanized vessels landed good quantities of prawns during April–June, an average of 8–30 per cent. with a peak of 56 per cent. in April. The species consisted of *Metapenæus affinis*, *Parapenæopsis stylifera* and *Metapenæus brevicornis* which fetched good prices. The areas exploited were 43, 48 and 60 at depths of 9–15 fathoms with trawl-net. Detailed records are being maintained of the species composition of catches, sex ratio, state of maturity and other aspects.

(4) AT ERNAKULAM

Sardine.—The oil-sardine fishery was exceptionally good during the year under review and on several days the catches were very heavy. There was such a glut in the market that in some places it is reported that the fish has been used as manure. The 2nd and 3rd year age-groups in more or less advanced stages of maturity and of the 14–16 cm. and 18 cm. length-groups were caught in May, June and July. Juveniles of the 1st year group (8–10 cm.) with the mode at 10 cm. appeared in August. The mostly immature 2nd year group (11–15 cm.) contributed the bulk of the landings

from August–March. The 13 and 14 cm. groups are especially noteworthy having sustained the fishery continuously from December–March.

Mackerel.—The mackerel fishery, however, did not show anything unusual and the landings are reported to have been quite moderate throughout this part of the Kerala Coast. Mackerel caught by trawlers in May measured 21–24 cm. with mode at 23 cm. Juvenile mackerel appeared in July. The size-groups, 8–10 cm., 12–13 cm. and 16–18 cm. were the dominant ones during July, August and September. Mackerel fishery which was of some intensity from November–March has been sustained by the 18–20 cm. length-groups.

Marine prawn fishery.—The prawn fishery at Narakkal was a failure in the latter half of the year and hardly any catches were landed during several weeks at a stretch. Even in the first half, except in August, the catches were not good. In this half *M. dobsoni* contributed about 50 per cent. of the catch in April and May and over 99 per cent. in July–September. *P. stylifera* was present in good numbers in April and May, but was almost absent in the rest of the year. The dominant size-group of *M. dobsoni* was 96–100 mm.

At Chellanam there was no fishing from June–September. In April and October *M. dobsoni* was dominant and in the other months *P. stylifera* replaced it. The majority size-group of *M. dobsoni* was markedly smaller than that at Narakkal during most of the months. It varied between 66–70 mm. to 71–75 mm. The dominant size-group of *P. stylifera* was 61–66 mm. in May, but in October and the following months 81–85 mm. groups predominated. Both at Narakkal and at Chellanam *M. affinis* contributed little to the fishery.

At Alleppey *M. dobsoni* dominated the catches from April–September, when the fishery is most active. In the other months its percentage value was much less, falling as low as 5.5 in December. The majority group was 71–75 mm. in April, but in the following months higher length-groups gradually began to dominate and 96–100 mm. and 106–110 mm. groups were the dominant groups in September. With the close of the season in November the larger groups disappeared and the 71–75 mm. group came again into prominence. The proportion of *P. stylifera*, which was not more than 15 per cent. in April–June, began to increase from October, and in December came to about 90 per cent. The number gradually declined from January. *M. affinis* and *P. indicus* contributed only a small percentage of the catch.

Backwater prawn fishery.—As usual, fishing with stake-nets, Chinese-nets and cast-nets has continued with little interruption throughout the year. The collection of data relating to the catches of the two stake-nets at Azhikal and Thevara continued regularly and the estimated monthly catches are given below:

Month	Azhikal	Thevara
	kg.	kg.
April	.. 128·82	71·44
May	.. 149·46	94·71
June	.. 148·32	66·68
July	.. 84·82	49·89
August	.. 30·39	12·70
September	.. Nil	Nil
October	.. 54·75	27·35
November	.. 10·07	39·83
December	.. 21·32	Not known
January	.. 52·96	21·77
February	.. 36·42	28·35
March	.. 19·96	33·23

Compared with last year's catches those of this are markedly less, the reasons for which it is difficult to explain.

Biology of Penaeus indicus.—The attempt at estimating rate of growth and age composition of the backwater catches by the length frequency method was not quite successful. Although frequencies were determined for each sex every month and for the different years separately the modes continued to show the irregular shifts that were noticed before.

Experimental prawn fishing.—The experiment in paddy field prawn fishery in the field at Kulasekharamangalam near Vaikom was started in January and come to a close in the last week of April. The experiment has been statistically designed to determine the effect of the number (equivalent to width) of sluices and area of the field on annual catch. The data collected during February were analysed and it was found that in one set of four fields the catch was lower in those that are provided with two sluices. In the

replicate, however, the catch is more. It is only after the results of all months are analysed that this variation could be explained.

Tilapia cum prawn culture.—This experiment is being carried out in a small enclosure in the uncultivated portion of the field at Kulasekharangalam. The object of the experiment is limited to ascertaining whether *Tilapia* would feed on prawn fry and the extent of tolerance of the fish to salinity changes. The evidence collected so far is negative in regard to the first. The salinity on 2-4-1958 was 24.31‰ and the fish did not seem to be affected in any way by it.

Offshore prawn fishery.—The trawlers of the Government of India 'Ashok' and 'Pratap' and 'Durga', which are stationed at Cochin, have been carrying out trawling operations in the sea, mostly off the Kerala Coast. The prawn catches of the bull-trawlers have been quite poor and during several voyages hardly any prawns were caught. Fairly good quantities of prawns have been caught by 'Durga'. The catch per hour was varied from 10.34 kg. in February 1958 to about 65 kg. in June 1957. The average catch per hour for all the months together is about 39 kg. making 36.4 per cent. of the total catch. The area of operations extended roughly from Cranganore in the north to Shertallai in the south in water ranging in depth from 5-22 fathoms.

The Norwegian medium boats M_1 to M_4 have also been going out regularly for fishing. Data on catches of these boats from May 1957-February 1958 have been analysed. The analysis shows that May and June recorded the best catches during the period May-February. December and January come next. Since the area covered by the Norwegian boats is practically identical with that of 'Durga' it would seem that the best months for trawling for prawns in waters up to about 20 fathoms are May and June and December and January. In regard to the composition of these catches it has to be stated that in general it agrees rather closely with that of the boat-seine catches of the local fishermen. One small difference, however, has been noted in regard to the percentage value of *M. affinis* which, on several days has ranked second, the first being *M. dobsoni*. Size-frequency studies have also tended to show general similarity to the boat-seine catches. On a few days large-sized specimens of *M. monoceros* and *P. indicus* have been captured in 18-26 fathoms; but their number was not large. Their capture points to the probability of such large prawns occurring in deeper waters.

Offshore fishing by mechanized vessels.—The Government of India cutters 'Ashok' and 'Pratap' commenced fishing with Cochin as base towards the end of February 1957 and the trawler 'Durga' by the middle of May.

The catch data of the Indo-Norwegian schooners also have been studied and analysed.

*The cutters, 'Ashok' and 'Pratap'.—*From the middle of March-June 1957, the cutters did daily trips based from Cochin and carried out bull-trawling in the areas 106, 106 A and 108, a few miles off the coast of Cochin. During this period they landed an estimated total catch of 86,498 kg. over a total trawling time of 180.9 hours, the catch per trawling hour varying from 449.78–595.52 kg. During this period also “small fish” constituted the largest part of the landings (52.82–56.13 per cent.) while other fishes which were caught in significant quantities were sharks (12.05–17.08 per cent.) and rays (5.73–24.14 per cent.). In June, the total landings dwindled to 3,312 kg. as the trawler could not go for fishing for most of the days due to adverse weather. The trawlers resumed fishing operations in November 1957 after the monsoon break. In this month they made four voyages and carried out bull-trawling, mainly in the areas 98–102, a few miles off the coast between Ponnani and Cannanore. They made thirty-two hauls in all at a depth of 18–27 fathoms over a total trawling time of 40.83 hours, the estimated total catch being 27,436 kg. and the catch per trawling hour being 671.89 kg. As observed in the previous season, in this month also ‘small fish’ constituted the largest catch (40.83 per cent.). Fair quantities of rays (27.43 per cent.), catfish, *i.e.*, *Arius* spp. (22.75 per cent.) and sharks (8.74 per cent.) were also obtained. In December, they made five voyages of which the first four were to areas 111 and 112 between Alleppey and Quilon and the last was to area 108 near Cochin. The total of landings was 45,998 kg. over a trawling time of 37.86 hours yielding a catch rate of 1,214.81 kg. per fishing hour which is the highest so far during the current season. Catch rates of individual voyages varied from 994.07–1,429 kg. per fishing hour. ‘Small fish’ formed the largest catch (44.18 per cent.) with rays (23.17 per cent.) and sharks (19.66 per cent.) coming next in importance. During January 1958, they made five voyages and operated chiefly in the regions 108–112, between Cochin and Quilon, except during the 5th voyage when they went to the Wadge Bank areas off Cape Comorin (Areas 116–118). The total landings came to 61,128 kg. which was higher than that of the previous two months. The trawl was operated for a period of 52.21 hours, the catch per fishing hour being 1,170.67 kg. ‘Small fish’ constituted the biggest catch (46.06 per cent.) with *Pristipoma* (17.57 per cent.), rays (12.59 per cent.), sharks (11.53 per cent.), and moon-fish (3.83 per cent.) forming the next best catches. A significant feature observed was the occurrence of large numbers of *Karkara* (chiefly *Pristipoma guoraca*) in the area 111 and 112 off Quilon as much as 537.56 kg. being

obtained per fishing hour in one voyage. The cutters made three hauls in the Wadge Bank area and the total catch was 802 kg. yielding a catch rate of 295.36 kg. per trawling hour. *Serranus* spp. (47.59 per cent.) and grey mullets (28.15 per cent.) formed the major catches, apart from a large number of fishes which frequent coral reefs such as *Chaetodon*, *Lutjanus*, *Synagris*, *Lethrinus*, etc., some of which were brightly coloured.

The trawler, 'Durga'.—In May 1957, it operated the trawl-net in the areas 106 A-108, a few miles off the coast of Cochin and landed a total catch of 12,189 kg., the largest portion of which was constituted by miscellaneous fish (44.43 per cent.) with prawns (37.82 per cent.), sharks and rays (11.80 per cent.) and Sciaenids (4.86 per cent.) forming the next important groups. It resumed fishing operations, after the monsoon break, in November 1957 and during November-February 1958 it operated trawl-net in the same region as before, a few miles off Cochin. A total weight of 49,806 kg. was landed during the four-month period over a trawling time of 480.10 hours, the catch per trawling hour varying from 80.32-119.29 kg. Miscellaneous fish formed the greatest part of the landings (48.81-65.67 per cent.), except in December when prawns constituted the largest catch (54.69 per cent.) While prawns continued to form a good percentage of the total catch in January (46.28 per cent.), their occurrence was less during November and February being 13.32 per cent. and 15.17 per cent. respectively. *Trichiurus*, sharks and rays and pomfrets were some of the fishes which were caught in some quantities.

The schooner 'Kalava'.—Among the three Indo-Norwegian schooners the 'Cochin' (renamed as 'Kalava') obtained the maximum catch of 39,880 kg. over a fishing time of 432.91 hours during the period, January-October 1957, 'small fish' (44.34 per cent.), *Serranus* spp. (44.12 per cent.) and shrimps (8.66 per cent.) forming the major catches. Large numbers of *Serranus* spp. were obtained in hooks and lines in the month of March 1957 while on a cruise to Wadge Bank. The catch per fishing hour varied from 61-68-312.98 kg.

(5) AT KARWAR

Sardine.—The approximate total of landings of oil-sardine at Karwar for the year under report has been estimated as 37,782 kg. The maximum catch recorded was for the month of April. Oil-sardine continued to occur in the catches up to July, and thereafter completely disappeared. A reappearance was noticed in the month of September, but the fishery dwindled again. In October, *yendi* and cast-nets were generally employed for the capture of the shoals. Good landings were reported from Kumta and

Bingae for the months of February and March where the fishermen plied *rampan* nets, for the capture. The minimum and maximum sizes recorded during the period under report were 9.1 cm. and 14.6 cm. respectively. From length frequency studies, it was seen that the 12.5 cm. was the dominant size-group for the month April and it remained constant during the succeeding months up to July. For September and October, the 13.5 cm. size-group dominated the catches, thus showing a one-centimetre increase in the growth of the oil-sardine. Other clupeoids that appeared in the fishery were *Thrissocles* sp., *Opisthopterus* sp., *Sardinella fimbriata* and *Dussumieria* sp.

Mackerel.—A revival in the mackerel fishery was noticed all along the Kanara Coast during this season, which commenced at most of the centres by about the second week of October 1957. The total landings of mackerel during the season at Karwar has been estimated as 2,250.25 tons as against 385.12 tons for the 1956-57 season. Mackerel alone contributed 94.8% of the total catch at Karwar. The landings of mackerel at seven observation centres in the Kanara District from Majali to Murdeshwar works out to 5,847.98 tons. The active fishery came to a close at Karwar by early February. During the post-mackerel season (April-May) and rainy season (June-September) only stray catches of mackerel were noted, the landings during the said period being 28 kg. and 9 kg. respectively. The type of gear employed was *yendi*. The largest specimens examined in July-August belonged to IV-V-VI maturity stages. At Bingae and Chendia, however, fairly good numbers of mackerel in this stage of maturity were landed by *pattabale* operations during the said period. After a lapse of five years, the fishery showed distinct recovery and November 1957 was the best month of the fishery. For November-December the rate of mortality for impounded mackerel went up to as high as 2 per cent. when on certain days an unusually large stock of mackerel was impounded. The number of *rampan* hauls during the season was comparatively higher. A record catch of 21,00,000 mackerel in one net was noted on 1-12-1957. The fishery was composed of fish in stage I of maturity scale. Spent and recovering ones continued to occur in small percentages up to March. The maximum and minimum sizes recorded for the season were 12.2 cm. and 25.9 cm. The dominant size-group of 21.5 cm. persisted throughout the season, in contrast to three dominant modes of 14-15 cm., 18 cm. and 23 cm. for 1956-57 season. No marked differences were noticed in the size-groups prevailing at various observation centres. Marked fluctuation were noticed in the prices of mackerel at all observation centres during the season. Mackerel was sold at Rs. 52 per 1,000 to the launch owners at the beginning, but the

price came down to Rs. 8 per 1,000 towards the peak period of the fishery. It was sold to the fish curers at Rs. 4 per 1,000 during November–December. Towards the end of the season, mackerel was quoted at Rs. 30 per 1,000.

(6) AT MANGALORE

Sardine.—The oil-sardine fishery revived during this year and large catches were obtained all along this coast. The fishery extended up to Gangoli and beyond in this zone during November although the longer season of heavy catches was limited to centres south of Moolki. The oil-sardine fishery commenced (at this coast) in early September and was composed of immature fishes between gonadial stages I and II. The dominant size-group at the commencement period of the fishery was 90–94 mm. (total length). Slightly larger sizes (105–109 mm.) entered the fishery during October when the fishery was most active and still larger sizes with a range of 115–119 mm. dominated the catches in the closing part of the active season, in January–February. The fishery was poor and erratic from the latter half of February. The catches of the entire season were limited to fishes with maturity conditions never reaching beyond stage III, although more mature specimens were studied from the catches brought to the Mangalore markets from southern centres. The feeding was moderate and on certain occasions even poor. The food was composed almost exclusively of diatoms and dinophysids, and to that extent selectivity was noticed. The scale and otolith studies revealed growth checks which were more or less comparable to the growth modes.

The other prominent clupeoid fisheries of this zone are of *Sardinella fimbriata* and *Hilsa kanagurta* locally known as “Erebai” and “Swadi” respectively. *Sardinella fimbriata* occurred in large numbers along with *Sardinella longiceps* late in August and again in September. The dominant size-group at the commencing period was 65–69 mm. (standard length) with indeterminate gonads. These were found to have fed actively on phytoplanktonic elements during this season. A progressive increase in size was noticed in the catches obtained subsequently and the dominant size range during March was 100–104 mm. Smaller crustaceans figured prominently in their stomach contents. *Hilsa kanagurta* contributed to an active fishery during September–October and also later in the year, forming large components in the catches during the periods of lull in the sardine and mackerel fisheries. Mature specimens with a size range of 145–149 mm. (standard length) occurred in the *pattabala* catches during the closing period of the year under review.

Mackerel.—The mackerel fishery during this year was exceptionally good and large catches were made from October–January and in moderate quantities thereafter. The active fishery commenced early in October with 184–195 mm. (total length) as the dominant size-group and with gonads in the stage I of maturity. The fishery continued to be very active and the price of mackerel fell to very low levels during this period and up to the end of December. During January and February the catches were moderate and there was a marked fall noticed in the catches towards the close of the year under review. The dominant size-range was 215–220 mm. (total length) at the close of the year. From January–March gradual development of the gonads was noticed and stage III in maturity was reached in March. The studies on food and feeding relationships of the mackerel have revealed active feeding during the commercial season from October–December and moderate feeding thereafter. The gut elements were predominantly zooplankters dominated by copepods. Side by side with the fishery of immature mackerels, a fishery of large sized mackerels was also noticed during January–March, in the Netravati estuary. The fishery was composed of fishes above 230 mm. in size and showing partially spent, spent and recovering stages of gonadial conditions which are quite unusual for this coast during this season. The maximum size obtained from the estuary was 272 mm. of total length. The large incidence of unequal caudal fin lobes in the estuarine samples was also too pronounced to be ignored. The scale markings were studied and compared with the materials studied earlier from the open coast centres with special reference to size and gonadial conditions. The presence of an active and continuous fishery both in Netravati and Chandragiri estuaries within a salinity range of 6.79–23.50‰ indicated the capacity of the mackerel shoals to withstand low salinities.

(7) AT NEENDAKARA (NEAR QUILON)

Inshore fishery.—A new unit was opened in Neendakara to study the inshore fishery conditions of the area and to gain some idea of the composition of offshore fish stocks by examination of the catches of the mechanized boats operated by the Indo-Norwegian Project. This became possible through the co-operation of the Project authorities. Heavy silting of the Neendakara harbour and consequent high breakers prevented the operation of the smaller boats in the first quarter. There was moderately good fishing in April 1957 in the bay of Quilon and at Sakthikulangara, dug-out canoes operating the sardine gill-nets. This was on the wane in May and June. *Sardinella* sp. formed the bulk of the catches. Mackerel gill-nets were operated off and on from Quilon beach but the catches were poor in

April-June 1957. *Thettupadi* (a kind of boat-seine) and shore-seines were operated intermittently catching miscellaneous fishes. At Sakthikulangara, stake-net fishing continued uninterruptedly in April-June, prawns forming over 50 per cent. of the catches. These observations suffered a break in the second quarter of 1957-58 but they have been resumed in March 1958.

Offshore fishing by mechanized vessels of the Indo-Norwegian Projects.—The only offshore fishing during the first quarter was a couple of purse-seine operations using 25 h.p. "steel dory-boats". A good catch of young tunnies was made in one of them. Line fishing and trawling were conducted off Quilon by some of the schooners of the Indo-Norwegian Project operating from Cochin. The data of fish caught by the schooner "Cochin" on a four-day cruise, 23-4-1957 to 26-4-1957, near Alleppey were collected and analysed for total weight caught (2,183 kg.), average catch per haul (145.54 kg.), catch per trawling hour (85.34 kg.), etc. The fifteen hauls brought in about 47 species of which *Leiognathus* spp. were dominant. This work, too, though interrupted, is being resumed from March 1958.

(8) AT VIZHINGAM

Mackerel.—The total landings of adult mackerel during the first quarter (1957) were estimated at 4,582 kg. as against 354 kg. landed during the same period in 1956. Sizes ranged from 18-31 cm. with the 23-24 cm. group dominating. It is noteworthy that 763 kg. of juvenile mackerel of sizes 10-17 cm. (13 cm. group dominating) were caught during this period. On 29th June 1957 there was a fishery exclusively for young mackerel of 3-6 cm. size; 170 boats operated in 15-18 fathom area landing approximately 1,041 kg. of young mackerel. Dominant size-groups of the first quarter were 4-5 cm., 13-15 cm. and 23-24 cm. Females predominated. Females with the ovary in the "plum-pudding" stage were collected on 27th and 28th of May. Male specimens oozing milt under pressure were also recorded in this quarter. The search for eggs and post-larvæ was continued. Total landings in the second quarter were 9,016 kg. There was exclusive fishery for mackerel on certain days although in general mackerel were caught along with sardines, whitebait, etc. A total of 4,478 specimens were measured this quarter for morphometric studies. The dominant size-groups were 5-13 cm. in July, 9-14 cm. in August and 16-19 cm. in September. Mature specimens were not available in July-September. Although the studies at Vizhingam were interrupted they were resumed in February 1958.

(9) AT LACCADIVES

Fishery investigations.—A reconnaissance visit to Minicoy and other important islands under the Laccadive Administration was made and pre-

liminary information on the fisheries in these islands was collected. Special attention was paid to the various aspects of the tuna fishery of the Minicoy Island. Live-bait fishes occurring in the area are being studied to see to what extent tuna fishing could be extended to other islands in the Laccadive archipelago.

(10) AT KANDLA (KUTCH)

Fishery biology studies.—Work was started at this new centre from August 1957. Data are being recorded on the several species of fish occurring in the local catches and special attention is being paid to *Mugil* species, *Polynemus* species and prawns. Length frequency measurements, gonad development stages, scale and otolith measurements, etc., are being recorded.

(11) AT PORTO NOVO

Mackerel.—Work was started at this new centre from July 1957. Special attention is being paid to the mackerel, *Rastrelliger canagurta*. At periods when mackerel material is scarce attention is diverted to studying the fishery biology of *Hilsa toli*, *Leiognathus*, *Dussumieria*, *Sciama*, *Synagris*, *Lactarius* and *Sardinella*. Stray specimens of mackerel were recorded at Porto Novo in August (11 specimens), September (1 specimen) and January (1 specimen). The mackerel season appears to be short and to begin in February. There are indications that the season would reach its peak in April. During this year length frequency measurements have been taken of 241 specimens. Sex composition, maturity stages, meristic characters and gut contents are also being studied and recorded.

(12) AT MADRAS

Fishing intensity in the inshore waters of Madras.—The total weight of fish for the year under review, based on an examination of 1,458 samples of *thuri valai* (boat-seine), *thundi* (hook & line), *periya vala* (shore-seine), *mada valai* (bag-net I), *thara valai* (gill-net) and *yada vala* (bag-net II) catches at the observation centres of San Thome and Harbour, was estimated at 4,22,367.54 kg. (422.37 tons) of fish. The yields for the first, second, third and fourth quarters were 65.66, 141.74, 105.38 and 109.98 tons of fish respectively. As in last year, landings at San Thome were better than at Madras Harbour and the second quarter showed higher yield than the rest of the year. The *thuri-vala* continued to be the most important fishing gear during 1957–58 also, hooks & lines being the second best efficient tackle.

The *yada valai* contributed least to the fishery, and the *irakka valai* (gill-net II), none. The contributions by the *mada valai*, the *periya valai*

and the *thara valai* were, negligible, the contributions by each type of gear being 233.09 (*thuri vala*), 122.05 (*thundi*), 35.03 (*mada valai*), 26.18 (shore-seine), 4.59 (*thara valai*) and 1.42 (*yada valai*) tons of fish respectively. All the units were in operation at San Thome, but only *thuri valai*, *periya valai* and *yada valai* were operated at Madras Harbour, where the fish catches were also smaller. Parallel to the fall in the total estimated production of fish, the catch-per-unit-of-effort for the year under review, also fell to 0.62 kg. per man-hour (it was 1.00 kg. in 1956-57). The returns were best in the fourth quarter (0.73 kg. per man-hour) being 0.43, 0.70, 0.61 kg. per man-hour in the first, second and third quarters respectively. It is of interest to note that though the production of fish was less in the Madras Harbour zone than at San Thome, the return per man-hour was greater at the Madras Harbour than that at San Thome, *i.e.*, 0.68 and 0.59 kg. respectively. The *thuri valai* and the hooks and lines continued to be the chief units operated throughout the year, their respective returns being 0.72 and 0.51 kg. per man-hour. However, as with the total production of fish during the different months of the year, the catch-per-unit-of-effort reached its peak twice, once in June and a second time in October. The fish landed included fifty-six species. Penæids, *T. haumela*, *L. insidiator*, *Carcharias* sp., *D. russelli*, *A. commersonii*, *S. commersonii*, *E. setirostris*, Sciænid, *Pellona* sp. and *U. sulphureus* were landed in measurable quantities and formed 56 per cent. of the total catch. The rest of the species contributed on an average 1 per cent. each. Penæid prawns took first place in this list. *T. haumela* (which was the foremost contributor last year) was the next in the list this year. Both *L. insidiator* and *Carcharias* sp. made comparatively better contributions during the year under report.

(13) AT WALTAIR

Scomberomorus guttatus.—Studies on the biology and fishery of this species was started in May 1957. The seer-fish fishery starts in the month of June and extends till October. Three main types of food were observed in the stomachs of *S. guttatus*, namely, teleosts, crustaceans and molluscs. The fish items included mainly *Trichiurus* sp., *Anchoviella* sp., Carangids and *Sardinella*. Of the crustaceans *Squilla* was the commonest food item. Larval and young prawns were also noticed in the stomach contents. A few cephalopods and gastropod larvæ were observed occasionally. Mature specimens were present in all the months (maximum percentage being in June and February) but the immature specimens were numerically predominant in all the samples observed. No fully mature specimen was noticed. Males were totally absent in the samples observed from June-October.

Length frequency measurements were recorded and their analysis shows that 40-45 cm. size-group was the dominating one from July-October and 45-50 cm. was the dominating size-group from October-December. From January-March it was found that 35-45 cm. size was dominating again. Fish falling under 12 cm. size were observed in February and March. In February there was equal representation of 4-8 cm. and 8-12 cm. size-groups whereas in March, 8-12 cm. group claimed a higher percentage composition.

Sardine.—Shore-seines and gill-nets were the major fishing units employed in the sardine fishery. About 87.50 tons of sardine were landed during the 12 months from April 1957 to March 1958, contributing 7.56 per cent. to the total fishery at Lawsons Bay. 70.53 per cent. of the total catch of sardines was landed by shore-seines, 29.46 per cent. by gill-nets, and 0.01 per cent. by boat-seines. October-December was the peak period of sardine fishery during which period 80.55 per cent. (70.48 tons) of the total sardine catch of the year was landed. The highest catch (about 56.90 tons) was made during November, contributed mostly by shore-seines. *Sardinella fimbriata* and *S. gibbosa* were the species comprised in the fishery at Lawsons Bay, the former species being dominant in the catches. During the peak period the catches were composed mainly of juveniles of *Sardinella fimbriata* ranging in size from 4-11 cm. There was a rapid fall in landings during January, February and March when mixed catches of both the species occurred. Length frequency analysis of *S. fimbriata* showed that 8 cm. was the dominant size-group during the period from October-January and 10.0 and 12.0 cm. were the major size-groups in February and March. Of *Sardinella gibbosa* 12.0-13.5 cm. were the dominant size-groups that occurred in the catches. Food of *Sardinella* spp. was found to be composed chiefly of copepods, larval crustaceans (mainly decapods), Mysids, *Lucifer*, juvenile prawns, cladocerans, polychæte larvæ, molluscan larvæ and juvenile teleost fish. Diatoms also frequently occurred in the stomach contents of the sardines of which *Coscinodiscus* is worth mentioning. Specimens of *S. fimbriata* collected during October-January period were all juveniles and in February and March stage I fish were recorded. Specimens of *S. gibbosa* collected in January were immature and in stage I. In February both males and females were in stages I-IV. In March the males were in stages I-V while all the females collected were uniformly in stage IV.

(14) AT CALCUTTA

Offshore fishing by mechanized vessels.—Work was continued in the present year in assessing the offshore fishing resources of the Bay of Bengal by examining the trawl catches of the four fishing boats of the Government

of West Bengal, Kalyani I, III, IV and V. Besides the examination of catches, much help was derived from data of fishing operations contained in the log reports submitted by the masters of the vessels which they made available for our use also. Composition of catches, weight of fish obtained in separate hauls, categories of fish obtained, regions of great productivity and reasons of greater yield could all be estimated in this way. There was no fishing in the months of April, May and July owing to rough weather and very little in June and August owing to engine trouble causing abandonment of operations. The total quantity landed this year was 3,81,464 kg. (that is, nearly double that of 1956-57) distributed under three classes as follows:

		kg.
A CLASS ..	Prawns	6,460
	Pomfrets	1,514
	Bhekii	471
	Tuna	1,116
B CLASS ..	Sciænids	2,06,689
	<i>Kurtus indicus</i>	97,541
	Silver-bellies	19,853
	Clupeids	13,387
	Perches	3,112
	Bombay-duck	1,745
	Indian salmon	1,159
	Mulletts	384
	Horse mackerel	378
	Catfishes	132
	Miscellaneous	20,388
C CLASS ..	Elasmobranchs	4,673
	Eels	643
	Miscellaneous	1,819
		3,81,464

Sciænids continued to be the most important category of fish. The glass fish (*Kurtus indicus*) though seasonal in occurrence was taken in large quantities during November-February and in lesser quantity in March. Monthly totals for each category of fish, when tabulated, revealed that *Bhola* (Sciænids) were never completely absent from the catches, that silverbellies were available throughout the year, that January was the peak month for glass fish, that clupeids including species of *Pellona*, *Ilisha*, *Setipinna*, etc.,

were present in quantity during December and January and that in general the winter months are the most productive followed by decline through April-June and complete cessation of fishing operations in July. Twenty-three fishing voyages were performed by the four vessels of which the highest average weight of fish per voyage (20,903 kg.) was obtained by Kalyani I and the lowest (7,750 kg.) by Kalyani IV. It is interesting to record that Kalyani V which accompanied the Japanese fishing vessel, *Sanketsu Maru* (of the goodwill mission), conducted tuna fishing in the deeper areas of the Bay and reported tuna as high as 18° N. latitude where the depth was approximately 1,800 fathoms. Previously tuna were reported to be common between the equator and 6° N. latitude only and to be rarer in higher latitudes.

The trawlers fished mostly in areas of 6-8 fathoms depth opposite Black Pagoda, Devi River, Prachi River and the Mahanadi, the yield in other areas being of a lower order. The vicinity of Devi River-mouth (34,690 kg.) and the area off Black Pagoda (31,423 kg.) gave high yields and the richest area was between Devi River-mouth and the Mahanadi (44,594 kg.).

IV. MARINE BIOLOGY

(1) AT MANDAPAM

Plankton studies.—The scope of planktological studies has been increased by increasing the number of observation centres. In addition to the samples of plankton obtained from the Gulf of Mannar and Palk Bay off Mandapam, regular samples were obtained from Adirampatnam, Tondi, Kilakarai and Tuticorin.

An important line of work, the estimation of organic production, was started. The data obtained so far are interesting and informative. A few preliminary experiments were also conducted on grazing.

The following interesting features were noticed in the inshore plankton of this area: *Noctiluca* did not swarm during the summer months but instead they appeared in August, second week of September and again in February 1958. Sudden blooms of *Rhizosolenia styliformis* in the Gulf of Mannar in October of *Thalassiothrix frauenfeldii* and *Thalassionema nitzschioides* in November in the Gulf of Mannar and Palk Bay, and of *T. frauenfeldii* and *Bacteriastrum hyalinum* in the Gulf of Mannar in January, were recorded. Colonial diatoms like *Navicula (Schizonema)* sp., *Cymbella (Encyonema)* sp., and *Frustulia (Navicula)* sp., were recorded in this area for the first time. There was a conspicuous absence this year of large numbers of *Evadne tergestina*, which generally occur during the colder months, but *Penilia*

avirostris and *E. tergestina* appeared in fair numbers during February–March 1958.

Besides the above, studies are also being carried on, on the populations of copepods in the Gulf of Mannar and Palk Bay, on the biology of *Acartia erythræa*, on the chætognatha of this locality on the fish eggs and larvæ.

(2) AT KOZHIKODE

Plankton studies.—Work on several aspects of phytoplankton in particular and plankton in general was in progress during the year. As in the previous years phytoplankton constituted the bulk of the plankton during the south-west monsoon period and zooplankton during the north-east monsoon months. There was no striking secondary bloom of phytoplankton during the year. The quantity of phytoplankton during the period in November–March has been of a very low order resembling the corresponding period in 1953–54; this is perhaps attributable to the grazing effect on it particularly by the oil-sardine, whose fishery this season (as in 1953–54 season) has been an outstanding success with record landings. This had already been foreseen from studies on the fluctuations of *Fragilaria* and mentioned in earlier reports.

Hydrological studies.—The average surface temperature, pH and phosphate content of the inshore and offshore waters remained more or less same throughout the period. Average surface salinity of the inshore waters slightly exceeded those of offshore waters in April 1957 and from January–March 1958; it was low during the rest of the period. In the case of bottom salinity, the inshore values were lower from September–November 1957 and higher during the rest of the period than the offshore values. In general, silicate content was lower in offshore waters than in inshore waters. Nitrite content of the inshore surface waters was generally higher than that of offshore surface waters and in the case of bottom nitrites it was *vice versa*. Oxygen values of the inshore surface waters were generally higher than those of offshore surface waters and in the case of bottom samples oxygen values were lower in inshore waters.

(3) AT KARWAR

Plankton studies.—The diatom population of this year was not so rich quantitatively as in previous years. Diatoms were found to bloom, only once during the period of observation, in July, at Kumta. *Fragilaria* was not noticed to bloom though it appeared to be a dominant constituent, on several occasions, during July–September. Dinoflagellates were common generally during September–November. *Noctiluca* swarmed by the middle of August at Chendia and Ankola. Their occurrence during the monsoon

months appears to be a common feature on this coast. Cladocerans and copepods were most common in September–October. The abundance of these species and of dinoflagellates in October coincides with the time of commencement of the mackerel fishery; their subsequent decline may be attributed to the intense feeding activity of the mackerel. Other features of interest are (1) the continued occurrence of fish eggs and larvæ in considerable numbers during September–January, and (2) the observation that at Karwar and Chendia *Sagitta enflata* was more common whereas further south *S. bedoti* was more common.

Hydrological studies.—As in previous years temperature was generally low during July–September coinciding with the south-west monsoon, with a secondary fall during December–January. Salinity and pH also were very low during July–August at Karwar. Dissolved oxygen content was high during July–August and January–February in general at all places except Chendia where it remained low in the former period as in previous years. Percentage saturation was generally high during July–August and January–February. Supersaturation was noticed occasionally during November–March at all places. Phosphates were high during July–October, nitrites had their peak between May and August with a secondary peak between December and March, and silicates were high during June–September.

(4) AT BOMBAY

Hydrological studies.—During the present year the routine estimations for salinity, dissolved oxygen and phosphorus compounds of the surface waters (both inshore and offshore) were continued, besides which, investigations were also planned on the determination of pigments, chlorophylls, and carotenoids in phytoplankton, on the amount of phosphorus in particulate matter in the sea, and on the distribution of iron (Fe) in the sea. The standardization of techniques for these three determinations has been undertaken as a preliminary step.

The pigment estimations have been done using Beckmann DU Model spectrophotometer. As the method is yet to be perfected these values are to be taken as approximate. The iron content in filtered samples of surface sea-water estimated by the Dipyrindyl method ranged between 40 and 110 mg. Fe per cubic meter.

V. OCEANOGRAPHY

AT COCHIN

Studies on physical oceanography.—Observations have been taken at various depths at 220 stations situated from Cape Comorin to Mangalore

at distances of 50–60 miles from the coast and also in the Laccadive Sea. Valuable marine biological and geological observations have been made besides those in physical oceanography. Using data on 204 stations, vertical and horizontal graphical sections showing values of temperature and salinity have been constructed. From the T-S diagrams constructed so far, the following features could be deduced:

(i) Indian equatorial water is found between 200–2,000 metres. (ii) The mixing of the Red Sea water with the Arabian Sea water is more or less similar to the mixing of the Mediterranean water with the Atlantic Ocean water. (iii) Shallowest level of mixing differs from year to year; anyway mixing takes place below 400 metres depth below surface. (iv) Indian central water could be traced below a depth of 800 metres. (v) The sub-antarctic drift may be responsible for the formation of the bottom water of the Arabian Sea but the source regions of the surface water masses is not yet clear. The very low salinity found in the Laccadive Sea, especially during the summer months is also very interesting and these may be expected to be elucidated when the dynamics of ocean currents is worked out.

VI. PHYSIOLOGY AND FISH-FARMING

The results of the experiments on *Plotosus arab* indicated that some additional experiments were necessary. Accordingly experiments on the density changes in various salinities, the range of tolerance of salinity and standard metabolism at the two acclimation levels of 12.5‰ and 30.4‰ were also performed. In brief the results are as follows: (i) There is a distinct size-effect as reflected in the fluctuations of the metabolic rates of a 5 gm. and a 45 gm. fish when tested in different salinities and after acclimation to salinities of 12.5‰, 30.4‰ and 40‰ (ave.) and temperature of 29° C. (ave.). (ii) The lethal oxygen level (the ability to survive in low concentration of O₂) in the medium for fish from the sea is 0.7 ml./l. for the 5 gm. and 0.38 ml./l. for the 45 gm. fish. This level is lowered (the ability to survive increased) when they are tested in a dilute medium (12.5‰) and the values then are 0.20 ml./l. and 2.29 ml./l. for the respective sizes. (iii) The practical value of this finding is in the transport of live seafish in a limited quantity of water (oxygen); it is clear that by lowering the salinity to 12.5‰, the fish can be made to live for longer periods than with the same quantity of oxygen in sea-water (at 29° C.). This is probably achieved by the lowering of osmotic stress on the metabolism of the fish in that salinity. (iv) The advantage of this lowered salinity is greater for the 5 gm. fish than for the 45 gm. fish and probably explains why only the young fish penetrates into the tidal creeks and lagoons during the monsoon period when the salinity

there is lower than in the sea. (v) Further confirmation was obtained by acclimating the species to 12.5‰ and testing the lethal level of oxygen. At this level of acclimation the values are 0.03 ml./l. and 0.15 ml./l. for the 5 and 45 gm. fish respectively which are the lowest values obtained in the entire series of experiments. (vi) Acclimation to higher salinity (40‰) shows a distinct disadvantage for the 5 gm. fish in that the lethal level remains proportionately higher indicating a greater osmotic stress on the metabolism of the small fish.

Marking experiments on *Chanos* yearlings, by clipping the fins or by punching holes in the fins or operculum were tried. The wounds healed completely in 15 days with a fair degree of regeneration of the clipped fins or by the holes becoming occluded. But the marked fish could still be recognized from the unmarked because of the scar tissue formed over the holes in the latter case.

Observations on the characteristics of the marine fish-farm and the surrounding saline lagoons have given the following general inferences. While the hydrological conditions in the ponds have not been very adverse for the growth of fish, the availability of fish food organisms has been uniformly poor. The level of both phyto- and zooplankton has been low throughout the period except during November–December when there was an influx of water from the sea. A very low content of essential nutrients and persistent turbidity of water (owing to the presence of a fine suspension of silt) seemed to be some of the contributing factors for poor plankton production. The initial experiments on the use of green manure or cheap organic fertilizers either resulted in the growth of the wrong type of algae for *Chanos* culture or failed to show the desired type of plankton production. The necessity of renewing the water in the ponds frequently to prevent undue rise in salinity resulted also in removing some of the nutrients. Groundnut oilcake and rice bran have been generally helpful for maintaining a satisfactory growth of larger fish while those which were not artificially fed were seriously affected. The fry of *Chanos*, mullets and prawns entering the lagoons from the sea have been utilized for stocking the ponds. Data on the fishery resources of the lagoons are being gathered. The problem of preventing predators from entering the ponds is receiving serious attention and improvements to the existing ponds and sluice systems are being contemplated.

VII. ALGOLOGY

During the year, research was carried out on the taxonomy and ecology of Indian agarophytes and algin-yielding seaweeds. Work towards a hand-

book on the agarophytes of South India was also pursued. New records of marine algæ for India and for South India were obtained during field-work. A new use of the common seaweeds, *Ulva lactuca* and *U. reticulata*, was found in the course of the year. They have been shown to yield a pectin-like substance which is particularly valuable as gelling medium for jam manufacture. The "pectin" is liberated after boiling the pulverized, sun-bleached seaweed in water with the addition of citric acid to make the pH 4.0. Agar was produced on a pilot scale during the year, and data on costing were obtained. The cottage industry method was modified by mechanical grinding of the seaweed initially and by freezing the gel at the final stage.

The ecological studies at the Palk Bay and the Gulf of Mannar, are progressing, one-year data having been collected and analysed. The chemical analysis of sea-water did not reveal any marked relation between composition of water and the changes in flora on the experimental boulders. The boulder in the Gulf of Mannar has not revealed any luxuriant algal growth so far, except for the first appearance of a dense growth of *Enteromorpha compressa* during the winter period from December 1956 to end of January 1957. This crop was immediately followed by a good crop of *Padina gymnospora* (Kütz) Vickers, of very short duration. Since May 1957, the boulder continues to be denuded, except for a sporadic appearance for a week or two, of very few *Padinas* and *Cladophoras*. On the other hand, in the Palk Bay, the boulder has indicated distinct phases of algal growth followed by durations of either complete depletion or retardation in the flora. Although the boulder has a complex community of green, brown and red algæ, the browns are found all through the year, the reds in most of the months, and the greens for short durations only. Further, from the point of abundance, the browns come first, followed by the reds and the greens, while from the point of species representation, the greens come first, followed by the reds and browns. The Palk Bay boulder is denuded only for a very short period, during the months of November and December. The maximum luxuriance is noticed in the months of July and August.

The studies on the genus *Hypnea* are being continued. From the tours so far made, it is found that the genus *Hypnea* is found all along the Indian coastline wherever the coast is rocky. The genus becomes progressively more scanty as one proceeds down south from the Dwarka reef. It attains luxuriance again at Bombay and at Ratnagiri coastal regions only. Farther south, it is abundant along the Pamban coastal areas, at Cape Comorin, and at Vizhingam. Beyond Vizhingam along the Kerala Coast, the aiga

is once again scanty or absent. The Dwarka reef, the Veraval reef, the Porbandar reef, and the Cape Comorin area on the west coast, as also the Pamban area on the east coast, may be mentioned as the best collecting and harvesting grounds for economically important marine algæ.

VIII. CHEMISTRY AND BACTERIOLOGY OF FISHES

Investigations were continued on the nitrogenous extractives of fish muscle, the denaturation of fish muscle proteins occurring during frozen storage, preservation of fish and prawns in ice, and objective tests for assessing the quality of fish. Considerable progress was made in the studies on the nitrogenous extractives. High levels of free amino acids were found to be characteristic of the skeletal muscle of invertebrates such as crustaceans and molluscs, unlike in the case of fishes. The high concentration of free amino acids in the muscle probably explains the greater susceptibility to spoilage experienced in prawns, lobsters, crabs, etc., compared with fishes. The results are significant from the processing aspect. Further differentiation of the non-protein-nitrogen of fish muscle by chromatographic techniques is in progress. The distribution of trimethylamine oxide in several fishes, crustaceans and molluscs was examined. Studies relating to the processing of prawns yielded results which are significant from the aspect of quality control of prawns preserved in ice prior to freezing. The acid-soluble ortho-phosphate content of the muscle was found to be useful for assessing the quality and storage duration of prawns preserved in ice. Observations on samples of prawns from the landings of Norwegian boats at Cochin indicate that the prawns had a keeping quality of at least a week when iced properly. Headless prawns remained free from darkening for over a week while whole prawns showed discoloration from the third day of storage. A number of bacterial species were isolated from prawns stored in ice and examined in detail. Gram-negative achromic rods predominated among the isolates. Preliminary studies showed that denaturation of the muscle protein occurred to the extent of 25 per cent. during one month's frozen storage of fish.

IX. FISH CURING AND FISHERY BY-PRODUCTS

The chemical quality of samples of salts and cured fish products collected during a survey of fish curing centres at Tuticorin, Alanthala and Idinthakarai has been assessed. Studies on the use of preservative chemicals in different methods of cure such as sun drying, dry curing, wet curing and pickling have been made in continuation of the work done during the previous year. Results obtained so far indicated that pretreatment of fish by giving a dip in citric acid solution might improve the keeping quality of dry cured

'choodai'. Similarly, pretreatment with propionic acid solution before salting gives products of both dry cure and wet cure which are resistant to the growth of moulds and red halophilic colonies. The economics of these are being worked out. Spoilage studies have been made of three lots of dry cured shark (salted in ratios of 1:3, 1:5 and 1:8) on storage under relative humidities of 95 per cent., 85 per cent., 75 per cent., 65 per cent. and 45 per cent. Changes in moisture levels, total volatile and trimethylamine nitrogen values and growth of moulds were followed during the period of storage. Samples of dry cured mackerel salted in 1:6 ratio were also subjected to similar spoilage studies. Study on the relation between the delay in salting and the keeping quality of the cured products was continued during the period under report, mackerel being chosen for the investigation. A few aspects in the curing and preservation of mackerel have been investigated, viz., effect of dressing, gutting, etc., on the shelf life of the cured product, the keeping quality of cured products stored in different packing materials and effect of salt ratios and moisture levels on shelf life of product. Studies on the relative digestibility of cured sardines prepared by the methods of sun drying, dry curing, wet curing, pit curing and pickling have been started. A comparative study is being made of the volumetric methods of estimation of calcium, magnesium and sulphate in marine salts and the conventional methods of their assay.

Investigations on the production of quality fish meal for human consumption were continued. One important advantage of the fermentation process has been found to be the almost complete removal of flesh urea nitrogen from elasmobranch fishes. It is found that on an average 80-85 per cent. of the total urea nitrogen is removed from shark, ray and skate by this method. Pilot scale production of quality fish meal from low oil bearing fishes was continued. The acceptability of the meal was tested by conducting chick feed trials and by using it in different food preparations in the laboratory. The latter showed that the meals prepared by the fermentation process could be mixed with other food materials up to 20 per cent. by weight without producing any fishy odour or taste. For detailed studies on the biological and nutritive values of the meals representative samples have been sent to the Nutrition Research Laboratories, Coonoor. A sample has also been sent to the Central Food Technological Research Station, Mysore, for incorporation in synthetic rice. The results of these are awaited. Studies on the changes in the quality of the fermented products during storage were continued. Meals prepared from Elasmobranchs, *Caranx*, *Arius*, etc., were found to maintain their chemical quality for a period of over twenty months.

A formula has been worked out for the composition of a jelly suitable for coating fish. Trials conducted on gutted and ungutted sardines, *Sillago*, *Nematalosa*, etc., stored at 14° F. showed that the process is very efficient in maintaining the quality and fresh flavour of frozen fish. It is also found that jelly coating helps to prevent dehydration of fish owing to "drip" (and consequent loss of soluble nutrients) to prevent development of rancidity of fat and to retard the degree of denaturation of fish protein. The process has got immense possibilities from the commercial point of view and further detailed work is under way. Laboratory and field trials showed that copper alginate is a comparatively better preservative for fishing nets than bark extracts. The optimum conditions of treatment of nets have been worked out and they are as follows: the nets are to be immersed in a 0.3 per cent. solution of copper alginate in 3 per cent. ammonia for 15-30 minutes and then dried in the sun. Work is now in progress to study the comparative efficiency of copper alginate with other indigenous and chemical preservatives.

Composted seaweeds and seagrasses were analysed chemically and found to contain a high percentage of minerals. The organic nitrogen is converted into the inorganic form during the process of composting. The carbohydrate material in the weeds holds the water for a long time. Tryptic and peptic enzymes were prepared from mackerel and shark and tested for their enzymic activity. The crude product is roughly 0.002 per cent. of the weight of fish. A comparative study was made of the various methods usually employed for following enzymic activity (hydrolysis) using casein substrate. Experiments on the preservation of fish waste with a combination of sodium nitrite and boric acid in the ratio of 1:2 proved effective in delaying the spoilage odours for a period of three to four days. Sardine oil and guano samples collected from the west coast were analysed for their chemical and physical characteristics. There is a wide variation in the constants of the different oil samples obtained from the west coast during the last season. Ray liver oil prepared in the laboratory was assayed and storage studies were made. The oil became rancid in two months' time, and it appears probable that liver oils are more susceptible to oxidation by light than body oils.

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