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**GOVERNMENT OF INDIA
CENTRAL MARINE FISHERIES RESEARCH STATION
MANDAPAM CAMP**

**ANNUAL REPORT OF THE CHIEF RESEARCH OFFICER FOR THE
YEAR ENDING 31st MARCH 1957**

ADMINISTRATIVE AND GENERAL

1. During the year 1956-57 the Central Marine Fisheries Research Station made further progress in its work on marine fisheries research at the Headquarters Station at Mandapam and at the subordinate establishments at different centres of the country. In addition to continuing the programmes of work of the normal establishment and of the First Five-Year Plan schemes, the initiation of expanded activities during the year under the Second Five-Year Plan programme gave an added fillip to the activities at all the existing centres and to the new programmes at new centres. The Research Units at Bombay and Cochin were upgraded as Substations and two new Research Units were opened at Calcutta and Mangalore. Additional Survey/Research Centres were also set up at Surat, Alleppey, Neendakara (near Quilon) and at Pondicherry. Arrangements have been made for opening a new Research Centre at Porto Novo and for setting up a Research Unit on the Saurashtra coast during 1957-58. Besides continuing work on the scheme for the collection and analysis of oceanographic data, a scheme of research on 'Pearl essence' has also been sanctioned by the Council of Scientific and Industrial Research. Volume III, No. 2 and Volume IV, No. 1 of the *Indian Journal of Fisheries* were published during the year.

2. During 1956 a substantial increase in the marine fish landings in India took place, estimated at 7,07,349 tons (7,18,695 metric tons) for 1956 as compared to 5,20,000 to 5,86,000 tons during the previous six years. While the fishery for the two major groups, the mackerel and sardines, registered some decline, an almost 50% increase in the landings of prawns and allied forms was recorded. The figures for Bombay-duck, Carangids, silver-bellies, *Lactarius*, red mullets and *Sphyraena* all indicated a definite upward trend in their fisheries which was partly offset by the decline in the landings of ribbonfish, eels and other miscellaneous groups. The zonal landings showed substantial increases on the coasts of Gujarat, Kerala, and Madras as against decreased landings in the Andhra and Kanara coasts. Owing to the increase in the number of power fishing vessels, belonging to

Government agencies and to private enterprise, the landings by mechanized fishing vessels indicated an almost ten-fold increase from 332 tons in 1955 to 3,125 tons in 1956.

3. The Research Substation at Bombay carried out very useful work in compiling and analysing the results of fishing operations by the power fishing vessels at Bombay, besides carrying on examination of catches and detailed biological investigations on the important commercial species. An important report on the trawling operations between Bombay and Saurashtra based on the work of the Deep-sea Fishing vessels operating from Bombay was completed during the year and is under publication by the Ministry.

4. Experiments on marine fish farming operations were started at Mandapam in the newly constructed Experimental Fish-farm. For more extensive field trials on *Tilapia* and prawns, a suitable field at Vaikom in the Kerala State was taken on lease and the field has been provided with boundary and partition bunds, sluice gates, etc., necessary for carrying on detailed investigations. Quantitative studies on plankton in the Mandapam area showed that a greater abundance of edible planktonic organisms often occur in the offshore fishing grounds as against the preponderance of inedible forms in the inshore area. Experimental boat-seine fishing was carried out during November and December 1956 in the Quilandy Bay near Kozhikode. During trial fishing in this area, whenever shoals of inshore fishes were noticed, the information was passed on to the fishermen in the nearest vicinity who made good use of the tip to derive maximum benefit. Light-fishing operations at the Institute were continued and the local fishermen evinced much interest in them.

5. A new technique of manufacturing fish meal has been developed at the Institute during the year. Detailed investigations on the product obtained by the new process showed that the meal prepared was wholesome; in chemical quality, it compared very well with meals prepared by conventional processes. The new process was found particularly suitable for non-oily types of fishes like sharks, rays, etc.

6. On the capital works side, construction of staff quarters at Mandapam at a cost of Rs. 6.4 lakhs and of the Research Substation buildings at Kozhikode at a cost of Rs. 2.17 lakhs was commenced during the year. Both these works made commendable progress and the buildings are expected to be ready for occupation during 1957-58. The staff residences under construction consist of 56 units distributed as follows: Chief Research Officer—1, Class I Officers—3, Class II Officers—12, Class III Officers—10,

and Class IV Officers--30. Construction of a Guest House at a cost of Rs. 1·37 lakhs and renewal of the superstructures of the existing laboratory buildings at Mandapam at a cost of Rs. 1·98 lakhs were also sanctioned during the year and actual work on these items will be taken up by the Central P.W.D. early in 1957-58. Construction of an overhead tank for augmenting supply of circulating sea-water to the Aquarium was in progress, as also the erection of a compound wall and barbed wire fencing around the existing Station buildings. On the electrical side, replacement of wooden posts of the power lines by iron ones, electrical installations in the Workshop and the new bath-rooms, and provision of power plugs in the laboratories and in a few of the residential units, were major items of work taken up and completed. Although the installation of a Cold Storage Plant was on the programme, only the civil portion of this work was completed in 1956-57. The cork sheets and other equipment ordered from abroad were received only in April 1957 and the installation of the plant is expected to be completed shortly.

A building to house the Research Unit at Karwar is proposed to be acquired at a cost of about Rs. 38,000. An additional area of about sixty-four acres of land on the Palk Bay side has been acquired for the Fish-farm.

7. Essential glassware, chemicals, scientific equipment, furniture and office equipment required for day-to-day work were procured during the year. Under the TCM programme, a Dan boat and three reels of films were received during the year; under TCA, a Muffle furnace and a centrifuge were received. Among the major items of scientific and other equipment purchased could be mentioned four dissecting microscopes, one microscope, a stove heated autoclave, an electrically heated autoclave, two hot-air ovens, a cencohycav pump, an incubator, microtomes (freezing and rocking), an enlarger, a calculating machine, a teakwood row-boat, and an outboard motor of $5\frac{1}{2}$ h.p. From the Workshop machinery ordered, only a machine vice and two drilling machines were received. Essentially required additional ceiling and table fans were also procured. Owing to foreign exchange difficulties procurement action on purchase of oceanographical and other special equipment, for which an indent was placed with the Director-General of Supplies and Disposals, could not be proceeded with.

8. Substantial additions have been made to the library and subscriptions to serial publications of fisheries interest were increased during the year. A notable addition to the library was a set of fifty-two monographs of the Siboga Expedition,

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9. For the implementation of the programmes of work accepted under the Second Five-Year Plan Schemes, two posts of Research Officers (senior scale), six posts of Research Officers (junior scale), six posts of Assistant Research Officers, one post of Fish-farm Engineer, and one post of Special Survey Assistant, in addition to over eighty Class III and Class IV posts were sanctioned during the year.

10. The following appointments to Class I and Class II (Gazetted) posts were made during the year:

<i>Name of Officer appointed</i>	<i>Post held</i>	<i>Post to which appointed</i>
1 Dr. R. Raghu Prasad	.. Research Officer (Marine Biology) (Junior scale)	Research Officer (Marine Biology) (Senior scale)
2 Shri N. K. Velankar	.. Assistant Research Officer (Bacteriology)	Research Officer (Chemist)
3 .. S. K. Banerji	.. Assistant Research Officer (Statistics)	Research Officer (Fishery Survey)
4 .. M. Krishna Menon	Assistant Research Officer (Prawns)	Research Officer (Prawns)
5 .. V. Sadasivan	.. Fisheries Develop- ment Officer, Andamans	Assistant Research Officer (Sharks and Rays)
6 .. M. S. Prabhu	.. Assistant Research Officer (Sharks and Rays)	Assistant Research Officer (Mackerel)
7 .. G. Venkataraman	.. Assistant Research Officer (Sardines)	Assistant Research Officer (Offshore Fisheries)
8 .. P. V. Kamasastry	.. Research Assistant	Assistant Research Officer (By-products Utilization).
9 Dr. V. Krishna Pillai	.. Assistant Research Officer (By-product Utilization)	Assistant Research Officer (Bacterio- logy)
10 Shri K. H. Mohamed	Survey Assistant	Assistant Research Officer (Offshore Fisheries)
11 .. M. J. George	.. Research Assistant	Assistant Research Officer (Prawns)
12 .. B. Krishnamoorthi	.. Research Assistant	Assistant Research Officer (Inshore Fisheries)
13 .. K. Nagappan Nair	.. Research Assistant	Assistant Research Officer (Molluscs)

Shri K. V. Sekharan, Research Assistant, was selected for temporary appointment to the post of Assistant Research Officer (Sardines) but owing to his departure prior to that date on deputation to Japan for further training in Sardines research this selection could not be implemented. Shri G. G. Suralkar took charge of the post of Administrative Officer from Shri P. S. Ponratnam in June 1956. As a result of special efforts, it was possible to make recruitment to most of the Class III and Class IV posts. A small number of Class III (ministerial) and Class IV posts were created by the Chief Research Officer in order to cope with the programme of work included under the Second Five-Year Plan, pending regular sanction of these posts by the Government.

11. During the year Shri M. Krishna Menon was confirmed in the post of Assistant Research Officer with effect from 13-10-1953. Miss Nora G. Sproston relinquished charge of the post of Assistant Research Officer (Scombroid Fishes) on the 13th January 1957. Shri P. R. Sadasivan Tampi, Assistant Research Officer (Fish-farm), proceeded to U.S.A. in July 1956 for advanced training at the University of Wisconsin taking advantage of a Fulbright-Smith Mundt scholarship awarded to him. Shri R. Viswanathan, Assistant Research Officer (Oceanography), continued to make good progress during the year with his studies at the Kiel University (West Germany) where he is undergoing training in Oceanography for two years on study leave from April 1956. Shri K. V. Sekharan, Research Assistant, proceeded to Japan on deputation in January 1957 for training in Sardines research under the Colombo Plan.

12. Dr. Panikkar, the Chief Research Officer, participated in the second and third meetings of the Fisheries Research Committee at Mandapam (April 1956) and Calcutta (January 1957), the meetings of the Standing Committee on Oceanography of the Central Board of Geophysics at Waltair (May 1956) and Dehra Dun (November 1956), the Symposium on Oceanography at Waltair, the Scientific Advisory Committee meeting of the Central Food Technological Research Institute, Mysore, and the All-India Fisheries Conference held at Madras. As Chairman of the Indo-Pacific Fisheries Council, he presided over the 24th and 25th Statutory Executive Committee meetings held at Penang (September 1956) and at Bangkok (March 1957) and also led the Indian Delegation to the Sub-Committee meeting on *Rastrelliger* (Indian Mackerel) held at Penang at which Dr. S. Jones and Shri S. K. Banerji participated as Alternate Delegate and Adviser respectively.

13. Among the distinguished foreign visitors to the Research Station could be mentioned Mr. C. Beever, Acting Secretary of the Indo-Pacific

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Fisheries Council, Prof. J. Soot Ryen of Norway, Visiting Professor of Oceanography, Travancore University, Mrs. Soot Ryen, Dr. Gunther Becker, Wood Preservation Officer, Material Testing Institute, Berlin (West Germany), Dr. J. L. Jakubowski, Member of the Polish Academy of Sciences and invitee to the Indian Science Congress from Poland, Dr. Van Cleve, T.C.M. Fisheries Expert, Prof. Mira Zore, Chief of the Physical Oceanography Section of the Institute of Oceanography and Fisheries, Split, Yugoslavia and Dr. Miyamoto, F.A.O. Gear Technologist who spent short periods at the Institute for visiting the laboratories and for discussing scientific and fisheries problems with the Chief Research Officer and members of the scientific staff. Other distinguished visitors who visited the Headquarters Station included General K. M. Cariappa, former Indian High Commissioner in Australia, Shri O. V. Alagesan, Union Deputy Minister for Railways, Shri S. V. Kanungo, member and Shri N. M. Kamte, co-opted member of the Union Public Service Commission, Dr. B. N. Chopra, Fisheries Development Adviser to the Government of India, Dr. Waman B. Date and Dr. D. S. Bhatia of the Central Food Technological Research Institute, Mysore, Shri A. M. Dam, Secretary to the Government of Assam, Shri S. Bhanti, Delegate to the All-India Fisheries Conference from Assam and Shri B. Joshi, Senior Marketing Officer, of the Directorate of Marketing and Inspection of the Government of India.

14. Among the visitors who visited the subordinate establishments of the Institute could be mentioned, Shri M. V. Krishnappa, Union Deputy Minister for Food who visited the Kozhikode Substation and Bombay Research Unit, Dr. Van Cleve, T.C.M. Fisheries Expert who visited the Substation at Kozhikode and the Research Units at Ernakulam, Madras, Karwar and Bombay, Prof. Soot Ryen of Norway, Mr. Hans K. Zimmer, Naval Architect and Marine Engineer, Norway, Mr. Eirik Heen, Director, Norwegian Fisheries and Prof. G. M. Gerhardsson, Professor of Fishery Economics of the Norwegian School of Economics and Business Administration, all of whom visited the Kozhikode Substation, Dr. G. D. Tapase, Minister for Fisheries, Bombay State, Shri Barlynd, F.A.O. Marketing Expert, Shri Bhote, Deputy Director, Marketing, New Delhi and Dr. A. B. Misra, Professor and Head of the Department of Zoology, Banaras Hindu University, all of whom visited the Research Unit at Karwar. Shri R. L. Mehta, Joint Secretary, Ministry of Agriculture, visited the Research Unit at Ernakulam.

The Museum, containing a representative collection of marine fishes and other forms and fishing gear and equipment, and the Aquarium proved

to be the main centres of interest for the general public visiting the Headquarters Station. Including several parties of University and College students, trainees, research workers, school students and the lay public, the visitors to the Museum and Aquarium numbered over 3,350 during the year.

15. The three Research Scholars, Sarvashri K. Ramalingam, A. V. Natarajan and M. Vasudev Pai, actively pursued their investigations. For the two additional scholarships awarded during 1956-57 Sarvashri M. Subrahmanyam and K. K. Tandon were selected and they started work here in March 1957. Sarvashri P. K. Talwar, M.Sc. and K. Raman, M.Sc., who initially joined here as Honorary Research Workers, were absorbed in the staff of the Institute during the year.

16. A Fisheries Extension Unit of the Ministry of Agriculture was set up at Mandapam during the year and Sarvashri K. Virabhadra Rao, Assistant Research Officer and M. Peter Devasundaram, Research Assistant in this Research Station, were appointed as Fisheries Extension Officer and Assistant Fisheries Extension Officer respectively in the new Unit. The Extension Unit will be organized to take the results of research to the fishing industries and fishermen. The Research Station is now in possession of several films of fishery interest which will be shown to the public from time to time.

17. A grant-in-aid of Rs. 350 sanctioned by Government for the Recreation Club at the Institute was utilized for the purchase of a radio set, a very essential amenity which the Club could not provide earlier for want of funds. To overcome, at least in part, the difficulties relating to medical attendance and treatment of the staff of the Research Station at Mandapam arrangements were made for the Lady Doctor at the Government Headquarters Hospital, Ramnad, to visit the Research Station twice a week from March 1957 onwards. An interest-free loan of Rs. 1,500 received from Government has been utilized for procuring essential equipment for the Canteen and Store and for starting a new Grocery Section which has functioned very successfully during the past six months. For meeting the essential requirements for the education of the children of the staff members, a Nursery School is being run at the Institute during the past two years solely by private funds contributed by members of the staff.

18. A list of research papers published by the staff of the Research Station in 1956-57 is appended at the end of this report.

FISHERY SURVEY

19. *Review of fisheries in 1956.*—The analysis of data collected in 1956 was completed during the year under review. The year 1956 witnessed a substantial increase in the marine fish landings in India. The total landings of marine fish in India were estimated at 7,07,349 tons (7,18,695 metric tons) in 1956, as compared to 5,86,315 tons (5,95,719 metric tons) in 1955, thus showing an increase of about 20 per cent. over the previous year. The total landings for 1955 and 1956 are shown in Table I according to different zones.

TABLE I
Fish landings in different zones

Zone			Fish landings in tons, 1955	Fish landings in tons, 1956
1	West Bengal and Orissa	..	5,874	15,631
2	North Andhra	..	10,586	15,151
3	Central Andhra	..	50,488	32,870
4	South Andhra	..	2,028	3,626
5	North Madras	..	12,328	17,993
6	Central Madras	..	15,021	19,200
7	South Madras	..	9,074	17,143
8	Travancore-Cochin	..	118,108	131,623
9	Malabar	..	42,700	77,167
10	Kanara	..	33,960	25,492
11	Bombay-Gujarat	..	267,806	319,007
12	Saurashtra	..	18,010	29,321
Mechanized vessels		..	332	3,125
TOTAL ..			586,315	707,349

From Table I it will be seen that the fish landings in all regions showed substantial increases in 1956 excepting only Central Andhra and Kanara coasts. The increase in landings in West Bengal and Orissa was mainly due to prawns, *Harpodon nehereus* and *Trichiurus* spp. Improved landings of prawns, *Caranx* spp., *Anchoviella* spp., and *Trichiurus* spp. were responsible for the increased landings in North Andhra coast. Failure of *Kowala* and *Caranx* fisheries (which contributed so largely to the landings

in 1955) was responsible for the decline in the fish landings figure for Central Andhra coast. The slight rise in the figure for South Andhra coast was due to increased catch of shrimps (*Acetes* spp.). The rise in the fish landings in various regions of the Madras coast was due to heavier catches of sardines, *Anchoviella* and *Engraulis* spp., *Scomberomorus* spp., *Caranx* spp., *Leiognathus* and *Lactarius* spp. In Travancore-Cochin, the fish landings increased by about 13,000 tons, being mainly due to very heavy catch of *Caranx kurra* and increased catches of prawns, *Upeneoides* spp. and *Sphyraena* spp. The catches of *Dussumieria* spp., Sciænidæ, *Leiognathus* spp., *Lactarius* spp., and pomfrets also showed some increase. As against these increases, substantial decline was noticed in the landings of *Sardinella longiceps*, *Sardinella fimbriata*, *Trichiurus* spp., and *Cynoglossus* spp. In spite of the failure of the oil-sardine fishery, a considerable increase in the fish landings on the Malabar coast was apparent in 1956, largely due to a very successful fishery of *Caranx kurra*. Landings of *Leiognathus* spp., *Cynoglossus*, *Arius* spp., *Rastrelliger canagurta*, *Sardinella fimbriata*, *Anchoviella* and *Engraulis* spp., pomfrets and prawns also registered some increase. The decline in the landings figure for the Kanara coast this year was due to a failure of mackerel and sardine fisheries. The catfish fishery was also not successful. In the Bombay zone, the fish landings increased by about 50,000 tons in 1956, of which about 29,000 tons were contributed by non-penæid prawns and shrimps (*Acetes* sp.). Catches of *Harpodon nehereus*, *Chirocentrus dorab*, *Cotilia dussumieri* and penæid prawns also showed some increase. But there was substantial decrease in the catches of eels, Polynemids, pomfrets and *Bregmaceros*. The fish landings figure for Saurashtra went up because of a very successful Bombay-duck fishery in 1956. Owing to the advent of a private fishing firm, namely, the New India Fisheries, who started bull-trawling operations in Bombay waters from April 1956, the total landings from mechanized vessels also increased.

20. *Composition of fish landings.*—The overall composition of total fish landings in India in 1956 is given in Table II, together with the corresponding figures of 1955 for comparison.

From Table II it will be seen that the salient features of 1956 fisheries were as follows:—

- (i) The catches of mackerel and sardines, which constitute the mainstay of Indian fisheries, showed some decline. This was mainly due to the failure of mackerel and oil-sardine fisheries on the Malabar and Kanara coasts.
- (ii) Similarly, catches of ribbonfish, eels and Polynemids declined on the whole. The decline in the total catch of ribbonfish was due to decreased

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TABLE II
Composition of fish landings

Name of the fish	Quantity landed in tons	
	1955	1956
1 (a) Prawns (penaeid)	43,898	65,852
(b) <i>Acetes</i> spp. and non-penaeid prawns	60,444	90,913
(c) Other crustacea	600	267
2 Mackerel	..	22,436
3 Seer-fish	..	5,950
4 (a) Oil-sardine	29,966	7,295
(b) Other sardines	41,031	35,868
(c) <i>Hilsa</i>	2,284	1,855
(d) Anchovies and whitebait	25,257	26,569
(e) Other clupeids	19,159	33,814
5 Bombay-duck	..	102,473
6 Jewfish	..	42,598
7 Ribbonfish	..	32,155
8 Catfish	..	18,383
9 Carangids	..	17,756
10 <i>Coryphaena</i> and <i>Elaeotis</i>	..	314
11 (a) Sharks	14,685	15,918
(b) Rays	4,305	14,562
(c) Skates	1,138	1,031
12 Pomfret	..	13,466
13 Eels	..	12,156
14 Polynemids	..	11,575
15 Perches	..	6,963
16 Silver-bellies	..	6,856
17 <i>Lactarius</i>	..	5,563
18 Sole	..	5,507
19 <i>Chirocentrus</i>	..	4,315
20 Tunnies	..	3,318
21 Flying-fish	..	3,207
22 <i>Bregmaceros</i>	..	3,140
23 Red mullet	..	1,110
24 <i>Mugil</i>	..	205
25 <i>Sphyraena</i>	..	387
26 <i>Hemiramphus</i> and <i>Belone</i>	..	434
27 Miscellaneous	..	23,281
TOTAL ..	586,315	707,349

landings of the fish in Central Andhra, Travancore-Cochin and Malabar coasts. The decline of eel catches in the Bombay zone accounted for the fall in the all-India figure for eel catches. Reduced catches of Polynemids in Bombay and Sourashtra zones were responsible for the decline of the total catch of Polynemids.

(iii) As against these declines there was considerable increase in the catches of prawns and shrimps. The increase in shrimp landings took place mainly in the Bombay zone. The landings of prawns were more than doubled in Travancore-Cochin, some increase in their landings being noticed in Bombay also.

(iv) There was an overall increase in the catch of Bombay-duck. This was due mainly to the very successful fishing in Saurashtra where the catch almost doubled and to some increased catches in Bombay.

(v) There were very heavy catches of *Caranx kurra* (*Decapterus russelli*) in Travancore-Cochin and Malabar together with considerable increase in the catches of silver-bellies, *Lactarius* sp., and soles. There was improved catch of *Leiognathus* and *Lactarius* in Madras coast.

(vi) Heavy landings of red mullets (*Upeneoides* spp.) occurred in Travancore-Cochin and Bombay coasts.

(vii) The increased catch of *Sciænidæ* was due to some improvement in the landings in various regions, notably Travancore-Cochin, West Bengal, Madras and Kanara coasts.

(viii) Similarly, increased landings of seer-fish in Kanara and Bombay coasts improved the total catch of this fish.

(ix) The *Sphyraena* fishery was again successful in Travancore-Cochin in 1956, after a comparatively poor yield in 1955.

21. *Catch per unit effort.*—Table III shows the total man-hours of effort put forth in each zone between 1954–56 and the corresponding catch in lb. per man-hour.

From an examination of Table III it is seen that in most of the zones the variation in the catch per unit effort is due to variation in the availability of fish during different years. But in Kanara zone, the effort has been increasing from 1954 to 1956, while the catch figures show some decline and the figures for catch per unit effort also declined. Though it is too early to say if this indicates overfishing, the situation needs careful observation. In zone 8, i.e., Travancore-Cochin, the catch and the effort both increased from 1954 to 1956 and the index of catch per man-hour showed decline as per the law

of diminishing returns. Here too, careful watch is necessary to see if decrease of catch continues with further increase of effort in future.

TABLE III
Fish catch as related to fishing effort

	Total effort in 100 man-hours			Catch per man-hour		
	1954	1955	1956	1954	1955	1956
1 West Bengal and Orissa	6,917	8,023	5,489	3.03	1.64	6.38
2 North Andhra	17,943	17,829	15,814	0.68	1.33	2.15
3 Central Andhra	72,855	98,342	60,717	0.61	1.15	1.21
4 South Andhra	3,017	1,221	2,324	4.70	3.72	3.49
5 North Madras	22,442	11,801	12,493	2.42	2.34	3.23
6 Central Madras	22,390	13,678	21,290	2.36	2.46	2.02
7 South Madras	18,596	8,799	15,822	1.12	2.31	2.43
8 Travancore-Cochin	32,501	54,549	79,836	5.43	4.85	3.69
9 Malabar	30,575	24,844	37,626	5.81	3.85	4.59
10 Kanara	8,472	13,322	14,201	7.63	5.71	4.02
11 Bombay	65,518	70,409	62,685	9.43	8.52	11.40
12 Saurashtra	16,046	8,216	6,589	2.39	4.91	9.97
TOTAL ..	317,272	331,033	334,887			

FISHERY BIOLOGY

(1) At Mandapam

22. *Mackerel investigations.*—The examination of samples of mackerel from various stations in India and elsewhere, the recording of morphometric data of meristic characters and detailed study of the variations with a view to delimit populations and races if such exist, were continued. Study of the mackerel gonads was continued with a view to define the several stages

of maturity and the approach of spawning season. There were some indications that perhaps two distinct spawning periods existed, the first during October-November and the second during May-June. Length-frequency study of samples of mackerel for the local fishery at Mandapam revealed much inconstancy of size in the fishes contributing to the local fishery.

23. *Sardine studies*.—The *choodai* fishery started in April and lasted up to December in the Gulf of Mannar side, whereas it stopped in October on the Palk Bay side. In the first quarter of the year the fishing was very irregular with abrupt increases and decreases and the fishery mainly depended on the 0-year-class. However, spent sardines (*S. Albella* and *S. gibbosa*) were recorded in samples from shore-seine catches at Dhanushkodi. Generally, when the landings were poor, there was an abundance of *Noctiluca* in plankton collected from fishing grounds. In the first two quarters of the year the bulk of the catches was formed of *Sardinella albella*, but *Sardinella gibbosa* was the dominant species towards the end of the season. There was an unusual absence of *S. gibbosa* from the catches of October.

24. *Biology of Hemirhamphus*.—Investigations have been started on the fishery for *Hemirhamphus* which forms a very important seasonal fishery in the Gulf of Mannar and Palk Bay. Field studies and laboratory work on the material collected periodically from various fishing centres revealed some interesting observations regarding the systematics, breeding habits and behaviour of these fishes. At Keelakarai and Muthupatnam on the Gulf of Mannar side, the fishery season was December-January and the dominant species was *H. marginatus*. At Theedai, on the Palk Bay side, fishing operations started in the latter half of March and the catches comprised only *H. georgii*. Shore-seines accounted for all the landings.

25. *Light fishing*.—The departmental light fishing operations were continued with a break during the monsoon. Catches during this period amounted to 3,673 lb. The fish obtained by this mode of fishing were chiefly *Atherina* sp., small clupeoids, *Leiognathus* sp., *Hemirhamphus* sp., *Belone* sp., and several species of perches. Details of species obtained, their size ranges, etc., are being recorded.

(2) At Kozhikode

26. *General fishery conditions*.—The mackerel and the oil-sardine occurred in fair quantities along the Malabar coast during the period under report and their catches at Kozhikode were higher than that of the previous season. While the mackerel fishery started earlier in August and continued till December, the oil-sardine fishery commenced late in December and con-

tinued till March, the bulk of the catches being composed of one to two-year old juvenile sardines. A noteworthy feature was the exceptionally heavy landings of *Caranx kurra* of size 14–17 cm. at Kozhikode and several other centres along the Malabar coast during the middle and latter half of September 1956. Such heavy landings of this species did not occur in the past few years. Most of the fish were beach dried and exported.

During the first quarter, the fishery was as usual mainly of a miscellaneous nature, comprising prawns, Sciænidæ and soles while the fisheries of mackerel and oil-sardines were poor. Fishing operations were suspended towards the end of June owing to the setting in of the south-west monsoon. In the second quarter, while the oil-sardine fishery continued to be poor, the mackerel catches were better, both medium and large-sized fishes of sizes 15–16 cm. and 17–21 cm. being encountered in the fishery. In July and August, good catches of the prawns *Parapenæopsis stylifera* and *Metapenæus dobsoni* the whitebait, *Anchoviella tri* and the silver-belly, *Leiognathus bindus* were landed. Appreciable quantities of the Malabar sole, *Cynoglossus semifasciatus* were obtained in September at several centres along the Malabar coast. Unprecedentedly heavy landings of this fish were reported from Tellicherry in the first week of September.

There was a considerable improvement in the mackerel fishery during the September–December period, the common size-groups being 17–22 cm. Their catches, however, declined in the subsequent months of January–March. As a contrast, the oil-sardine fishery commenced late in the second half of December and continued till March, when large quantities of juveniles of modal size 10–14 cm. were landed at several centres. The peak of the oil-sardine fishery was reached at Kozhikode in January, after which there was a decline in the catches. During the third and fourth quarters, hook and line fishery was fair.

The inshore fishery was of a miscellaneous nature during April–June as in the previous years, with prawns forming the bulk of the catches on many occasions. During June–July, when the south-west monsoon was active, fishing operations were suspended. The Malabar sole, *Cynoglossus semifasciatus* formed the dominant catch during August–September, while in October, *Anchoviella tri*, *Anchoviella commersoni* and *Caranx kalla* were common in the catches. During December–March period, prawns, chiefly *Parapenæopsis stylifera*, formed the main catch, thus showing the cyclic occurrence of various species in different periods of the year.

Useful information on the fishing industry in general and tuna fishery in particular have been collected from Minicoy Island. Further data relating

to Minicoy fisheries are being collected to provide background information for any future programme of fisheries development in this area.

27. *Oil-sardine fishery*.—Oil-sardine fishery was poor during the first half of the year but improved remarkably during the latter half, catches then being constituted largely by the juvenile fish having the modal size 10–14 cm. The total yield of oil-sardines at Calicut was higher than in the previous year.

28. *Mackerel investigations*.—The mackerel fishery at Calicut was better during the current season than during the previous season. The total landings during this season amounted to 484 tons, of which more than 60 per cent. were obtained during the peak period from September–October. The fishery started by about August, reached the peak during September and October, remained more or less steady up to December, and dwindled from January onwards. The bulk of the commercial landings was contributed by the 16–19 cm. group and the 19–21 cm. group (total length) in the early and latter half of the peak season. A noteworthy feature of the fishery of the current season was the absence of fishes measuring more than 24 cm. in the commercial catches. The fishery was composed mainly of spent and immature fish, the latter predominating. In the commercial catches males and females were present in the ratio of 50:50, though the males always outnumbered females during the spawning period.

29. *Sole fishery*.—The fishery for *Cynoglossus semifasciatus* was better during the year under review as compared to last year. The heaviest landings were, however, localised in the Badagara–Tellicherry area during the first week of September. The unprecedentedly large catches in Tellicherry resulted in a glut in the market, and consequently a good quantity of the catches was converted to manure. The fishery extended north up to Malpe and beyond, indicating a notable variation in the distribution of the fishery. The dominant size-group of sole obtained during the active fishing season was the 120–130 mm. group with gonads approaching maturity. There was no fishery for soles, of appreciable magnitude during the closing months of the season. Ripe female specimens in oozing condition were obtained in November during dredging operations in the Quilandy Bay. The ovaries were examined. The ovarian egg was about 0·6 mm. in diameter, nearly spherical, transparent and included many oil-globules.

30. *Fishing intensity in the inshore waters of Kozhikode*.—The study of this subject was taken up this year. The catch-per-unit-effort and the size variations of eight species of fishes and one species of prawn are being studied. The catch per man-hour varied from 1·3 lb. to 10·45 lb. in different months, the highest catch rate of 10·45 lb. per man-hour being

obtained in September and the lowest, 1·3 lb. in June. The return per man-hour was more than 5 lb. in July, September, October and January.

(3) *At Mangalore*

31. *General fishery conditions.*—The fishery of the juvenile oil sardine continued on a very moderate scale during February and early March and the dominant size-group represented was the 110–120 mm. group with immature gonads. Dinophysids formed the largest single group of stomach inclusions during this period. The mackerel fishery was poor during February and March, although 190–210 mm. size mackerel specimens were noticed in the catches brought to the market. There was large-scale landings of catfishes in this zone from the last week of March and the fishery continued to be active in the Coondapore-Malpe strip.

(4) *At Bombay*

32. *Bull trawling by 'Ashok' and 'Pratap'.*—During the period March to May 1956 the Government of India cutters *Ashok* and *Pratap* made eight voyages and took 227 hauls during a total trawling time 337·0 hours. The total quantity of fish landed was estimated at 3,49,440 lb. In March 1956 more than 60% of the catch was obtained from area K of the Dwarka region. In this month the bulk of the landing consisted of sharks (19·29%), *Ghol* (15·7%), *Wam* (14·2%) and *Karkara* (18·8%). *Dara* formed only 5·5% of the total catch in the month, more than three-quarters of the landings being from the K area. The catch per hour varied from 420·4 lb. to 1,647·5 lb. The highest catch per hour of fish obtained as well as the highest fishing effort occurred in the K area (fishing effort in K area: 26 hauls over 39·4 hours). The fishing in April was mainly in Cambay and Porbundar regions, and *Ghol* (20·1%), *Wam* and sharks (19·74%) formed the bulk of the catch. The catch per hour ranged between 620 and 1,498 lb., the higher catch rates having been obtained exclusively from the Porbundar region. In May the fishing was fairly extensive, distributed in the regions of Bombay, Porbundar, Veraval and Gulf of Cambay. Sharks, *Wam* and catfishes constituted the bulk of the catch, the highest being *Wam* (24·2%).

In the current season the boats made seven voyages in all. The analysis has been completed of the results of first four voyages only, because of the non-receipt of the log reports for the other three voyages. This covers the period up to the end of November 1956. In the two months, October and November, the boats made altogether four voyages. The operations in October 1956 were confined to Bombay region excepting for a few hauls

in areas 10 and 11 of the Gulf of Cambay. Fifty-four hauls were made (total fishing time 80·5 hours) and the total landings were estimated to be 85,106 lb. yielding an average catch per unit of effort of 1,057·2 lb. per hour of trawling (range 520·4–1,266·8 lb. per hour). In November 1956 the boats fished in Dwarka region working for 60 hours and making 41 hauls. The total catch amounted to 128,674 lb. yielding a catch rate of 2,136·4 lb. per hour of fishing. The major categories in October 1956 were *Wam* 30·9% and sharks 22·8%. *Dara*, *Ghol* and *Koth* were negligible. Catfish were as high as 15%. In November, *Wam* continued to rank high (25·7%), but good quantities of *Dara*, *Ghol* and *Koth* also were obtained. *Karkara* formed nearly 20% of the landings in this month.

33. Small-sized vessels of the Government of India fishing with otter trawls and drift nets.—The data up to the end of February 1957 have been compiled and analysed. During this period all the vessels (*Champa*, *Bumili*, *Bangada* and *Durga*) excepting *Meera* operated small otter trawls. The last-mentioned boat operated the nylon gill-net. While the season lasted for 8 months for *Meera* and *Bumili*, it was 9 months in the case of *Champa*. In the case of *Bangada* and *Durga*, the fishing period was 7 and 6 months respectively.

Champa and Bumili.—These Reekie boats made 149 and 110 voyages respectively during this year, fished in the grounds near Bombay, mostly in areas 43 A and 38. The depth of fishing ranged from 7 to 22 fathoms, the bulk of the fishing was confined to 10 to 15 fathoms. While *Champa* made 434 hauls in all over a fishing time of about 815 hours, *Bumili* made 318 hauls over 613 fishing hours.

Bangada.—This vessel made 103 voyages during the year (up to the end of February), fishing mostly in the Bombay region. The depth of fishing ranged from 9 to 31 fathoms, and 323 hauls were made over an approximate trawling time of 677 hours.

Durga.—The operations of *Durga* lasted up to the end of January 1957 after which it left for Kerala waters. During the six months of fishing in the Bombay area the boat made 91 trips and took 277 hauls from depths of 8 to 22 fathoms.

Meera.—This boat, which is a drifter, has been fishing with the new nylon gill-net. During this period the boat made 147 trips in the Bombay areas 43 A, 43 and 38. The total number of hauls was 207, the average time for each haul being 2½ hours.

The total quantity of fish landed by the four boats working the otter trawl was 547,014 lb. while the landings by *Meera* (the drifter) amounted

to 75,930 lb. Among the small otter trawlers, the highest landings were by *Bangada* (192,603 lb.) while *Champa* came second with 148,928 lb. The landings by *Bumili* amounted to only 76,310 lb. Considering the period of operation, the landings by *Durga* should be taken to be good, because during only six months of fishing this boat landed 129,173 lb. In all the four otter trawlers, the bulk of the catch consisted of *Dhoma* (small sciaenids mostly *Otolithus* spp.) and prawns. The major category in the case of *Meera* was sharks, among the classified items, although the unclassified miscellaneous group (21,629 lb.) occupied a very high place, probably the highest.

Catch per unit of effort.—The catch per unit of effort (catch per hour) varied in the case of the four trawlers from 124.5 lb. (*Bumili*) to 284.5 lb. (*Bangada*). The return per unit of effort in the case of *Durga* which is the smallest among the four trawlers is considered very good, being 263.6 lb. In the case of *Meera*, the unit of effort is taken as one set of the net and catch per set of net works out to 366.8 lb. The best results have been obtained between September and December 1956. All the boats (the drifter *Meera* as well as the trawlers) obtained the highest catch rates in the month of November.

Working of the New India Fisheries Trawlers.—During the year under review a private fishing company, the New India Fisheries Ltd., started fishing operations in Bombay and Saurashtra waters. Two sets of bull trawlers, *Arnalla* and *Paj* and *Satpatti* and *Pilotan* commenced their operations in April 1956 and continued fishing without break even during the monsoon months. Up to September the boats worked in the Bombay and Gulf of Cambay regions and later they moved over to the Dwarka fishing grounds. These boats made three trips per month on an average. A total weight of 61,07,340 lb. of fish was landed by these boats up to the end of February 1957. *Dhoma* (18.9%), *Wam* (15.0%) and sharks (14.9%) constituted the bulk of the landings. *Dara* (8.9%) and *Karkara* (7.9%) also occupied a fairly high place in the landings. *Ghols* formed 5.2% and catfishes 6.7%. *Koth* formed only about 2.7% in the total landings. The monthly landings ranged between 4,55,730 lb. and 7,16,655 lb. except in April 1956 when the operations were just commenced. The months of very high landings were August, September, November and February. *Dara* and *Koth* landings were seen to be best during November to February, while good catches of *Wam* were obtained in April, May, July, August, October and November, the maximum quantity having been obtained in August (2,14,360 lb.) out of an annual total of 9,17,160 lb. *Karkara* was caught in good quantities from September to February, the maximum being in November. *Rawas* and pomfrets formed a very small percentage of the landings.

34. *Pomfret fishery*.—The pomfret fishery along the Bombay coast is constituted by three species, namely, the silver pomfret (*Pampus argenteus*), white pomfret (*Pampus chinensis*) and black pomfret (*Parastromateus niger*). Among the three species occurring in the local fishing grounds the silver pomfret is the commonest, and the black pomfret is next in importance. In the northern region near the gulf of Kutch, the white pomfret is the dominant species. Juveniles of all the three species are caught in the *dol* nets (bat nets) whereas the gill-nets catch only the bigger size-groups. Gill-nets operating in surface waters yield better pomfret catches than those operating in the bottom waters. Young ones of all the three species ranging from 2 to 8 cm. have been occurring along the coastal waters from September 1956 onwards with the peak season extending from December to January. Generally pomfrets have not been found to constitute a significant part of the catches landed by trawlers engaged either in otter-trawling or bull-trawling. The inshore stock of pomfret has been found to be constituted by juveniles and mature individuals of all the three species. A preliminary study of the intraovarian eggs has indicated that the pomfrets have a protracted spawning period. Scales of one species only (*P. niger* of over 20 cm.) have shown the presence of 3 to 4 growth checks but the otoliths did not show any such checks.

(5) At Karwar

35. *General fishery conditions*.—The total quantity of fish landed at Karwar declined from 13,58,335 lb. (636·3 tons) in 1955-56 to 10,50,689 lb. (469·0 tons) in 1956-57. This was mainly owing to the failure of the mackerel fishery this year. Only the *yendi* (shore-seines) were operated during the post-mackerel season, April to May, and in the rainy season, June to September. During the latter period the chief species landed were prawns, *Otolithus* sp., *Trichiurus* sp., *Arius* sp., *Opisthoterius* sp. and *Engraulis* sp. Towards the end of September *putta bale* also began to be used, particularly to catch large-sized mackerel. In the mackerel season, October to March, *rampan* nets came into use, as also *buddi vale* (drift-nets) and cast-nets. The mackerel season of this year commenced on the Karwar coast in the second week of October. Mackerel landings were appreciable to begin with but dwindled considerably later on.

36. *Mackerel fishery*.—The landings of mackerel were studied at six observation centres. They have been estimated to total 1,373·8 tons. October saw the best mackerel fishery. The secondary peak period was noticed in January at Karwar, Binge and Kumta, in February at Chendia and in March at Majali. Sizes of mackerel at Karwar ranged from 10·5 : n.

to 25 cm. total length, the minimum and maximum sizes being 9.8 cm. and 26.2 cm. Measurements of 2,947 specimens were taken for length-frequency studies. There were three dominant size-groups in the fishery (14 to 15 cm., 18 cm. and 23 cm.). Price of mackerel sold to fish-carrier launches at Karwar was Rs. 12 per thousand in October rising to Rs. 54 to 60 in February. At Binge the highest price of Rs. 65 per thousand was obtained in February.

37. *Sardine fishery*.—The fishery for oil-sardine lasted from November to February, the peak month being December. An estimated total of 77,175 lb. of oil-sardine was landed at Karwar during the period. Sizes ranged from 81–146 mm. The dominant size-class was 115 mm. in December and 105 mm. in January. Size-groups at other observation centres were not markedly different from those at Karwar. Twenty-one samples, comprising 2,310 sardines in all, were measured for length-frequency studies. Cast-nets were the chief gear used for capture of oil-sardine.

(6) *At Ernakulam*

38. *General fishery conditions*.—The sardine and mackerel fishery of last season closed somewhat early in February 1956. Sporadic catches, mostly of sardines, continued to be reported, particularly from landing places near the southern end of the Kerala coast, from places like Chellanum and Manassery, in April and the following two months.

The mackerel fishery started again in the first week of September (1956) but after the first few days it became intermittent and continued in that state till about the first week of December. Since then mackerel have seldom been reported. The oil-sardine fishery started at Narakkal in December, but at places some miles to the south like Chellanam it had commenced a little earlier. It continued intermittently till the first week of March at Narakkal, occasional catches being reported even in the first week of April from villages to the south. The earlier catches consisted of mostly small fish but larger ones were also present in later catches. The small fish were obtained mostly by the boat-seines. As usual, boat-seine operations commenced when the oil-sardine fishery declined in February 1956 and continued till about the middle of November. After an interval of 2 to 3 weeks they were resumed at Narakkal primarily for the capture of small-sized oil-sardines in the evenings. From the latter half of January the boat-seine has been in regular use every day. The catches consist of a miscellaneous collection of small fish together with varying quantities of prawns.

39. *Marine prawn fishery*.—This fishery was in operation during the first two quarters of the year under report and came to a close towards the

end of September. The catches, so far as could be judged from the observations made here, have seldom been heavy, the largest catch rarely exceeding 200 lb. The continuance of the fishery into September was somewhat unusual since both in 1954 and 1955 the fishery had closed earlier. The catches consisted of the same species as were reported in previous years with this difference, viz., that in May 1956 a species rarely noticed before in appreciable numbers, *Hippolytmata ensirostris*, accounted for as much as 20·2% (numerical) of the catch. Its appearance and disappearance were equally abrupt. *Parapenaeopsis stylifera* was the dominant species in April and May 1956 and *Metapenaeus affinis* in June, in which month the proportion of *P. indicus* also rose significantly. Its percentage value rose still further in July to 34·1 (numerical) and then suddenly dropped so low as to make it insignificant. *M. affinis* continued to dominate in July and August; but in September *M. dobsoni* was the most abundant, the average value being as high as 98·8. With the resumption of regular boat-seine operations towards the end of January 1957, the prawn fishery has again started at Narakkal and neighbouring places.

An investigation has been initiated to discover if the association of prawn fishery with mud banks, as observed in some places, is capable of scientific explanation. Statistical and biological data bearing on the landings at the two places were collected throughout the year, together with data on the hydrology of the sea-water (both surface and bottom samples). The following figures representing the estimated total landings at Alleppey and Narakkal for the months April to September 1956 provide an idea of the magnitude of the fishery at these centres. The fishery at Alleppey, where a mud bank is formed annually, is far richer than that at Narakkal, where no bank exists.

Month	Estimated total in lb.	
	Alleppey	Narakkal
April	..	9,990
May	..	26,381
June	..	24,70,650
July	..	15,92,222
August	..	34,689
September	..	4,302
		29,640

The observations so far made have not revealed any significant chemical features but they tend to show that the area covered by the mud bank at Alleppey offers a comparatively calm and safe region where prawns migrating into shallow inshore waters could find shelter. This probably is the explanation for the concentration of prawns in the mud bank areas.

40. *Mechanized fishing.*—The collection of data of fishing by the schooners began by the first week of February. From the data of the composition of catches very little difference was noticed between the catches obtained by indigenous gear and the trawl catches. The depths of trawling have ranged from 12 to 27 fathoms and the catches were made up of prawns of much larger size than those of the inshore catches. The species represented are *P. carinatus*, *P. indicus*, *M. monoceros* and *M. affinis*, the smaller species *M. dobsoni* and *P. stylifera* being almost absent. Though the evidence available at present is not adequate, it certainly points to the presence of larger prawns in deeper waters—a conclusion previously arrived at on mostly circumstantial evidence. The urgent need for undertaking exploratory fishing in deeper waters to discover the existence of large commercially exploitable concentrations of such prawns cannot be overemphasized, especially at a time when various fishery development schemes are being vigorously pushed through.

41. *Backwater fishery.*—Stake nets being one of the most important fishing gear in the backwaters, several hundreds of which are in operation throughout the year, it was thought that a fairly good idea of the amounts and composition of the catches from month to month might be useful. The catches of two nets, one at Azhikkal near the harbour entrance and the other at Thevara, a couple of miles south of the premises of the Station, have been regularly studied from June 1956. The total catch of the net at Azhikkal is higher in all the months except June, but the percentage of prawns in the catches is generally somewhat less in this net and in August and September it is comparatively quite small. From December the catches of the net at Thevara dwindled considerably showing thereby that the monsoon months are the best months for nets situated in similar localities.

42. *Experimental paddy-field prawn fishery.*—Arrangements for taking a large field on lease for conducting statistically planned experiments in prawn fishing were finalised and it was formally taken possession of on 26-12-1956. Preliminary steps like putting up of fresh bunds, installing of sluices, etc., were completed and the rest of the work is in progress.

(7) At Madras

43. *General fishery conditions.*—The fishery in general was good and consistent throughout the year under report. Of the many fishing units in operation the boat-seines and the hooks and lines were the chief operating units all round the year. The shore-seines, bag-nets and gill-nets were purely seasonal. Accordingly, the boat-seine catches were of first rank, forming nearly 40% of the total catches. The hooks and lines were second in rank with 25% contribution. Other nets together contributed only 35% of the catches. The bulk of the catches was composed of *Anodontostoma chacunda*, *Trichiurus haumela*, *Decapterus russellii*, *Leiognathus* spp., *Anchoviella commersonii*, Penæids, *Caranx* spp., Perches, *Engraulis mystax*, *Scomberomorus* spp., *Carcharhinus* spp., and *Rastrelliger canagurta*. Other fishes landed in fair quantities were Sciænidæs, *Sardinella sirm*, *Pellona* sp., *Dussumieria hasseltii*, *Arius thalassinus*, *Acetes indicus*, *Stromateus* sp., *Polynemus* sp., *Therapon* sp., *Lactarius lactarius* and *Cypsilurus spilopterus*. The *Anodontostoma*, the *Trichiurus* and the *Decapterus* fisheries were seasonal. There was no intensive fishing by the 'kola-catamarans' for the flying-fish fishery as during the previous years. A note of interest during the year was the occurrence of the juveniles, ranging in size from 4·5 to 10 cm., of *Rastrelliger canagurta* in the shore-seines during February and March 1956.

44. *The study of fishing intensity in the inshore waters of Madras.*—A special scheme of study of the inshore fisheries was started at Madras, particularly from the point of view of its bearing on possible overfishing. Two observation centres, at San Thome and at Madras harbour, have been selected and collection of detailed data on craft and gear in operation, the duration of fishing time, the total catch, the catch per man-hour and the species-composition of catches, has been initiated. Approximately sixty-three species occurred in the fish catches but of them only about fifteen species were predominant, the first and second ranks being taken by *Trichiurus haumela* and *Decapterus russellii*. The total catch for the year was estimated at 949·59 tons, to which the contribution of the *thurivala* was 50·01% and of the hooks and lines was 31·05%. Shore-seines, *madavala*, *yadavala*, and *tharavala* together contributed only 18·96%. Good catches were obtained from April to October, with the peak in August. The catches diminished from November to February, perhaps to some extent because of the adverse weather conditions during the north-east monsoon period. The catch per man-hour was 2·20 lb. for the year. The return was greater in the second quarter than in the other quarters with August showing the peak return of 3·38 lb. per man-hour. A range of 2·39 lb. per man-hour occurred between the maximum and minimum returns.

45. *Biology of clams.*—Investigations on clams have been continued. The clams were found to pass through a phase of indeterminate gonadic condition just previous to the stage of active proliferation of the germinal cells. Their spawning season appears to start in July, lasting for a period of four months. Based on the observations on the gonadal condition and the non-availability of seed clams during any period other than July to September it was presumed that *Meretrix casta* spawned only once a year. From the fat composition analysis during the course of this study it was clear that the clams held the maximum amount of fat during January to May. It was concluded that this was the best time for their collection when they occurred in most edible condition.

(8) *At Waltair*

46. *General fishery conditions.*—Data on fish landings were collected at Lawson's Bay from July 1956 to March 1957. Four types of fishing units, viz., boat-seine, shore-seine, gill-net and hooks and lines were in operation during the nine-month period of observation. The boat-seine catches consisted of clupeids, *Chirocentrus dorab*, *Trichiurus*, *Leiognathus*, *Polynemus*, *Sciæna* and prawns. The highest return from the boat-seine during this period was in the month of July 1956. The best period for shore-seine operations was found to be from November 1956 to February 1957. The landings comprised mainly clupeids, *Chirocentrus dorab*, *Leiognathus* and *Caranx*. Gill-net fishing yielded the best results from November 1956 to March 1957. The catches were exclusively made up of sardines. The hook and line catches were composed of sharks, *Scomberomorus*, *Chorinemus* and *Arius*. In general, the fishery was good from July to September 1956. There was an abrupt decline in the fishery in October 1956 which may be attributed to unsavourable weather conditions and rough seas. A general improvement in the fishery was, however, seen in the succeeding months with the starting of the sardine fishery from November 1956. Clupeids consisting of sardines, *Anchoviella*, *Thrissocles* and *Dussumieriæ* formed the major portion of fish landings. The other important fishes were *Trichiurus*, *Scomberomorus guttatus*, *S. commersonii*, *Chirocentrus dorab*, *Polynemus*, *Sciæna*, *Sillago*, *Upeneus*, *Leiognathus*, *Arius* and sharks. *Harpodon nehereus* and *Cypsilurus* made their appearance for a brief period of two months and were caught in small numbers. The former was recorded in August and September 1956 and the latter in September and October 1956. *Cypsilurus* again appeared in February after a lapse of four months. *Trichiurus* and *Polynemus* were absent in the fish landings from November to January 1957.

47. *Mackerel observations.*—Juvenile mackerel were encountered in all the months except February 1957. This is interesting because, so far, observations on the occurrence of juvenile mackerel have shown that they appear in the Malabar and Kanara coast only during June to September and off Vizhingam during April to June. On the east coast off Madras they have been recorded in March and April. It is possible that we are dealing with different populations of one or more species with slightly different breeding seasons. A detailed study is being made in order to find the explanation for the observed phenomenon.

The adult specimens of mackerel were encountered in only five months, namely, April, August, September 1956 and February and March 1957. The maturity stages of male and female fish in April were III, IV and IV respectively. In August and September, male mackerel were in stages IV, V, and VI, and the female in IV and V. In February 1957, males in all stages of maturity I to V or VI were noted and the females in stages II to V. In March 1957, only female fish were examined and they were in stages II to V.

48. *Clupeoid fishery.*—Observations on the clupeoid fishery at Lawson's Bay were made from July 1956, to March 1957. From July to October, boat-seines were the main gear operated and clupeoids caught were (in the order of abundance) whitebait, anchovies, *Pellona ditchela* and rainbow sardine. Sardine fishery started in November. Gill-nets were the main gear operated from November to March and their catches were exclusively composed of sardines. Shore-seines were also operated frequently for sardines. From November to March sardines formed the major fishery along with whitebait and the rainbow sardine. The size-range and stages of sexual maturity of different species of clupeoids caught at Lawson's Bay from May 1956 to March 1957 were recorded for study.

(9) At Calcutta

49. *Report of trawling operations in Bay of Bengal.*—Five trawlers, namely, *Kalyani I* to *Kalyani V* belonging to the Deep-sea fishing scheme of the West Bengal Government conducted fishing operations during the year, mainly in the months of January, February, March, November and December. Fishing was concentrated off Black Pagoda Point and Sand Heads regions. Fishing was also done off Tiger Point, False Bay Point off the Baitarani river mouth. Trawlers made 27 voyages altogether, and did fishing for 108 days, out of which 68 days were spent in the Black Pagoda area. The total quantity of fish landed by all these boats during the year is estimated at 5,44,650 lb. (247.01 metric tons). The average catch per

fishing day works out at 6922·8 lb. in the Black Pagoda region and 1566·0 lb. in the Sand Heads region. The following table shows the catch composition from the various regions.

Table showing the composition of fish at various regions

(Figures in lb.)

	Black Pagoda region	Sand Heads region	Tiger Point	False Bay, False Point and Baitarani R.	Unspec- ified	Total
	(1)	(2)	(3)	(4)	(5)	(6)
*A. Class:						
Prawns	4,173	3,126	..	..	124	7,423
Pomfrets	6,944	5,202	..	..	207	12,353
Mackerel	19	14	..	..	1	34
*B. Class :						
Sciaenids <i>(Bhola)</i>	173,572	13,290	1,280	960	3,747	192,849
<i>Kurtus</i> <i>indicus</i>	122,252	9,360	902	676	2,639	135,829
Bombay-duck	118,827	9,098	876	658	2,565	132,024
Herring	6,582	504	48	36	143	7,313
Ribbonfish	2,134	164	16	12	46	2,372
Miscellaneous	21,346	1,634	158	118	461	23,717
*C. Class:						
Elasmobran- chs and Eels	14,903	15,550	246	..	37	30,736
	470,752	57,942	3,526	2,460	9,970	544,650

* This classification is based entirely on the prices they fetched in the Calcutta market.

It may be seen from the above table that although the catch per fishing day from the Sand Head regions is much lower than that from the Black Pagoda region, the relative proportion of the first quality fish is higher in the former than in the latter region.

(10) *At Vizhingam*

50. *Mackerel studies.*—The appearance of mackerel in the fishery has been erratic, and catches for the year were estimated at about 12·7 tons. Of this about 30·0% was composed of juveniles (11–13 cm.), 34·0% by the typical commercial size-group of 19–21 cm. and 35·0% by spawners measuring 24·0–27·0 cm. The last-mentioned size-groups have been recorded in the fishery for the first time in India.

During the year under review, 14,220 specimens were measured for length-frequency studies and their stages of maturity recorded with a view to fixing their spawning season and determining their age and length at maturity. Post-larval mackerel, 11–22 mm. in length, have been recorded from October to June. This is the first time they are obtained in such large numbers in Indian waters for such a continuous period. This as well as other evidence suggests that the spawning season of mackerel is a prolonged one extending from July to March. There are reasons to believe that the spawning area is outside the present fishing limits, but not too far from the 30 fathom area which is about three miles from the shore. Some eggs believed to be of mackerel have been separated from the plankton collected off Vizhingam during two seasons, April to June and September to January. Since the attempts to rear the eggs failed, the identity of the eggs could not be established. It has been shown that mackerel grows to about 14–15 cm. in the first year. The commercial fishery size of 19–21 cm. may be two years old; they are immature. By the time they begin to spawn, they are three years old and have grown to 23–24 cm. The probability of a fourth year-class in the 25–27 cm. group is indicated. Specimens up to 30·2 cm. have been recorded.

(11) *At Quilon*

51. At this newly started unit a regular survey of the fish landing at Quilon and at Sakthikulangara was started. Analysis of the catches brought by the indigenous craft and the mechanized boats of the Indo-Norwegian project was made with a view to comparing their catches and the size composition of the common species entering the inshore and offshore fisheries.

MARINE BIOLOGY

(1) *At Mandapam*

52. *Plankton Studies.*—Comparative studies on the plankton of the fishing ground (offshore) and that of an inshore station off Thangachimadam have decidedly indicated that the plankton of the offshore area is relatively

greater in quantity. Detailed analysis, however, revealed that such inedible forms as *Noctiluca* and hydromedusæ were often found in greater numbers in the inshore region while copepods, chætognaths, *Eavadne*, *Oikopleura* and *Lucifer* appear to be more abundant in the offshore waters. Larval forms of echinoderms and polychætes may be said to be more common in the inshore region, whereas those of lamellibranchs, gastropods and decapods are almost equally abundant in the offshore and the inshore regions. The greater abundance of edible forms in the offshore region may be one of the important reasons for the occurrence of larger fish populations there.

Routine analysis of plankton of the Gulf of Mannar and Palk Bay revealed the following interesting features. (i) Exceptionally large populations of *Lucifer* occurred during April to May; *Eavadne tergestina* during December to January and *Cresolis acicula* and *Penilia avirostris* during February to March were encountered in this area but only in the Gulf of Mannar, (ii) *Thalassiothrix frauenfeldii* and *Noctiluca* which were conspicuous in the Gulf of Mannar during July to August 1955 were almost completely absent during the same period this year, (iii) For the first time enormous numbers of *Dinophysis miles* Cleve were recorded in this area; they appeared in September, (iv) Unusually large numbers of *Ceratium massiliense* were seen in this area; they first appeared in Palk Bay during the early part of October and were abundant by the middle of the month; in the Gulf of Mannar they appeared in appreciable numbers only towards the middle of October and they began to decrease in both regions by November. The mackerel caught locally during this period had their stomachs gorged with these dinoflagellates, (v) There was a conspicuous absence of blooms of *Trichodesmium* both in Gulf of Mannar and in Palk Bay during the year under review. A plankton calendar for the waters around Mandapam has been prepared for publication.

53. *Fish eggs and larvæ*.—Monthly fluctuations in the occurrence of fish eggs in the Gulf of Mannar and the Palk Bay were recorded. Attempts to collect *Chanos* eggs and early larval stages were not a success.

(2) At Kozhikode

54. *Plankton studies*.—Routine work on plankton (phytoplankton and zooplankton), was in progress during the year at inshore and offshore stations. Data were collected on the quantitative and qualitative fluctuations of the standing crop and its magnitude in terms of Harvey units, displacement volume and dry weight and so on. Hydrological studies were continued and data recorded on several aspects. Phytoplankton production

was at its maximum during the south-west monsoon months and attained a peak in July. There was a secondary bloom in January. There was no sustained bloom of *Fragilaria* this year though intense blooms occurred on a few occasions. Zooplankton attained its zenith of development after the phytoplankton bloom. The employment of better collection methods has yielded a large number of forms not so common in the collections hitherto. Hydrological data showed that the nutrient salt content during the year was of a higher order when compared with the previous year.

(3) At Karwar

55. *Studies on plankton and hydrology.*—Temperature was low during July to September and December to February. Alkalinity, pH and salinity were on the decline at all places of observation during June to September, the lowest values being obtained in the Karwar Bay owing to the influence of the Kali River. Dissolved oxygen and percentage saturation were low during April to May and October. The peak values for phosphates occurred as expected between July and October. The nitrate contents reached the primary maximum during May to July with a secondary rise during December to April. Silicates reached their maximum values during the monsoon.

The different constituents of the plankton and their seasonal distribution were as follows; The diatoms reached their peak during July to October with a secondary peak sometime between December to May. Dinoflagellates were abundant during August to September and November to December. Blooms of *Dinophysis miles*, usually observed during November to December, were not noticed. *Noctiluca* was found to occur in abundance during June to October, cladocerans, copepods and crustacean larvae were found to abound during August to December.

56. *Studies on fish eggs.*—Plankton samples collected from six different stations were examined and eleven types of fish eggs were recorded during the year. Of these nine types have been tentatively assigned to certain groups of fishes. Of the six stations, Karwar Bay appeared to be the best spawning ground.

(4) At Bombay

57. *Hydrological studies.*—The main trends in the hydrological conditions are indicated below. In regard to surface temperature, the annual range of variation was about $6^{\circ}\text{C.} \pm 0.3^{\circ}\text{C.}$, the variations being greater in the neighbourhood of Sassoon Dock than in the other two areas. The mean monthly values for temperature fluctuated between 23.7°C. in the

winter months and 30.0°C . in May (midsummer). In general, low temperatures prevailed between December and March. In the case of salinity, the range of variation was $17.7\% \pm 0.2\%$. The salinity was very high in the two months preceding the south-west monsoon and in the two months following the monsoon. During the monsoon months, June to August, the salinity was lowest in these inshore stations. Values as low as 18.25% were obtained in the Apollo Bundar and Sassoon Dock sampling stations. Lowest values were generally in the July to August period.

Inorganic phosphate values range between 0.10 and $0.66 \mu\text{g. at P/l.}$; the range of values for total phosphorus was 0.27 – $1.84 \mu\text{g. at P/l.}$ Lowest values for inorganic phosphates were seen in September 1956, November 1956 and February 1957; while in the other months phosphate values were, in general, high. The fluctuations were greatest in the month of August 1956. In the case of total P, the concentrations were seen to be high in August 1956 and also during December 1956 to March 1957. Not much regularity was seen in the variations of these two constituents.

The oxygen content of these waters, in general, ranged between 3.00 and 6.00 ml./l. although more extreme values were occasionally observed. In November, for instance, there was a variation from 1.5 – 7.0 ml./l. within the same month. In December again the oxygen content went up to 6.9 ml./l. Excepting for these two months, the mean variation in the dissolved oxygen content within a month was found to be about 1.0 – 1.5 ml./l.

In regard to conditions more offshore (in the fishing areas 43 and 38) although similar salinity trends were seen, the range of variations was much less; the temperatures did not go so low as in the inshore areas described, the lowest value being 24.25°C. The salinity varied between 34.71 and 35.78% . In November, when bottom samples were also collected it was seen that while the surface temperature was 25.8°C. , the bottom temperature was 23°C. The values for salinity, phosphate and dissolved oxygen for bottom waters were respectively 36.11% , $0.50 \mu\text{g. at P/l.}$ and 1.15 ml./l.

(5) At Ernakulam

58. *Plankton studies.*—Diatom blooms did not occur in the monsoon months in Cochin waters as they did at Kozhikode, very probably owing to the subsaline conditions prevailing in this area at the time. The plankton volume was observed to be high in May and June 1956, and also in the first quarter of 1957. Zooplankton was the dominant fraction almost right through the period but there were various instances of blooming of phytoplankton. *Trichodesmium erythraeum* bloomed on 27–12–1956 and 14–3–1957;

Rhizosolenia setigera on 26-9-1956 and *Chaetoceras* sp. on 31-5-1956 and 27-12-1956. In all these instances the plankton volume increased and the phytoplankton fraction exceeded the zooplankton fraction. *Coscinodiscus concinnus* and *Hemidiscus* sp. occurred, though in small numbers, through all the months of the year. The zooplankton included a diversity of species of copepods, larvæ and post-larvæ of decapod crustacea, *Lucifer*, amphipods, chætognaths and fish eggs and larvæ. Among the copepods, *Acartia erythræa*, *Paracalanus parvus* and *Oithona brevicornis* were of very general occurrence with a number of other species occurring at intervals. Two species which were very common at Kozhikode, namely, *Temora turbinata* and *Macrosetella gracilis*, were rather infrequent in Cochin, at least during 1956. On the other hand *Centropages trispinosus*, which was observed only rarely in Kozhikode, was quite numerous in several collections in Cochin. The detailed study of the various plankton constituents was being pursued.

59. *Physical oceanography*.—Theoretical studies on the changes of heat in the Bay of Bengal off Visakhapatnam were made from Andhra University data. They relate to three different periods, viz., 21-10-1952 to 29-10-1952, 19-2-1953 to 4-3-1953 and 4-3-1953 to 17-4-1953. It was found that during the entire period there was a continuous loss of heat from the sea and that the maximum loss occurred at about 10 to 15 miles from the coast. The net loss was more during winter than in summer. Both evaporation from the sea surface, and vertical mixing of sea-water played important roles in the heat changes off Visakhapatnam during the entire period. There were regions at subsurface depths where heat was stored up in each of the seasons.

Two bottom profiles of the continental shelf perpendicular to the coast near Mangalore were recorded with the echo-sounder of the ship INS Rajput and the preliminary analysis showed a layer of mud, with a maximum thickness of about thirty feet, at the bottom over the continental shelf where the depth is less than 200 feet.

PHYSIOLOGY AND FISH FARMING

60. It appears from experimental data that fry of *Chanos* weighing 1·0 gm. and less are more sensitive to temperature changes than those larger than 1·0 gm. The former prefer a warmer environment and probably for this reason they move into the shallow tidal creeks for development.

Changes in salinity show interesting relationship for *Plotosus arabicus* which normally occur in sea-water. At salinities of 10‰ and 46‰ they sur-

vive in lower levels of oxygen in the medium than they do even in their natural environment, sea-water.

The ponds in the newly formed marine fish-farm were stocked with *Chanos* and observations on their rate of growth were being made.

BACTERIOLOGY

61. Studies on the storage of fish in ice and the bacterial flora of fresh and processed fish were continued. Investigations during this period dealt mainly with the use of antibiotic ice for enhancing the storage life of iced fish. Experimental observations using different fishes indicated that ice containing 5 p.p.m. of aureomycin had an advantage over ordinary ice from the second week onwards during storage. Increase in the iodine titre of the muscle as a test for spoilage appeared to be useful. In addition to the viable plate count method used so far for determining the bacterial population of fish muscle, microscope counts were also determined in some of the investigations. Denitrifying bacteria were constantly present in fish kept in aureomycin as well as in fish kept in ordinary ice; pink yeasts and *Nocardia* were present mainly in fish kept in the antibiotic ice. The effect of aureomycin on the growth was determined in the case of a number of marine bacteria isolated and identified during previous studies. 70% of the bacteria were sensitive to the antibiotic at the level of 5 p.p.m. Observations on the quality of fish in boat-landings made on the Rameswaram Island were continued. Bacterial counts in a number of dry and pickle-cured fish were determined in samples obtained from the fish curing section. Investigations on the nitrogenous extractives present in fresh fish muscle were resumed late during the period. The trimethylamine oxide content was estimated in a number of fishes. The TMAO nitrogen varied from 21 to 73.1 mg. N/100 g. of muscle; in the majority of fishes it ranged from 40 to 60. The alpha-amino nitrogen content of cold, aqueous muscle extracts varied from 9 to 42 mg. N/100 g. muscle; in the majority of fishes examined it ranged between 12 to 20 mg. N/100 g.

FISH CURING AND FISHERY BY-PRODUCTS

62. Survey of the regional curing practices and quality of cured fish of the west coast of India have been completed. Work on the use of tetrazolium compounds for the detection of fish spoilage was continued and a new chemical test capable of serving as a routine test has been reported. Experiments dealing with the pit curing and pickling of fish were made and recipes for large-scale pickling of fish with vinegar and spices were devised, suitable for tropical conditions. Along with further studies on the quality

of salt in relation to fish curing, fundamental investigations on other aspects of fish curing have been commenced like the role of humidity conditions.

63. Work on the production of quality fish meal was continued during the year under report. A process involving the fermentation of well-macerated fish flesh with defatted buttermilk at a pH of about 4·0 for a period, not exceeding four hours, was developed in the laboratory and tests carried out on a number of fishes. Detailed investigations on the product obtained by this process showed that when fermentation is carried out under optimum conditions there was appreciable reduction in the fat content and volatile bases. The meal prepared by this process did not have the offensive fishy odours associated with certain types of fish meals. In chemical quality they compared very well with meals prepared by the conventional processes of reduction and solvent extraction. The fermentation process was found particularly suitable for non-oily types of fishes like sharks, rays, etc. Arrangements have been made to have the fish flour tested at the Nutrition Laboratory, Coonoor. Investigations were also carried out on the changes taking place in fish meals during storage under ordinary conditions. The meal prepared by the fermentation process did not develop high rancidity during storage irrespective of whether the sample contained high amounts of fat or not.

64. Efforts were made to put the process of fish meal production on a pilot-plant scale. A small fish meal plant capable of handling 100 lb. of fish at a time was designed and constructed. The plant works on electricity and the total period taken for one set of operations is found to be 5½ hours, which includes the time taken for the treatment and that taken for drying of the sample. Test trials are now being carried out with this plant on different varieties of fish. Further improvements on the plant are being effected with a view to perfecting a small self-contained unit which could be operated on cottage scale.

65. A new method has been worked out for the preparation of pure alginic acid from *Sargassum* seaweeds. In this method complete bleaching of the alginic acid is effected by treating the crude colloidal suspension of the alginic acid with a 2% solution of potassium permanganate in the presence of hydrochloric acid. The most common and commercially important salts of the acid such as sodium alginate, calcium alginate, copper alginate, etc., have been prepared in a fairly pure form from the seaweeds by this new method which seems to offer commercial possibilities.

ALGOLOGY

66. Economy was effected in the cottage industry method of preparing agar for food and general purposes by introducing the step of coagulation with potassium biphosphate of proteins and carrying down with them of suspended cellulose particles. Preparation of bacteriological agar with the critical setting temperature of 34° C. was worked out using a mixture of the main agarophytes which have setting temperatures of 40° and 46° C., with *Hypnea musciformis* which has the setting temperature of 26° C. for the standard concentration of 1·5% agar solution. For this purpose potassium biphosphate is used initially as a coagulant and further coagulation is done by freezing-thawing-melting; the use of an electrolyte (KCl) is necessary to obtain a product that will have the required gel strength. The gel is dried on a plastic net.

An alternate method of preparing agar with a sufficiently low setting temperature for bacteriological work is being investigated. For this *Gracilaria lichenoides* and *Gelidium micropterum* are the raw materials. The setting temperatures of their gels are reduced by the process of prolonged bleaching for about 10 days at cold storage or at ordinary temperatures. Hence bacteriological agar may be prepared entirely as a cottage industry where cold storage facilities are not available. It is not essential to use an electrolyte to ensure that the product will have the required gel strength.

It was found that *Gracilaria lichenoides* beds at Pamban require two years to be re-established after harvesting by the method in which the plant is cut three inches above the holdfast. The possibility exists for organizing a part-time seaweed-drying industry, for it has been shown that repeated sprinkling of the agarophytes with sea-water is better than using fresh-water to bleach the seaweeds while they are drying in the sun. The section of Algology has been in touch with various firms and institutions interested in seaweed utilization.

67. Studies on the genus *Hypnea* of the Indian waters, particularly its taxonomy and distribution, were in progress. Studies on the growth and succession of algae on a coral substratum in the inter-tidal zone have been taken up. These studies are confined to two places, one in the Gulf of Mannar and the other in the Palk Bay. Compilation of a check list of Indian Marine Algae is nearing completion.

CENTRAL MARINE FISHERIES
RESEARCH STATION,
Mandapam Camp, S. India,
15th April 1957.

DR. N. K. PANIKKAR,
Chief Research Officer.

The following scientific papers based on the work at the Research Station have been published during 1956-57:—

115. R. RAGHU PRASAD. 1956. further studies on the plankton of the inshore waters off Mandapam. *Indian J. Fish.*, 3 (1), 1-42.
116. V. KRISHNA PILLAI, A. P. VALSAN AND M. RAJENDRANATHAN NAIR. 1956. Studies on the chemical quality of cured fish products from the west coast of India. *Ibid.*, 43-58.
117. M. S. PRABHU. 1956. Maturation of intra-ovarian eggs and spawning periodicities in some fishes. *Ibid.*, 59-90.
118. L. B. PRADHAN. 1956. Mackerel fishery of Karwar. *Ibid.*, 141-85.
119. S. JONES. 1956. Some deaths due to fish poisoning (Ichthysarcotoxism) in India. *Indian J. Med. Res.*, 44 (2), 353-60.
120. V. KRISHNA PILLAI. 1956. Chemical studies on Indian seaweeds, I. Mineral constituents. *Proc. Indian Acad. Sci.*, 44 B (1), 3-29.
121. G. SESHPAPPAN AND R. JAYARAMAN. 1956. Observations on the composition of bottom muds in relation to the phosphate cycle in the inshore waters of the Malabar Coast. *Ibid.*, 43 B (6) 288-301.
122. G. SESHPAPPAN. 1956. Occurrence of *Johnius hololepidatus* (Lacépède) in Indian waters. *Curr. Sci.*, 25, 121-22.
123. R. VISWANATHAN AND V. KRISHNA PILLAI. 1956. Paper chromatography in fish taxonomy. *Proc. Indian Acad. Sci.*, 43 B (6), 334-39.
124. N. K. VELANKAR. 1956. Bacterial flora, trimethylamine and total volatile nitrogen of fish muscle at 3° C. *Indian J. Fish.*, 3 (2), 261-68.
125. ————— AND P. V. KAMASASTRI. 1956. Studies on Storage of fish at low temperatures—II. Bacterial flora and the trimethylamine and total volatile nitrogen of the muscle at 0° C. (in ice). *Ibid.*, 269-89.
126. G. VENKATARAMAN. 1956. Studies on some aspects of the biology of the common Anchovy, *ThriSSocles mystax* (Bloch and Schneider), *Ibid.*, 311-33.
127. K. VIRABHADRA RAO AND K. NAGAPPAN NAIR. 1956. Rate of growth in spat and yearlings of the Indian backwater oyster, *Ostrea madrasensis* Preston. *Ibid.*, 231-60.
128. K. VIRABHADRA RAO. 1956. Seasonal changes in the adult backwater oyster, *Ostrea (Crassostrea) madrasensis* Preston, from Ennore, near Madras. *Proc. Indian Acad. Sci.*, 44 B, 332-56.
129. V. KRISHNA PILLAI. 1956. Chemical composition of lagoon muds, *Ibid.*, 130-36.

130. V. KRISHNA PILLAI. 1956. A fermentation process for the production of quality fish meal. *Curr. Sci.*, **25**, 293-94.
131. S. V. SURYANARAYANA RAO, M. R. NAIR AND A. P. VALSAN. 1956. Tetrazolium reduction as an index of spoilage in cured fish. *Ibid.*, 396-97.
132. K. H. MOHAMED. 1956. On the occurrence of mummified eels in the internal organs of *Polydactylus indicus* (Shaw) and *Pomadasys* species. *J. Bombay Nat. Hist. Soc.*, **54** (1), 199-201.
133. B. S. BHIMACHAR, S. K. BANERJI AND G. VENKATARAMAN. 1957. A study of the variability in the fish catches taken by successive hauls in the inshore waters off Calicut. *Indian J. Fish.*, **4** (1), 1-19.
134. R. RAGHU PRASAD. 1957. Seasonal variations in the surface temperature of sea-water at Mandapam from January 1950 to December 1954. *Ibid.*, 20-31.
135. V. KRISHNA PILLAI, A. P. VALSAN AND M. R. NAIR. 1957. Studies on the curing and preservation of "Choodai", I. Some aspects of dry salting. *Ibid.*, 32-46.
136. M. KRISHNA MENON. 1957. Contributions to the biology of penaeid prawns of the south-west coast of India, I. Sex ratio and movements. *Ibid.*, 62-74.
137. H. L. ARORA AND S. K. BANERJI. 1957. Flying-fish fishery along the Coromandel Coast. *Ibid.*, 80-91.
138. L. R. KASTURIRANGAN. 1957. A study of the seasonal changes in the dissolved oxygen of the surface waters of the sea on the Malabar coast. *Ibid.*, 134-49.
139. N. K. VELANKAR. 1957. Bacteria isolated from sea-water and marine mud off Mandapam (Gulf of Mannar and Palk Bay). *Ibid.*, 208-27.
140. V. BALAKRISHNAN. 1957. Occurrence of larvae and young mackerel (*Rastrelliger canagurta* Cuvier) off Vizhingam, near Trivandrum. *Curr. Sci.*, **26** (2), 57-58.
141. S. V. SURYANARAYANA RAO. 1957. Preliminary observations on the total phosphorus content of the inshore waters of the Malabar coast off Calicut. *Proc. Indian Acad. Sci.*, **45 B**, 77-85.
142. V. KRISHNA PILLAI. 1957. Trace element requirements of two halophilic Blue Green Algae. *Proc. Indian Sci. Cong. Assn.*, Part III, 269.
143. ——. 1957. Chemical studies on Indian seaweeds. Part II. *Proc. Indian Acad. Sci.*, **45 B** (2), 43-63.
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146. N. K. VELANKAR. 1957. Protein hydrolysate from fish. *J. Sci. and Ind. Res.*, 16 A (3), 141.
147. ———. 1957. Inhibition of bacteria from marine sources by aureomycin. *Proc. 44th Ind. Sci. Cong.*, Part III, Abstracts, 321.
148. ———, AND P. V. KAMASASTRI. 1957. Spoilage of fish on board of the fishing boats. *Ibid.*, 316.
149. ——— AND ———. 1957. Preservation of mackerel in ice. *Ibid.*, 317.
150. S. JONES. 1957. Notes on the frigate mackerels, *Auxis thazard* (Lacèpède) and *A. tapeinosoma* Bleeker, from Indian waters. *Ibid.*, 319.

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- B. KRISHNAMOORTHI. Fishery resources of the Rameswaram Island. *Indian J. Fish.*, 4, 229-53.
- N. RADHAKRISHNAN. A contribution to the biology of the Indian Sand Whiting, *Sillago sihama* (Forskal). *Ibid.*, 254-83.
- V. KRISHNA PILLAI AND M. RAJENDRANATHAN NAIR. Determination of total volatile nitrogen in cured fish products. *Ibid.*, 259-303.
- R. JONES. On the late winter and early spring migration of the Indian Shad, *Hilsa ilisha* (Hamilton) in the Gangetic delta. *Ibid.*, 304-14.
- N. K. VELANKAR. Protein hydrolysate from fish. *J. Sci. and Ind. Res.*, 16 A (3), 141-42.
- R. JAYARAMAN, AND G. SESHPAPPA. Phosphorus cycle in the sea with particular reference to tropical inshore waters. *Proc. Indian Acad. Sci.*, 46 B (2), 110-25.
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- S. V. JOB. The routine active oxygen consumption of the milkfish. *Proc. Indian Acad. Sci.*, 45 B (6), 302-13.
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