

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

**ANNUAL REPORT OF THE CHIEF RESEARCH OFFICER  
FOR THE YEAR ENDING 31st MARCH 1955**

**ADMINISTRATIVE AND GENERAL**

1. All-round progress has been maintained during the year 1954-55 in all research activities at the Headquarters Station at Mandapam Camp and subordinate establishments at Kozhikode, Bombay, Madras, Karwar and Narakkal.

2. Fisheries survey was intensified at twelve selected centres, representative of the various sectors of the Indian coastline, and statistics of production and of catch per unit of effort at these centres have been collected. The total quantity of marine fish landed in India during 1954 was estimated as 5,78,966 tons which shows a small increase of 6,688 tons over the 1953 figures. ~~83%~~ of the total catch was obtained from the west coast, only the remaining 17% has been contributed by catches on the east coast. Among the groups forming the major fisheries, the set-backs in the mackerel and sardine fisheries were offset by increased landings of prawns, particularly in the ~~Bombay~~ area. Among others, increased landings were recorded of sciænids in Bombay and of flying-fishes on the Coromandel Coast.

Studies on the seasonal variations in landings indicated that, as usual, the quarter from October to December was the richest, contributing 38.51% of the total annual yield. The average annual catches per fisherman and boat were 1,693 lb. and 17,130 lb. respectively, on the basis of which an average annual income of Rs. 400 per fisherman for the year is computed.

3. Steps have been initiated for more intensive studies of the two groups forming our major fisheries, viz., mackerel and sardines. Two additional observation centres have been started, one at Malpe and the other at Vizhingam, near Trivandrum. Interesting records have been made of the occurrence of young mackerel at Madras on the east coast and at Vizhingam on the Travancore-Cochin coast, of oil-sardines in Bombay waters and large-scale occurrence of post-larvæ of the clupeoid *Sardinella fimbriata* at Vizhingam. Some general ideas about the relationship of the west coast sardine fishery to the occurrence of certain species of diatoms in the sea have been developed,

which, if confirmed by further observations which are in progress, will help in forecasting this fishery.

4. Substantial progress was made by the Offshore Fisheries Research Unit at Bombay in the study of the composition of the fish stocks in offshore waters. In continuation of the report on the work of the Steam Trawler *Meena*, reports on the working of the Cutters *Ashok* and *Pratap* for the fishing seasons 1949-52 were prepared for publication. Study of the data relating to exploratory fishing operations carried out from Bombay already indicates that, in spite of initial difficulties, trawling can be carried out with really successful results in Indian waters and that deep-sea fishing can substantially contribute to the food resources of the country. The operations carried out by the deep-sea fishing vessels have shown that the yield of fish from Indian waters compares very favourably with that from some of the richest fishing grounds in other parts of the world. These studies also indicated that bull-trawling yields much better results than otter-trawling in Indian waters. In February 1955, during the course of one of the bull-trawling operations made by the Cutters *Ashok* and *Pratap*, in a single haul of 1½ hours' duration made off Dwaraka just outside the Gulf of Cutch, a record catch of 12 tons, consisting mainly of the prime fish "Dara", was made. The total catch obtained on the same voyage was 54 tons, showing an average catch of 2,058 lb. (about a ton) per hour, which is the highest overall average so far obtained for trawling in Indian waters.

5. The Research Station imported a consignment of the exotic fish *Tilapia* from Thailand in August 1952, and has since then been making observations on this fish in experimental tanks and fish ponds. The results of these observations, made under laboratory conditions, indicated the suitability of the fish for introduction in Indian waters, at least in limited areas in the country. A review article on the introduction of *Tilapia* in Indian waters was published during the year by Dr. N. K. Panikkar and Shri P. R. Sadasivan Tampi in the first issue of the *Indian Journal of Fisheries*. The Fisheries Research Committee of the Government of India, at its recent meeting held at New Delhi, in which the Chief Research Officer participated, recommended that *Tilapia* culture should be encouraged in certain parts of the country and that this Research Station should undertake further work on the culture of the fish in brackish waters.

6. During the year further work on possibilities of sea-weed utilization on a cottage industry basis was carried out. Cottage industry methods of agar extraction have been applied successfully to certain species of sea-weeds. It is hoped to have these methods passed on to the Cottage Industries Officers

of the maritime States who may be in a position to popularise the methods in the National Extension Service Blocks and the Community Development Project areas.

7. A notable feature of the work during the year was the starting of studies on fish curing. In order to collect data on the different methods of fish curing practised in various parts of the country and to assess their relative merits a programme was initiated with a general survey of the fish curing yards in Travancore-Cochin, Malabar and Bombay coasts. Chemical analysis of samples, collected from various centres, indicated that the cured product was generally of a very low quality. The Fish Curing Section also carried out investigations on the processing and preservation of *choodai* (sardines) which forms a major fishery near Mandapam.

8. The value of reliable scientific data on the oceans in the field of studies on marine fisheries is widely recognized. But in our country scarcely any such data have so far been collected. With a view to collecting data on the hydrological conditions of the seas around this country, a scheme for the collection of sea-water samples and their analysis was approved by the Ministry of Natural Resources and Scientific Research to be implemented by this Research Station from September 1954. A nucleus staff of three Chemical Assistants and other auxiliary personnel has been sanctioned for the scheme and the staff recruited against these posts was given initial training at Mandapam. Some of the essential equipment, including special kinds of bottles for the collection and transport of sea-water samples, have been procured and preliminary work has been started. The co-operation of the Indian Navy has been secured for the collection of sea-water samples through naval and other patrolling vessels. A number of shipping companies have also been contacted, most of whom have given assurance of their willing co-operation in the collection and supply of sea-water samples from areas covered by their vessels during their voyages and some samples have already been received for analysis. This work is comparable to meteorological studies on land, and the essential need is to have a machinery for the collection of reliable data. The first step for the establishment of a standing organisation has been taken now, and it is hoped that it would be possible to continue and intensify the scheme in future years.

9. On the basis of a request made by the Ministry of Commerce and Industry to the Ministry of Food and Agriculture, a scheme of research on the possibilities of pearl essence production in India has been drawn up and submitted to the Government. There is considerable demand for pearl essence in this country which is at present met by imports. The possibilities of our

domestic fisheries supplying suitable raw material for establishing a pearl essence manufacturing industry need investigation. Although work relating to the final stages of production of this material will be a purely technological problem requiring chemical guidance at a high technical level, a considerable amount of preliminary work, particularly relating to the source from which the raw material can be obtained, could best be carried out in a fisheries research laboratory, provided the necessary staff and equipment were available. Similarly, there is scope for research on the manufacture of fish powder in this country.

10. An amount of Rs. 6 lakhs was allotted by the Government during the year for the construction of permanent residential quarters for the staff at Mandapam and for acquisition of land and construction of a permanent building for the Research Sub-Station at Kozhikode. The Senior Architect, Central P.W.D., visited the Research Station in May 1954, and as a result of the discussions which the Chief Research Officer had with him and other Central P.W.D. authorities, layout plans and preliminary estimates for the construction of permanent residential quarters were prepared by the Central P.W.D. and forwarded to the Government for administrative approval and expenditure sanction. However, owing to departmental delays and difficulties, these estimates were sanctioned only in September 1955.

After detailed examination of the various sites offered for the construction of the Research Sub-Station building at Kozhikode, a site in close proximity to the Madras Government Marine Biological Laboratory was selected because of the several mutual advantages in having the two establishments of the Central and State Government Fisheries Organisations situated close together. Acquisition proceedings for obtaining the land have been initiated and the layout plan and preliminary estimates for the construction of the building have also been prepared and submitted to the Government by the Central P.W.D. in consultation with this Research Station.

The work of laying pipe lines extending the sea-water circulation system to the laboratories at Mandapam has been completed. Another item of capital work carried out was the formation of a jetty and renovation of the suction line of the aquarium sea-water circulation system. Work on the construction of the marine fish farm was started in March 1955, and some progress has been made. Provision of additional street lights, construction of a workshop and installation of a cold storage plant were all items which were sanctioned towards the end of the financial year, but actual work had to be postponed till the beginning of the ensuing year. The acquisition of private land for the marine fish farm has been completed during the year.

11. Financial provision was made during the year for securing a Fisheries Research Vessel for the Institution and strenuous efforts were made for the acquisition of a suitable vessel from various foreign sources. These attempts have so far proved unfruitful owing to no suitable vessel being readily available for purchase. Under the T.C.M. Programme equipment for extension work has been ordered and this is expected to be received shortly.

It has also been possible to purchase during the year, essential furniture, an autoclave, a pH meter, a few microscopes, essential chemicals, glassware, apparatus and other scientific and office equipment from funds sanctioned by the Government for the purpose. A sum of Rs. 3,500, sanctioned by Government, was utilized for providing a few additional showcases for the museum. This has enabled the Station to display exhibits of fishing craft and gear collected from different parts of the country, in a satisfactory manner in a separate room as an extension of the museum. The library of the Research Station has also been augmented by the addition of current numbers of periodicals and latest issues of publications and books having a bearing on marine fisheries.

12. The following Class II appointments have been made during the year against posts sanctioned under the Five-Year National Plan Scheme.

- |                                   |    |  |
|-----------------------------------|----|--|
| 1. Assistant Research Officer     | .. | Shri P. R. Sadasivan Tampi                         |
| (Marine Fish Farm)                |    |  |
| 2.     .. (Marine Biology)        | .. | Shri L. R. Kasturirangan                           |
| 3.     .. (Fish Embryology)       | .. | Shri S. V. Bapat                                   |
| 4.     .. (Physical Oceanography) | .. | Shri A. A. Rama Sastry                             |
| 5.     .. (Physiology)            | .. | Dr. S. V. Job                                      |
| 6.     .. (Fish Curing)           | .. | Shri V. Krishna Pillai                             |
|                                   |    | (Pending selection of a candidate by the U.P.S.C.) |
| 7. Administrative Officer         | .. | Shri P. S. Ponratnam                               |
|                                   |    | (Pending selection of a candidate by the U.P.S.C.) |

Various Class III ministerial and technical posts sanctioned under the Five-Year National Plan, including those of an artist-photographer and a Librarian, have also been filled. Four of the existing Survey Assistants (*viz.*, Sarvashri S. Gopalan Nayar, K. H. Mohamed, S. J. Rajan and A. S. Kaikini) were promoted during the year from the ordinary grade to the selection grade. One of the two newly sanctioned posts of Special Survey Assistants (Class II) was filled by the promotion of the Survey Assistant

Shri A. V. V. Satyanarayana. Some Class IV posts sanctioned have also been filled by recruiting suitable candidates or by departmental promotion.

13. During the year an *ad hoc* Fisheries Committee was set up by the Government of India consisting of the Fisheries Development Adviser to the Government of India, Dr. W. H. Rich of the Stanford University, U.S.A., and the Chief Research Officer of this Station. The Chief Research Officer fully participated in the work of the Committee which concluded its deliberations and submitted its report early in August 1954, after visiting various centres of Fisheries work and after a careful study of the research and development activities at the Central fisheries institutes, the State Government fisheries organizations and University zoology departments. The report of the Committee, since published by the Government, indicates that work of the Central Marine Fisheries Research Station as a whole has shown very satisfactory progress within the framework of its sanctioned programme.

Dr. N. K. Panikkar, the Chief Research Officer, attended the Second Congress of the Pan-Indian Ocean Science Association held at Perth (W. Australia) from the 17th to 24th August 1954 as a member of the Indian delegation. On the conclusion of the Congress, Dr. Panikkar was deputed by the Government to visit various fisheries research centres in Australia and Indonesia before returning to India. A report on fisheries research and developmental activities in both these countries was prepared based on his findings and submitted to the Ministry.

During the year, Dr. N. K. Panikkar continued his duties as Chairman, Technical Committee I and as Member, Special Committee on Fisheries Development of the Indo-Pacific Fisheries Council, as Convener of the National Committee on Oceanography for the Pan-Indian Ocean Science Congress and as Member of the Oceanography Committee of the Central Board of Geophysics.

14. Miss Mary Samuel and Shri R. Velappan Nair, Assistant Research Officers, who were deputed for training in U.S.A. under the Point-Four Programme, rejoined duty in their posts in this Department after successful completion of their training, in August and June 1954 respectively. Shri L. B. Pradhan, Assistant Research Officer, who had been selected for special training at the Marine Biological Laboratory, Plymouth, for a period of about six months, proceeded to the U.K. in December 1954. On being selected by the Union Public Service Commission for the Class I post of Fisheries Research and Investigation Officer in the Ministry of Food and Agriculture, Miss Mary Samuel was relieved of her duties at Mandapam in September 1954

to enable her to join her new post. Shri K. Virabhadra Rao, Assistant Research Officer, was temporarily deputed to officiate in the post of Fisheries Research and Investigation Officer, pending the return of Miss Samuel to India from the U.S.A. Shri R. Velappan Nair, Assistant Research Officer, has been appointed to officiate in the post of Research Officer (Fishery Survey) from December 1954 in the leave vacancy caused by Dr. H. L. Arora proceeding on leave out of India.

15. The first volume of the *Indian Journal of Fisheries*, of which the Chief Research Officer is the Managing Editor, has been published. The *Journal* has been very well received in scientific circles. The second volume of the *Journal* is expected to be issued shortly—(Part I already issued).

16. *Extension*.—The growing popularity of the Research Station as a centre of interest to the educated public and to the less enlightened fishermen communities and other village folk could be well gauged by the increasing number of visitors to the Institution. The marine aquarium and the museum, calculated to create and stimulate general interest in marine animal life and in fishery resources of the country, technology, boats and gear, socio-economics and fish culture, are proving to be valuable aids for adult education. The Institute has also been giving facilities to visiting research workers and students from various parts of the country. These persons are taken around the Institute and the research work carried out in different subjects explained to them. Specialist lectures and demonstrations by the staff of the Research Station were also arranged for the benefit of visiting students' parties from different universities and technical institutes. An extension article on fisheries research was published in Malayalam.

17. Shri Ajit Prasad Jain, Union Minister of Food and Agriculture, visited the Offshore Unit of the Station at Bombay and the Mollusc Research Unit at Madras. Shri J. N. Hazarika, Parliamentary Secretary to the Minister for External Affairs, and Shri C. C. Desai, former High Commissioner for India in Ceylon, visited the Headquarters Station at Mandapam.

Among other distinguished scientific visitors to the Institution during the year may be mentioned the Chairman, Dr. Boon Indrambarya of Thailand, and Members, Mr. J. A. Tubb and Dr. Cecil Miles, of the Executive Committee of the Indo-Pacific Fisheries Council, in March 1955. Along with them Mr. W. J. Ellis, Chief, UNESCO South Asia Science Co-operation Office, New Delhi, and Mr. E. R. A. de Zylva, Deputy Director of Fisheries, Ceylon, also visited the Research Station. The Chairman and Members of the *ad hoc* Fisheries Committee of the Government of India inspected the headquarters

and the subordinate establishments of the Research Station in May-June 1954. Among other scientists who visited the Station may be mentioned Dr. J. N. Nanda of the Defence Science Organization, New Delhi, Dr. C. P. Gnana-muthu, Director of the Madras University Zoology Laboratory, Dr. M. Sirsi, Head of the Department of Pharmacology and Experimental Medicine, Indian Institute of Science, Bangalore, and Mr. Klaus Sander and Mr. K. H. Buschman, two research scholars from Germany. University teachers, who visited the Institute and discussed problems of research, included Dr. S. G. M. Ramanujam, former Vice-Chancellor of the Annamalai University, Prof. Seshachar of the Mysore University and Prof. J. P. Joshua of the Madras Christian College, Tambaram.

18. At the request of the Andhra State Government, the molluscan fisheries specialist of the Research Station inspected the Gokulapalle Oyster Farm and a report containing suggestions for its improvement had been forwarded to the Director of Agriculture and Fisheries, Andhra State.

19. On the basis of a request made to the Railway Board by the Ministry of Food and Agriculture at the instance of this Research Station, the Southern Railway authorities have taken steps to provide additional passenger amenities at the Mandapam Camp railway station by providing cement slab flooring and rail-type covered way to a length of 250 feet for the passenger platform and the rebuilding of a new upper class waiting room.

20. A list of scientific papers published by the staff of the Research Station is appended at the end of the Report.

#### FISHERY SURVEY

21. The analysis of the data collected in 1954 was completed during the year under review. Up to August, 1954, data were collected at one representative centre only of each zone. No data were collected in Zones 3 and 4 up to August, 1954. From September, 1954, observations were made in all zones, and the number of centres under observation was increased to three in each zone, excepting the Travancore-Cochin zone where the centres of observations were raised to six. Since collection of data in Zones 3 and 4 began in September 1954, the estimates of landings in each of these zones could be obtained only for the last four months of the year. These have been converted into annual estimates by extrapolation. The figures are, therefore, necessarily very approximate.

22. *Statistics of fish landings.*—The total weight of landings of marine fish during 1954 along the entire coastline of India and including the landings



from mechanised vessels is estimated at 5,78,966 tons. Table I shows the total marine fish landings of India during the last five years.

TABLE I  
*Statistics of Total Marine Fish Landings*

Year	Landings in tons (1 ton = 2,240 lb.)
1950	5,70,860
1951	5,25,482
1952	5,20,002
1953	5,72,278
1954	5,78,966

23. The zone-wise figures of landings for the five consecutive years, from 1950 to '54, are shown in Table II.

TABLE II  
*Zonal Statistics of Total Marine Fish Landings*

Zones	Fish landings in tons (1 ton = 2,240 lb.)				
	1950	1951	1952	1953	1954
1. West Bengal and Orissa ..	15,439	5,004	6,031	6,773	9,356
2. Andhra Coast (south of Gopalpur to north of Visakhapatnam) ..	39,831	27,839	27,013	10,172	5,447
3. Andhra Coast (Visakhapatnam to Masulipatnam) .. ..	40,588	29,442	22,603	30,878	19,840
4. Andhra Coast (south of Masulipatnam to north of Pulicut Lake) .. .. .	954*	954*	954*	954*	6,330
5. Coromandel Coast (Pulicut Lake to Cuddalore) .. ..	29,807	13,901	8,846	16,640	24,245
6. Coromandel Coast (south of Cuddalore to Devipatnam) ..	9,500	5,627	9,769	21,787	23,589
7. Palk Bay and Gulf of Mannar (south of Devipatnam to north of Cape Comorin) .. ..	3,967	7,081	13,385	7,918	9,298
Total for East Coast ..	140,086	89,848	88,601	95,122	98,105

\* No data were collected in Zone 4 during the four years from 1950 to '53. The figure given is the estimate as obtained from an incomplete survey in 1949.

TABLE II—(Contd.)

Zones	Fish landings in tons (1 ton = 2,240 lb.)				
	1950	1951	1952	1953	1954
8. Travancore-Cochin and South Malabar (Cape Comorin to Ponnani River) .. ..	92,126	111,318	147,588	66,074	78,786
9. Malabar and South Kanara (north of Ponnani River to Mangalore) .. ..	163,702	139,996	50,709	81,584	79,304
10. Konkan Coast (north of Mangalore to south of Ratnagiri) ..	39,789	65,355	87,287	65,787	28,858
11. Bombay and Gujarat Coast (Ratnagiri to Broach) ..	115,858	97,441	127,699	242,172	275,820
12. Kathiawar Coast .. ..	15,685	17,480	16,344	20,029	17,121
Total for West Coast ..	427,160	431,590	429,627	475,646	479,889
Catches by mechanized vessels ..	3,614	4,044	1,774	1,510	972
Grand Total ..	570,860	525,482	520,002	572,278	578,966

The slight improvement in the catch in Zone 1 was due to an improvement of the white-bait fishery in the zone. The decline of the same fishery, along with the failure of the ribbon-fish fishery and a partial failure of the sardine fishery in Zones 2 and 3, was responsible for the lower yields in Zones 2 and 3. The improvement in the landings in Zone 6, noticed in 1953, was also maintained in 1954. The improvement was due to an overall good fishing and a successful flying-fish fishery in the zone.

The total catch in Zone 8 in 1954 was slightly better than that of 1953, but poorer than those of the years 1950, 1951 and 1952. The reason for the lower catches in 1953 and 1954 was the comparatively lower catches of sardines, mackerel, white-baits and cat-fishes. There was also a fall in the ribbon-fish fishery in the zone in 1954. While the catch in Zone 9 in 1954 remained more or less the same as in 1953, the catch in Zone 10 in 1954 was very much poorer than that of 1953. This was due to an utter failure of both mackerel and sardine fisheries all along the zone. The mackerel fishery also failed in Zone 9 in 1954, but the sardine fishery remained good, though not to the same extent as in 1953, and in addition, there was good fishing of *Leiognathus*, prawns, cat-fish and pomfrets. As a result, the total production in Zone 9 did not show any substantial decline in 1954.

The continuous improvement in the landings of Zone 11 seems to be due to increased fishing activities and not due to sudden improvement in some particular fishery. The total catch in Zone 12 remained more or less of the same order as in previous years.

The catch along the east coast in 1954 was about 17% of the total marine fish production in India, the rest of the catch being obtained along the west coast of India.

24. *Composition of fish landings.*—The appendix at the end of the report shows the quantities of the major groups of fishes landed in 1954 in each zone. The overall percentage yield of the various groups of fishes landed along the Indian coast during 1954 is shown in Table III. The corresponding figures for the past four years are also shown in the same table. During the years 1950–52, the Saurashtra Government furnished only the figures of total catch, but not the composition of fishes constituting the total catch. In the absence of analysis of the total catch into constituent groups, the whole catch was put under the item “Miscellaneous” and the overall percentage of various fishes for the whole of India calculated.

It will be apparent from Table III that the mackerel fishery was a failure this year. The higher percentage of prawns is due to increased landings of the same in the Bombay zone. The same reason holds good for higher percentage of sciænid in the total catch. The decline in the percentage of sardines is due to a failure of the *Sardinella fimbriata* fishery in Zones 8 and 2 and due to comparatively lower catch of oil-sardines all along the west coast.

25. *Notes on the various fisheries.*—The composition of each of the above groups of fishes and their geographical distribution are briefly described below:

(a) *Sardines.*—In this group have been included as usual all species of the genera *Sardinella* and *Dussumieria*. The total landings of sardines in 1954 were 52,680 tons. The contribution by the various genera and species is shown in Table IV. The corresponding figures for the past four years are also shown for purpose of comparison.

It will be seen from the table that the fishery for *Sardinella longiceps*, which attained a new height in 1953, was also good in 1954, though a much smaller catch was obtained than in 1953. The oil-sardines are obtained in Zones 8, 9 and 10; but the Zone 9 accounts for most of the catch. In 1954, the Zone 9 accounted for 90% of the total oil-sardine catch, the corresponding figure in 1953 being 91%. It may be of interest to note here that some shoals of *S. longiceps* were reported around Bombay early in 1955.

TABLE III  
Percentage Composition of Fish Landings

Name of fish	Percentage of yield during				
	1950	1951	1952	1953	1954
1. Mackerel .. ..	15.37	19.65	14.77	12.17	4.80
2. Prawns and other crustaceans ..	12.91	14.38	14.57	15.60	26.22
3. Sardines .. ..	18.90	13.04	11.57	12.52	9.10
4. White-bait .. ..	4.24	11.16	7.89	5.00	5.41
5. Elasmobranchs .. ..	2.99	5.53	7.20	2.74	2.72
6. Sciaenids .. ..	5.14	6.22	7.07	5.93	12.45
7. Ribbon-fish .. ..	3.12	3.17	6.75	9.68	5.02
8. Bombay-duck and <i>Saurida</i> ..	2.44	1.36	4.66	7.78	6.13
9. Other clupeids .. ..	4.00	2.49	4.05	3.27	4.80
10. Cat-fish .. ..	2.03	3.25	3.55	4.01	3.69
11. Silver-bellies and <i>Lactarius</i> ..	2.63	3.75	2.70	1.62	3.51
12. Perches .. ..	4.44	0.57	2.51	0.77	0.81
13. Carangids .. ..	1.06	1.84	1.83	1.24	2.79
14. Soles .. ..	5.21	0.37	1.22	0.82	0.29
15. Seer-fish .. ..	1.19	1.33	1.19	0.77	1.06
16. Pomfrets .. ..	0.85	1.73	1.12	3.53	3.16
17. <i>Bregmaceros</i> .. ..	0.38	0.90	0.61	2.51	1.66
18. <i>Chirocentrus</i> .. ..	1.37	0.24	0.41	0.39	0.91
19. <i>Sphyrana</i> (Barracuda) .. ..	..	0.04	0.29	0.04	0.69
20. Flying-fish .. ..	0.35	0.40	0.26	0.09	0.33
21. Red mullets .. ..	0.25	0.28	0.21	0.20	0.26
22. Polynemids .. ..	..	0.15	0.20	0.17	0.39
23. Tunnies .. ..	0.81	0.16	0.16	0.15	0.39
24. <i>Mugil</i> .. ..	..	0.01	0.06	..	0.01
25. Miscellaneous .. ..	10.32	7.98	5.15	9.00	3.40

TABLE IV  
Details of Landings of Sardines

Name of fish	Landings in tons during				
	1950	1951	1952	1953	1954
<i>Sardinella longiceps</i> .. .. .	33,876	16,968	13,676	51,012	33,416
Other species of the genus <i>Sardinella</i> ..	57,813	45,605	43,019	20,647	16,497
<i>Dussumieria</i> spp. . . . .	16,210	5,970	3,365		
Total ..	107,899	68,543	60,060	71,659	52,680

As against an improvement in the oil-sardine fishery, the fishery for other sardines like *Sardinella fimbriata*, *Sardinella gibbosa*, etc., shows a decline. The decline is due to the failure of *Sardinella fimbriata* fishery in Zones 2 and 8.

*Dussumieria* spp. were caught in small quantities in all the zones excepting Zones 11 and 12.

(b) *Anchovies and Whitebait*.—In this group are included *Engraulis* (*Thrissoles*) and *Anchoviella* spp. Excepting the Zone 12, each zone has landed one or the other of these genera. The total landings of this group in 1954 were 31,309 tons. The corresponding figures for the last five years are shown in Table V.

TABLE V  
Landings of Whitebait

Year	Landings in tons
1950	24,231
1951	58,622
1952	41,001
1953	28,637
1954	31,309

The decline in the catch of this group of fish in 1953 and 1954 was due to a decline in the yield of *Anchoviella* spp. in Zone 8.

(c) *Other clupeids*.—This group consists of the following principal genera : *Hilsa*, *Pellona*, *Coilia*, *Kowala*, *Chatoessus*, *Opisthopterus*, *Chanos*, *Dorosoma*, *Raconda*, *Elops* and *Megalops*. One or the other of these genera was found in every zone. The total catch during 1954 was 27,773 tons. The contribution by the various genera are as follows:—

	Tons
<i>Coilia</i> spp. . . . .	11,849
<i>Hilsa</i> spp. . . . .	2,013
<i>Kowala</i> spp. . . . .	5,357
<i>Pellona</i> spp. . . . .	4,122
<i>Chatassus</i> spp. . . . .	3,547
Other genera . . . . .	885
Total . . . . .	27,773

The major portion of *Coilia* spp. was landed in Zone 11. About 78% of the catch of *Kowala coval* and 74% of the catch of *Chatassus* spp. came from Zone 3. *Pellona* spp. were obtained in varying quantities in all the zones. *Hilsa* were caught in Zones 1, 2, 3, 4 and 6 on the east coast and in Zones 9, 11 and 12 on the west coast.

The quantity of catch of this group of fish for the last five years is shown in Table VI.

TABLE VI  
*Landings of Other Clupeids*

Year	Landings in tons
1950	22,826
1951	13,104
1952	21,061
1953	18,720
1954	27,773

(d) *Mackerel*.—*Rastrelliger canagurta* is the only species forming this fishery. The fishery was a failure in 1954. The total catch of mackerel in 1954 was only 27,812 tons. As will be seen from Table VII, this was the lowest mackerel yield for the last five years. The table also

indicates the extent of the mackerel fishery in the different zones during the last five years. It will be noticed that, while it completely failed on the Malabar and South Kanara coasts, it was not so bad on the North Kanara coast.

TABLE VII

Zones	Landings in tons during				
	1950	1951	1952	1953	1954
Zone 1	..	39	2	24	5
„ 2	..	287	73	45	29
„ 3	982	969	581	794	..
„ 4	..	..	..	..	34
„ 5	1,252	..	47	275	293
„ 6	155	9	..	..	..
„ 7	..	1	5	..	..
„ 8	8,687	4,586	2,288	79	693
„ 9	71,865	61,766	25,542	15,060	7,732
„ 10	4,814	35,586	48,244	53,359	19,026
„ 11	..	..	..	..	..
„ 12	..	..	..	..	..
Total	87,755	103,243	76,782	69,636	27,812

(e) *Marine prawns, shrimps and other crustaceans.*—Marine prawns of various genera, principally *Metapenæus*, *Penæus*, *Parapenæopsis*, and the shrimp *Acetes* were obtained throughout the coastline in varying quantities. The total catch of this group was 1,51,789 tons in 1954 and is the highest during the last five years. The weights of yield for this group for the past five years are given in Table VIII.

The increase in yield in 1954 was due to a heavy increase of landings of this group in Zone 11. Though all zones contributed towards the landings of this group, the share of Zone 11 alone accounted for 92% of the yield. The corresponding figures for 1953, 1952, 1951 and 1950 are 86%, 81%, 76% and 64% respectively.

TABLE VIII  
*Landings of Prawns, etc.*

Years	Landings in tons
1950	73,694
1951	75,584
1952	75,785
1953	89,254
1954	1,51,789

(f) *Sciænids*.—This group includes all the species of the genera *Sciæna*, *Sciænoides*, *Otolithus*, *Umbrina* and *Pseudosciæna*. The total landings of sciænids are 72,055 tons and this is the highest yield during the last five years. The zonal contributions towards the total yield of this group are shown in Table IX for the years 1950-54.

TABLE IX  
*Landings of Sciænids*

Zones	Landings in tons during					
	1950	1951	1952	1953	1954	
Zone 1	..	..	144	362	11	173
.. 2	..	1,227	309	378	128	171
.. 3	..	2,654	2,711	2,877	3,931	1,159
.. 4	..	112	112	112	112	629
.. 5	..	..	156	226	1,200	1,486
.. 6	..	1,721	1,357	1,366	2,828	4,377
.. 7	..	..	22	758	13	69
.. 8	..	5,591	8,215	2,849	1,004	6,170
.. 9	..	2,259	1,232	1,597	416	1,514
.. 10	..	3,796	5,150	20,146	1,079	2,798
.. 11	..	11,991	13,281	6,117	22,280	53,178
.. 12	..	..	..	..	571	151
Mechanized vessels	..	..	..	..	420	180
Total	..	29,351	32,689	36,788	33,993	72,055



The high increase in the yield of this group of fish in 1954 was due to a heavy increase in the landings of sciaenids in Zone 11. It may be noted that sciaenids were being landed in greater quantities in Zone 11 from 1953.

(g) *Elasmobranchs*.—The total landings of this group in 1954 was 15,767 tons. The figures for the years 1950–54 are shown in Table X.

TABLE X  
*Landings of Elasmobranchs*

Year	Landings in tons
1950	17,088
1951	29,053
1952	37,449
1953	15,661
1954	15,767

The fall in the catch of elasmobranchs in 1953 and 1954 was due mainly to a decline of this fishery in Zone 8.

(h) *Silver-bellies and Lactarius*.—In this group are included the genera *Leiognathus*, *Gerres*, *Gaza* and *Lactarius*. The yield of this group shows a recovery after a decline in 1953. The figures of landings for the last five years are given in Table XI.

TABLE XI  
*Landings of Silver-bellies and Lactarius*

Name of fish	Landings in tons during				
	1950	1951	1952	1953	1954
Silver-bellies .. ..	9,774	17,036	8,225	9,259	14,640
<i>Lactarius</i> .. ..	5,259	2,676	5,811		5,682
Total ..	15,033	19,712	14,036	9,259	20,322

Both *Leiognathus* and *Lactarius* were caught in all the zones excepting Zone 12. The Zones 8 and 9 are the principal regions for these fishes, although they are also obtained in fair quantities in Zones 5 and 6 along the east coast.

(i) *Ribbon-fish*.—*Trichiurus savala* and *Trichiurus haumela* are the two species of this group. The catch in 1954 has declined to some extent. The yields of this fish for the years 1950-54 are given in Table XII.

TABLE XII  
*Landings of Ribbon-fish*

Zones	Landings in tons during				
	1950	1951	1952	1953	1954
Zone 1	.. ..	52	68	73	148
.. 2	.. 1,028	679	786	788	217
.. 3	.. 1,201	274	258	352	77
.. 4	.. 141	141	141	141	944
.. 5	.. 2,918	272	149	2,052	868
.. 6	.. 124	106	149	126	205
.. 7	.. ..	159	5,205	1	1,914
.. 8	.. ..	10,063	25,075	22,895	11,062
.. 9	.. 5,926	2,352	335	139	56
.. 10	.. 529	124	26	72	141
.. 11	.. 5,955	2,456	2,912	28,770	13,267
.. 12	.. ..	..	..	Nil	190
Total	.. 17,822	16,678	35,104	55,409	29,089

The decline in the total catch of this fishery is due to its fall in Zones 8 and 11, where the fishery was very successful in 1953. There were also good catches of Ribbon-fish in Zone 8 in 1952.

(j) *Bombay-duck and Saurida*.—The total landings of this group in 1954 was 35,482 tons, of which only 474 tons were of *Saurida* spp. The major portion of the catch came from Zones 11 and 12, which contributed 62% and 36% of the total catch respectively. The rest of the catch came from other zones. The landings of this group of fish during the past five years were as follows:—

TABLE XIII  
Landings of Bombay-duck, etc

Year	Landings in tons
1950	13,937
1951	7,147
1952	24,258
1953	44,546
1954	35,482

Compared with the 1953 landings, the catch in 1954 has declined. This is primarily due to a lower yield in Zone 11. The figures for 1950-52 were very poor compared to those of the last two years. This happened because the total catches of Zone 12, more than 60% of which consisted of Bombay-ducks, were grouped together as miscellaneous fishes.

(k) *Cat-fish*.—*Arius* and *Plotossus* are the two genera comprising this group, of which the genus *Arius* was predominant, being landed in all zones. The total landings of cat-fishes in 1954, together with the figures for the years 1950-53, are presented in Table XIV.

TABLE XIV  
Landings of Cat-fish

Year	Landings in tons
1950	11,593
1951	17,073
1952	18,450
1953	22,950
1954	21,354

The trend during the last five years shows an improvement. The Zones 6, 8, 9, 10 and 11 were the principal regions in which cat-fishes were landed in 1954.

(l) *Perches*.—This group includes such genera as *Serranus*, *Lutjanus*, *Lethrinus*, *Synagris*, *Scolopsis*, *Pristipoma*, *Therapon*, *Sillago*, *Sparus*, *Diagramma*, *Lates*, *Apogon*, *Aprion*, *Teuthis*, *Caesio*, etc. The total landings of perches are shown in Table XV.

TABLE XV  
*Landings of Perches*

Year	Landings in tons
1950	25,326
1951	2,969
1952	13,052
1953	4,388
1954	4,713

The yield in 1954 is of the same order as that in 1953, but is much lower than the corresponding figures of 1950 and 1952. Those heavy yields were due to a heavy catch of *Casio cuning* in Zone 5 in 1950, and to a heavy catch of *Synagris* sp. in Zone 11 in 1952. *Casio cuning* was practically absent in subsequent years.

(m) *Carangids*.—*Caranx* and *Chdrinemus* are the two important genera constituting this group. The total landings during the last five years are given in Table XVI.

TABLE XVI  
*Landings of Carangids*

Year	Landings in tons
1950	6,025
1951	9,664
1952	9,529
1953	7,068
1954	16,150

These fish are obtained in all zones in varying quantities, the principal zones of catch being Zones 5, 8 and 9. The improvement in the catch in 1954 was due to a good yield in Zone 5.

(n) *Soles*.—*Cynoglossus* and, to some extent, *Synaptura* constitute this group. The catches for the last five years are presented in Table XVII.

TABLE XVII  
Landings of Soles

Year	Landings in tons
1950	29,717
1951	1,931
1952	6,367
1953	4,718
1954	1,657

After the decline following a bumper catch of *Cynoglossus* in Zone 9 in 1950, the fishery has not yet shown signs of recovery.

(o) *Seer fish*.—*Cybium* spp. constitute this group. The landings for the last five years are shown in Table XVIII.

TABLE XVIII  
Landings of Seer Fish

Year	Landings in tons
1950	6,797
1951	6,979
1952	6,212
1953	4,434
1954	6,156

Seer fish were obtained in all the zones in 1954, but Zones 2 and 5 were the regions where it was obtained in good quantities.

(p) *Pomfrets*.—This group consists of three species, *Formio niger*, *Stromateus cinerus* and *S. sinensis*. These fish were caught almost in all the zones. The zonal production figures are shown in Table XIX.

TABLE XIX  
Landings of Pomfrets

Zones	Landings in tons during					
	1950	1951	1952	1953	1954	
Zone 1	..	..	64	153	46	52
.. 2	..	574	356	354	118	62
.. 3	..	483	403	678	926	10
.. 4	..	187	187	187	187	409
.. 5	..	1,562	865	724	339	419
.. 6	..	201	167	399	17	601
.. 7	..	..	6	74	13	26
.. 8	..	..	579	354	2,101	630
.. 9	..	556	5,978	183	4,920	5,670
.. 10	..	..	203	131	39	124
.. 11	..	1,263	166	2,592	10,728	9,240
.. 12	..	..	..	..	773	1,077
Total	..	4,826	9,074	5,829	20,207	18,320

From 1953 onwards the landings of pomfrets in Zone 11 have increased.

(g) *Bregmaceros maccllelandi*.—This fish is found mainly in Zone 11. Its total landings during the last five years are shown in Table XX. The catch during 1953 and 1954 was very high.

TABLE XX  
Landings of Bregmaceros

Year	Landings in tons
1950	2,167
1951	4,755
1952	3,154
1953	14,337
1954	9,599

(r) *Chirocentrus*.—This fish is landed in all zones and Table XXI shows the zonal production during the last five years.

TABLE XXI  
Landings of *Chirocentrus*

Zones	Landings in tons during				
	1950	1951	1952	1953	1954
Zone 1	..	50	107	87	245
„ 2	191	72	165	60	63
„ 3	653	465	327	448	1,869
„ 4	20	20	20	20	87
„ 5	..	..	46	180	366
„ 6	269	238	567	939	1,830
„ 7	..	319	509	371	297
„ 8	6,679	..	59	13	221
„ 9	..	..	..	..	8
„ 10	..	85	70	6	92
„ 11	..	..	255	97	165
„ 12	..	..	..	..	51
Total	7,812	1,249	2,125	2,221	5,294

The slight improvement in the landings of *Chirocentrus* in 1954, was due to increased catches in Zones 3 and 6.

(s) *Sphyræna (Barracoudas)*.—The total landings of *Sphyræna* spp. during the last five years are given in Table XXII.

TABLE XXII  
Landings of *Sphyræna*

Year	Landings in tons
1950	(Not available)
1951	208
1952	1,494
1953	232
1954	3,988

A good catch of this fish in Zone 8 was responsible for the higher yield in 1954. The Zone 8 accounted for 90% of the total catch in 1954.

(t) *Flying-fish*.—The fishery consists of two or three species of the genus *Cypselurus*. Although they are caught in some four or five of the 12 zones, it is important as a fishery only in Zones 5 and 6. The fishery in these two zones is highly seasonal; it starts from the end of May and is over by the middle of July, featuring significantly in the economy of the fishermen in the region. After a failure of the fishery for three consecutive years, it yielded very good catches in Zone 6 in 1954. The figures for the last five years are given in Table XXIII.

TABLE XXIII  
*Landings of Flying Fish*

Zones	Landings in tons during				
	1950	1951	1952	1953	1954
Zone 2 ..	299	933	719	95	69
„ 3 ..	..	..	52	71	..
„ 5 ..	954	944	324	325	87
„ 6 ..	724	240	257		1,748
„ 7 ..	..	..	..	..	31
Total ..	1,977	2,117	1,352	491	1,935

(u) *Red mullets*.—This group consists of *Upeneus* spp. and *Upenoides* spp. These fish are mostly obtained in Zones 3, 8 and 10. The catch for the last five years are shown in Table XXIV.

TABLE XXIV  
*Landings of Red Mulletts*

Year	Landings in tons
1950	1,440
1951	1,501
1952	1,071
1953	1,136
1954	1,513



(v) *Polynemids*.—Various species of *Polynemus* constitute this group. They are obtained in small quantities in all zones. The zonal distribution of the catch during the last four years is shown in Table XXV. There has been some improvement in the catch in Zones 6 and 11 in 1954.

TABLE XXV  
*Landings of Polynemids*

Zones	Landings in tons during			
	1951	1952	1953	1954
Zone 1	256	670	..	61
„ 2	..	5	14	25
„ 3	141	75	102	341
„ 4	..	..	..	..
„ 5	17	4	193	240
„ 6	61	43	244	607
„ 7	..	..	..	..
„ 8	..	..	..	8
„ 9	..	..	..	8
„ 10	39	44	..	17
„ 11	273	217	266	772
„ 12	..	..	..	9
Mechanized vessels	..	..	200	160
Total	787	1,058	995	2,248

(w) *Tunnies*.—The total landings of tunnies in India for the five years can be seen in Table XXVI. The best catches of tunnies were made in Zone 8 during this year.

(x) *Mugil* spp.—Only 40 tons of this fish were landed in 1954, most of the landings being from the Zone 12. In 1953 the catch was insignificant. In 1952, the yield was 292 tons, and 43 tons in 1951.

TABLE XXVI  
*Landings of Tunnies*

Zones	Landings in tons during				
	1950	1951	1952	1953	1954
Zone 1 .. ..	..	8	13	43	43
.. 2 .. ..	..	..	..	9	14
.. 3 .. ..	..	121	5	6	..
.. 4 .. ..	..	..	..	..	..
.. 5 .. ..	..	..	4	..	..
.. 6 .. ..	..	..	..	..	..
.. 7 .. ..	..	70	47	197	164
.. 8 .. ..	4,496	623	753	516	2,017
.. 9 .. ..	..	..	..	114	..
.. 10 .. ..	123	13	..	..	46
.. 11 .. ..	..	..	26	..	..
.. 12 .. ..	..	..	..	..	..
Total .. ..	4,619	835	848	885	2,284

26. *Seasonal distribution of fisheries.*—Table XXVII (a) gives the percentage of the total catch for each month for the last five years.

It is at once evident from the figures that the fourth quarter, as usual, yielded the best catches. The third quarter of 1954 was poorest from the point of view of fish landings as in previous years.

A notable departure from other years is noticed in the first quarter. In 1954, the catch was comparatively poorer during the first quarter. Similarly, unlike in other years, a very good catch was obtained during the second quarter of 1954. This was mainly due to very heavy landings in Bombay zone during the months of April and May 1954.

TABLE XXVII (a)  
Seasonal Distribution of the Total Catch

	Percentage of total annual landings				
	1950	1951	1952	1953	1954
January .. ..	9.08	10.88	10.82	10.83	6.03
February .. ..	7.77	5.59	7.50	9.46	6.06
March .. ..	11.38	6.50	7.85	7.60	4.81
April .. ..	7.13	7.83	5.67	5.47	9.91
May .. ..	5.74	9.25	8.37	11.39	13.86
June .. ..	2.66	3.78	4.94	8.16	4.38
July .. ..	3.43	3.66	5.61	3.12	4.16
August .. ..	8.20	6.10	3.36	4.26	4.14
September .. ..	6.46	12.51	4.84	7.09	8.08
October .. ..	13.44	9.67	13.23	7.51	14.52
November .. ..	12.89	9.40	17.10	10.99	15.16
December .. ..	11.82	14.83	10.71	14.12	8.89

The same figures, grouped together by quarters of a year, are rearranged as in Table XXVII (b).

TABLE XXVII (b)

	Percentage to the total annual landings				
	1950	1951	1952	1953	1954
First quarter (January-March) ..	28.23	22.97	26.17	27.89	16.90
Second quarter (April-June) ..	15.53	20.86	18.98	25.02	28.15
Third quarter (July-September) ..	18.09	22.27	13.81	14.47	16.38
Fourth quarter (October-December)	38.15	33.90	41.04	32.62	38.57

It is at once evident from the above figures that the fourth quarter, as usual, yielded the best catches. The third quarter of 1954 was poorest from the point of view of fish landings as in previous years.

A departure from other years is noticed in the first quarter when the catch was comparatively poor. Also unlike in other years, very good catches were obtained during the second quarter of 1954. This was due mainly to very heavy landings in the Bombay zone during April and May, 1954.

27. *Average return per boat and per fisherman.*—The average catch obtained per fisherman during 1954 was 1,693 lb. while the average catch per

boat worked out to be 17,130 lb. The corresponding figures for the other years are presented in Table XXVIII. Taking 4 annas as the value per lb. of fish, the average annual income of a fisherman is of the order of Rs. 400.

TABLE XXVIII  
*Annual Production of Fish per capita and per Boat*

Year	Annual catch in lb.	
	per fisherman	per boat
1950	1,662	16,815
1951	1,521	15,390
1952	1,515	15,328
1953	1,663	16,820
1954	1,693	17,130

28. *Catch per unit-effort.*—If the total catch in an area is greater than that of another area, it does not necessarily mean that the first area is economically more productive than the second. The higher catch may be due to the efforts of more men with more equipment. Hence, for 1954 the catch per unit effort in each zone, for every month was calculated. Table XXIX records these values.

From the above figures, it is seen that the average annual catch per man-hour during 1954 was 4.91 lb. If the productivity is to be judged by the weight of catch per man-hour the twelve zones were not equally productive. In general the west coast is more productive than the east coast. Also the return per man-hour was greater during the months September–December. The high average return during April and May was due solely to the comparatively higher return in Bombay zone during these two months.

#### FISHERY BIOLOGY

##### (a) Mandapam

##### *General Fishery Conditions at Mandapam*

29. *The Choodai fishery.*—Very good catches of *Choodai* (sardines) were recorded in the Mandapam area for the 1954 season. The total yield was greater this year, being about 2,050 tons, compared with the 747 tons landed in 1953. Fishing by hand-nets (along with torches) ceased in the second week of June, but shore-seines, the main gear employed in the industry, continued to operate until the end of October. The monthly catch-per-haul by shore-seines did not deviate much from the seasonal average catch-per-haul. This seems to indicate that the abundance of the stock in the coastal waters remained

TABLE XXIX  
Catch per Man-hour during 1954

Zones	Catch per man-hour (in lb.) during												Mean
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	
1	No data	0.89	0.52	2.31	3.34	1.47	0.73	1.79	2.64	4.25	3.39	3.44	3.03
2	0.98	0.92	0.79	0.78	0.68	0.68	0.66	0.56	0.51	0.53	0.49	0.68	0.68
3	No data available								0.64	0.83	0.40	0.53	0.61
4	..								1.67	3.90	5.60	2.84	4.70
5	3.44	3.90	2.18	1.36	2.21	2.96	1.85	2.31	2.65	2.53	3.61	2.84	2.42
6	1.36	1.79	2.53	2.19	1.28	1.60	1.58	2.18	2.67	9.00	3.23	2.33	2.36
7	0.89	1.05	0.95	0.71	0.60	0.66	0.66	0.71	4.60	5.71	2.14	2.88	1.12
8	5.40	0.82	1.51	1.49	2.73	6.38	3.70	6.40	9.64	6.39	5.66	3.11	5.43
9	2.58	6.77	2.14	1.18	5.00	3.93	4.68	5.54	7.22	6.75	15.38	3.66	5.81
10	53.65	8.57	2.08	3.88	5.12	3.97	6.13	4.90	2.18	3.41	16.17	13.79	7.63
11	10	4.34	4.05	14.09	18.16	..	..	6.37	6.61	15.04	10.62	5.84	9.43
12	1.45	3.01	2.60	2.46	2.68	..	..	..	2.11	5.60	10.20	6.74	2.39
Monthly Average	3.03	3.59	2.82	7.59	9.21	3.51	2.42	3.74	4.69	6.48	6.21	4.60	4.91

practically the same throughout the season; and as the catch-per-haul by shore-seines in October was greater than the seasonal average, the closure of the fishery has to be attributed to adverse weather conditions rather than to an uneconomic level of abundance of the sardines. Better catches of *Choodai* were recorded during the waning phase of the moon than during the waxing phase and, as during the last two years, the fishery was supported mainly by the 0-year class of *Sardinella* spp. The food of *Sardinella* spp. was found to consist mainly of copepods and diatoms.

30. *The dorab fishery*.—All the four year-classes were present in the commercial landings of *Chirocentrus dorab*. The first and second year-classes comprise the major part of the shore-seine catches while the third and fourth year-classes dominated the gill-net catches. Also, the mean size of dorab caught by gill-net was greater than of those caught in shore-seines and the proportion of total landings by shore-seines and gill-nets was in the ratio 1 : 12. When data on percentage of dorab caught in shore-seines and gill-nets during three years were plotted separately against their respective size-groups, the lines were found to intersect exactly at the same place (46–50 and 50–54 cm. size-groups) during all the three years, indicating that individuals in these size-groups are not affected by the highly selective nature of gill-nets. Even the percentage of fishes in this particular size-group was more or less the same during all the three years. The present study has also shown that the dorab attains sexual maturity when about 50–51 cm. long and that fishes above this size-group are caught mostly in gill-nets. Therefore, in the event of a future check on indiscriminate fishing of spawning or fully ripe dorab, the inference made from the present study is a clear pointer that the restriction need be only on gill-net fishing and not on both types of gear. Analyses of over 100 shore-seine catches from different places along the coasts of Gulf of Mannar and Palk Bay indicate that although dorab are landed at all places, there is an apparent fall on those days when shoals of *Hemiramphus* sp., *Belone* sp., *Anchoviella* spp. and cat-fishes are netted, but the occurrence of other shoaling fishes like sardines, silver-bellies, *Caranx* sp. and *Sphyræna* sp., does not seem to be correlated with the dorab fishery.

31. *Studies on Caranx leptolepis*.—This species was found in the catches by both shore-seines and bag-nets, but young ones were usually caught in the latter. The fishery is constituted by individuals ranging from 3 to 19 cm., but fishes of 9–15 cm. length formed the major part of the catches. The present study has confirmed an earlier observation that this species spawns twice a year. From size-frequency distribution studies the fishery appears to be constituted by only two year-classes. One-year old specimens, measuring 11–12 cm. in length, were found to be sexually mature.

32. *Survey of Rameswaram Island.*—The amount of fish landed on the island during the year was estimated to be 1,696·6 tons of which 729·8 tons were contributed by gill-nets, 87·43 tons by shore-seines, 853·79 tons by boat seines, and 25·76 tons by drift-nets. The total landings were slightly less than last year's, the Gulf of Mannar and the Palk Bay yielding 261·68 tons and 1,435·28 tons respectively, as against 288·35 tons and 1,479·98 tons during 1953–54. The return per man-hour during this year was 0·56 tons (1,254·4 lb.) as against 0·58 tons (1,299·2 lb.) of last year. *L. splendens*, *S. guttatus*, *C. dorab*, *S. gibbosa*, sharks, perches and *L. lactarius*, in the order of importance mentioned, were of significance to the fishery. As during last year *L. splendens*, being 39·999% of the total catch, held the first rank, with *S. guttatus* (24·011%) holding the second place. The percentage of the various species in the total landings was as follows:—

Name of species	Estimated amount (lb.)	Percentage
1. <i>Leiognathus splendens</i> .. ..	15,20,417·30	39·999
2. <i>Scomberomorus guttatus</i> .. ..	9,12,712·21	24·011
3. <i>Chirocentrus dorab</i> .. ..	2,86,339·89	7·533
4. <i>Sardinella gibbosa</i> .. ..	2,03,766·01	5·361
5. Sharks .. ..	1,95,843·10	5·152
6. Perches .. ..	1,91,150·27	5·029
7. <i>Lactarius lactarius</i> .. ..	1,34,486·45	3·538
8. <i>Dussumieria hasselti</i> .. ..	67,271·12	1·770
9. <i>Gerres filamentosus</i> .. ..	63,393·31	1·668
10. <i>Hemiramphus georgii</i> .. ..	59,102·96	1·552
11. <i>Caranx</i> sp. .. ..	57,769·77	1·520
12. <i>Sillago sihama</i> .. ..	38,777·58	1·020
13. <i>Pellona</i> sp. .. ..	28,660·55	0·754
14. <i>Therapon quadrileneatus</i> .. ..	12,236·57	0·322
15. <i>Chorinemus</i> sp. .. ..	6,911·87	0·182
16. <i>Sciæna indica</i> .. ..	4,869·45	0·128
17. <i>Upeneus indicus</i> .. ..	4,679·67	0·123
18. <i>Formio niger</i> .. ..	4,403·46	0·116
19. Cat-fishes .. ..	4,230·99	0·111
20. <i>Rastrelliger canagurta</i> .. ..	2,452·36	0·065
21. <i>Anchoviella indica</i> .. ..	1,031·99	0·027
22. <i>Sphyrana</i> sp. .. ..	655·27	0·017
23. <i>Mugil</i> sp. .. ..	92·45	0·002

(b) *Bombay*

33. *Off-shore Fisheries at Bombay*.—During the year under report the work of the Unit consisted of the examination of the catches of the trawlers working from Bombay and the compilation and analysis of the results of trawling in the off-shore waters off the Bombay and Saurashtra coasts.

The Japanese Trawler *Taiyo Maru 17*, which conducted fishing with the permission of the Government of India, was out of port for 76.5 days (in April–July 1954) doing 1,095 hours of actual fishing. The greater part of the time was spent in the Dwarka region where, during 486.4 hours of fishing, 6,32,000 lb. of fish were landed. Nearly half this quantity was landed in May alone. Fishing in June was mainly in regions III and IV, while in July it was restricted to region I. The landings of *Dara* during the season were comparatively small; sciaenids and eels, however, showed considerable (and gradually increasing) yields in the later months.

The Government of India trawlers, *Ashok* and *Pratap*, did 236 hours of fishing (in 38.4 days) in April–May 1954 and 179.2 hours of fishing (in 41 days) in January–March, 1955. In the earlier cruise a total of 2,50,706 lb. of fish were landed, more than half of which (1,91,223 lb.) was from the Dwarka region. Unlike in the operation of *Taiyo Maru*, there was a gradual reduction in the landings of the various categories of fish, month by month. Though the total quantity landed in May was higher, the percentage of commercially important fish, landed during that month, was less. In January–March 1955, *Ashok* and *Pratap* made five voyages and 122 hauls, with a total catch of 3,10,240 lb. The catch per hour for February this year was the highest obtained so far in these operations, being 2,153.4 lb. The most interesting feature was the very high catch of “*Dara*” and “*Koth*” in February from the Dwarka region and practically the entire quantity was from area ‘M’. One haul, on 19th February (of 1.5 hours duration), brought in nearly 12 tons of fish, of which *Dara* formed nearly 11 tons. This appears to be an all-time record for a single haul. In another haul, on the 20th February, in the same area ‘M’ about 6 tons of fish were obtained, 4.6 tons of which were “*Koth*”. Because of these two ‘huge’ hauls, the catch-per-hour in the Dwarka region for the month of February comes to 3,059.2 lb., the catch-per-hour for “*Dara*” being 1,371 lb. while that for “*Koth*”, 822.0 lb.

34. *Studies on Eels*.—The study of the *Wam* fisheries (marine eels) of Bombay has been continued with special reference to the fishery biology of the common species *Muraenesox talabonoides*. 14 species of eels were found to occur in Bombay waters, some of them being recorded now for the first time from this country. Analysis of the data of *Taiyo Maru No. 17* for the



fishing season 1953-54 showed that 3,13,960 lb. of eels (*M. talabonoides*), forming 14.8% of the total catch, have been landed by that vessel. The major portion of the catch was landed in May and June from Saurashtra areas. In the same season the Government of India Cutters landed 61,146 lb. of eels, forming 7.6% of their total catches. During the monsoon months no data were available on this fishery. In the current season the cutters worked for three months and landed 12,902 lb. of eels (3.24% of the total catch). From measurement of nearly 2,000 specimens it was seen that the species occurred in very wide size-ranges, viz., 1,100-1,800 mm., though the dominant size-groups continued to be 125-135 cm. and 145-155 cm. Sexually mature eels were landed from the end of January onwards. A large number of Leptocephali and eivers, collected from the local fishermen's catches, were found to belong to the following species:—

- (i) *Muraenesox talabonoides*,
- (ii) *Uroconger lepturus*
- (iii) *Ophichthus* sp. and
- (iv) *Murana* sp.

35. *The Sciænid Fishery.*—The sciænids formed an important part of the landings of the trawlers throughout the season. *Taiyo Maru*, which fished in April-May 1954, brought in "Ghol" (mainly *S. diacanthus*), "Koth" (*S. biauritus*) and "Dhoma" (all small sciænids) in considerable quantities, the catch-per-hour ranging from 27.1 to 80.4 lb. The Dwarka region gave the maximum yield, mainly on account of the longer period of operation there. The yield of "Ghol" was more or less constant for the period, viz., 107.6 lb. Landings of "Koth" were far below the previous year's yield, the maximum catch per hour being only 52.8 lb. (in Dwarka region) as against the 101.1 lb. of last year's. The small sciænids "Dhoma", however, gave the highest values for the year, 299.9 lb. per hour from Veraval and 212.94 lb. per hour from Porbunder.

The bull-trawlers *Ashok* and *Pratap*, operating in April-May, brought in greater landings of sciænids than *Taiyo Maru* (352.1 lb. as against 160.2 lb.). During the resumed operation in January-February, the February figures for "Koth" (822 lb.) was the highest on record for this fish so far, but was due to a very large single haul of 1,253.7 lb. An interesting feature of the "Koth" fishery was that it was concentrated in area 'M' and did not occur elsewhere.

As in previous years, juveniles occurred in "Koth" fishery in large numbers especially from Dwarka region. The maximum percentage, 77.7-88.8%, occurred in March-April.

The sciænids caught in January–March were all below Stage III of maturity, while by May they had attained Stage IV and in June a few were in Stage V. Spawning seems to occur in monsoon months, the “Koth” commencing spawning several weeks earlier than the “Ghol”.

(c) Calicut

36. *General Fishery Conditions at Calicut.*—The salient features of the fishery along the Malabar Coast during the year were the continued good landings of the oil-sardine, *Sardinella longiceps*, and the poor catches of the mackerel, which, however, showed a slight improvement in some centres towards the close of the season. In April and May, the fishery was, as usual, of a miscellaneous nature and comprised mainly soles, sciænids, prawns and pomfrets (*Formio niger*). During the period of south-west monsoon, from June to August, fishing operations were frequently interrupted due to adverse weather. The main fishery during this period was that of the silver-bellies, which was particularly good this year, and of prawns, chiefly *Metapenæus dobsonii*. The fishery during the latter half of August was characterised by the intermittent landings, in small quantities, of oil-sardines and mackerel of adult size caught by *kolli vala*. The post-monsoon period marked a fairly good fishing season for oil-sardines, and both medium-sized and adult specimens occurred in abundance from September onwards. The fishery of the sole, *Cynoglossus semifasciatus*, was generally a failure along the Calicut coast. The mackerel fishery too was poor along this coast. Line fishery was good during the post-monsoon period and good catches of sharks, rays, skates and cat-fish were obtained.

37. *Fish Population Studies.*—The inshore fishery at Calicut was steady during the months of April and May, the bulk of the catches by boat-seine being composed of juvenile stages of the Malabar sole, *Cynoglossus semifasciatus*, the anchovy, *Thrissocles mystax*, and a number of miscellaneous species along with prawns and crabs. The gill-nets landed *Kowala coval*, *Thrissocles mystax*, *Lactarius lactarius*, etc., as also small quantities of medium-sized oil-sardines. During the monsoon months, owing to adverse weather, catches were generally poor and of a miscellaneous character. Towards the close of September, the anchovy, *Thrissocles mystax*, was obtained in great abundance in the departmental collections. The usual revival of the Malabar sole fishery was not noticed in September; but the fish began to appear in October and November. From about the beginning of December there was a distinct improvement in the inshore fishery and the usual cyclical occurrence of a good number of post-larval and juvenile specimens of a large variety of fish, along with prawns and crabs and uneconomic elements like *Squilla* and *Cavernularia* was

noticed. Large numbers of post-larval and juvenile stages of *Cynoglossus semifasciatus* were also obtained.

38. *Studies on the Oil-sardine*.—The oil-sardine fishery was somewhat unsteady during the second quarter and the shoals were composed of three-year-old sardines with a modal size of 17 cm. Active spawners were caught in large numbers during the last week of August 1954. Another noteworthy feature of the quarter was the occurrence of very small oil-sardines with a modal size of 5.5 cm. during September 1954. The fishery showed an improvement during the third quarter throughout the coast and the catches were heavier at a number of centres along the Malabar Coast. Unusually good catches were also made at Bombay by the middle of December 1954. Uniform size-composition was noticed at most of the different centres, with the 12 cm. size-group forming the dominant size. The last quarter again showed an erratic fishery with occasional good catches at some centres. The modal size showed marked variation from 13 to 15 cm. Large shoals of oil-sardines were reported from Bombay and Karwar waters and the Rampan catches at the latter place were mainly composed of oil-sardines.

Large numbers of one-inch post-larvæ of *Sardinella fimbriata*, together with those of *Rastrelliger canagurta* and *Cybium* spp. in stray numbers, were detected at Vizingam during March 1955 and it is probable that this sea and the adjoining areas are important breeding grounds of this sardine.

#### (d) Karwar

39. *General Fishery Conditions at Karwar*.—Fish landings at Karwar were heavy during November-February. The period of diatom abundance was mainly during August-October. Oil-sardine fishery was good in January when there was a minor bloom of diatoms. The fishery statistics for Binge Bay during the monsoon also did not show any landing of oil-sardine, even though dense blooms of *Fragilaria oceanica* occurred in this period. However, it cannot be ruled out that the occurrence of large shoals of mackerel in Karwar area, following the blooming of *Fragilaria oceanica*, might have inhibited the movements of oil-sardine shoals.

40. *Mackerel Investigations*.—The mackerel fishery at Karwar this year was a failure, the landings totalling only about 951.2 tons, as against 1,203.5 tons of the 1953-54 season. In April-May, the post-mackerel season of 1953-54, mackerel were landed at Karwar only on two occasions. The fish ranged from 11.3 to 16.4 cm. with the majority size at 15 cm. In the following rainy months mackerel were occasionally caught in small numbers in the shore-seines—*Yendi*—operated at this time of the year, especially in the last two

weeks of July, when the size ranged from 12.9 to 25 cm., the majority size being 22 cm. In August mackerel, caught only on two days, measured 15.1–23 cm. Comparatively larger numbers of mackerel, up to 500, were registered per haul of *Yendi* in September, the size-range being 13.1–20.1 cm. The dominant size-group for the month was 14 cm. During this month three spent females were also recorded.

The mackerel season of this year was characterised by the erratic appearance of mackerel shoals. During November 1954, mackerel were caught in Rampan nets almost daily. The intensity of fishing was the greatest during the second and third week of November when on the same day 3–4 Rampan nets were operated. In December and January, there were frequent breaks in the fishing activity, due to the small number of shoals and at times the fishery was at its lowest ebb. Thus the mackerel season was one of hopes and despair for the local fishermen. During January and February, the fishery was completely eclipsed by the sardine fishery.

41. *Mackerel Investigations at Malpe.*—The 1954–55 season for mackerel in the Malpe area was an exceptional failure. There were marked fluctuations in the monthly catch-per-haul of Rampan nets. The mackerel catches were better during the period of the waning phase of the moon than during the waxing phase. Data on length-frequency show that the fishery in the Malpe area draws its support mostly from one age-group.

(e) *Cochin*

42. *Prawn Investigations at Narakkal.*—The backwater fishery has been in continuous operation this year, floods and swift currents not having occurred during the monsoon months to interrupt it. Among the species constituting the catches the porportion of *Penæus indicus* was strikingly small in October. In November there was a marked increase in numbers and concomitantly a fall in the length of the majority group, indicating thereby the arrival of smaller prawns in the backwaters, probably from the sea. During the months of September, October and November there was a fairly good fishery of *Palæmon carcinus*, caught chiefly in stake nets and Chinese nets. The marine fishery, as usual, started in October and came to a close in April—the catches were seldom heavy and did not appear to be as good as those of last year in this place. Since the sardine and mackerel fisheries terminated earlier, fishing with the boat-seines has been resumed earlier than usual and appreciable quantities of prawns have been landed on most days from the middle of February.

*Studies on the Biology of P. indicus.*—The detailed study of the biology of *P. indicus*, started in November 1953, was continued this year and valuable

data on growth and duration of life, breeding, migration, sex-ratio, etc., have been collected. It has become clear in the course of this study that the species normally grows to a length of 121–125 mm. in the backwaters. Last year's farming experiment yielded 641 lb. of prawns as against 716 lb. in the previous year. But the average percentage value of *P. indicus* was only 15.4 and showed no definite improvement on the corresponding values for the last two years. A similar experiment has been started on November 1 of this year, of keeping the fry and other prawns inside the field for a few months without catching them and thus allowing them sufficient time (about 5 months) to grow, to ascertain the effect on the yield, proportion of the species and their size. Water is being let in and out as usual on every day.

Studies on the biology of *P. monoceros* were also undertaken.

(f) Madras

43. *General Fishery Conditions at Madras.*—Hooks and lines, boat-seines, bag-nets, gill-nets and shore-seines were in operation along the Madras coast. The major catches included ribbon-fishes, anchovies, silver-bellies, sardines, carangids, *Cybium*, cat-fishes, mackerel and prawns. The flying-fish fishery was of very short duration this year (May–June). The occurrence of young ones of *Rastrelliger canagurta*, of size 5 cm., in shore-seines was a point of special interest.

44. *Studies on the Backwater Oyster and Edible Clams.*—Studies on the rate of growth of spat and yearlings of oysters were completed during the year. Spawning commenced in the Adyar oysters late in October and extended up to December as in previous years. Spat setting had occurred only during the periods when the sea was in communication with the estuary, and lasted for several weeks. There was no fresh setting of spat when the bar was closed. Growth was observed to be fairly rapid. The oysters attain a maximum height of 60 mm. in 6 months, 84 mm. in 13 months and 109 mm. in 17 months, the mean height for the corresponding period being 39 mm., 50 mm. and 64 mm. The percentage increase in height during October–January ranged from 83.1 to 87.9 and that in width from 51.6 to 163.1 mm., depending upon the initial size of the individuals, the smaller ones showing greater growth than the larger ones.

Based on studies on seasonal gonadal changes it was found that the best seasons for oysters are from March to June and September to October. The main spawning period, being November to December, it is advisable that the oysters are not fished during September and October. They can be fished with advantage from March to June. A study on the seasonal gonadal changes

in the edible backwater clam, *Meretrix casta*, continued from last year showed that: (1) spawning commenced by about the end of April and lasted up to the beginning of July, (2) the residual reproductive elements are gradually absorbed after the period of spawning, the gonads entering a stage in which the sexes are indistinct, and (3) reorganization of the gonads begins by about the middle of November and the clams are full by the middle of January.

#### MARINE INVESTIGATIONS

45. *Plankton Studies at Mandapam.*—Planktological investigations in the inshore waters off Mandapam were continued in order to arrive at a satisfactory picture of the seasonal variations in plankton of this area. A report on the comparative study of the characteristics of plankton at two inshore stations, one in the Palk Bay and the other in the Gulf of Mannar, was completed. The final analysis has confirmed the preliminary results obtained earlier. The plankton this year presented the following interesting differences from the usual trend—(1) non-appearance of *Dactylometra quinquecirrah*, *Rhopilema hispidum* and *Labonema smithi* in the Palk Bay and *Physalia utriculus* in the Gulf of Mannar during May–June; (2) an unusually large phytoplankton population in the Gulf of Mannar in October and December, the largest recorded so far in these months since 1950, whereas in the Palk Bay the phytoplankton level was strikingly low in October–November. The zooplankton, on the other hand, did not exhibit such striking differences. The preparation of plankton calendars for the two regions was begun and the work has already progressed satisfactorily.

Two new lines of work were initiated during the year under review: (1) a study of the carbonates, bicarbonates and total alkalinity with a view to finding out whether these act as limiting factors in the primary production. The data available so far indicate that the carbonates and the total alkalinity were often higher in the Gulf of Mannar than in the Palk Bay, whereas the bicarbonates were relatively higher in the Palk Bay. Slight differences in the fluctuations of these were also noticed. The possible relationship these have to the phytoplankton cycle is being examined. (2) a detailed study of the fluctuations in the chaetognath population in the Gulf of Mannar and the Palk Bay was started, because in the Palk Bay the chaetognath maximum was in August–September when the salinity was high and in the Gulf of Mannar during February–April when the salinity was low. But, owing to difficulties experienced in correctly indentifying some of the species from old preserved samples, fresh material is being collected and studied with particular reference to the distribution of the various species in relation to salinity. An attempt

was made at analysing the surface and atmospheric temperature data collected during the last five years and report on this is being prepared.

46. *Hydrological Studies.*—Work was continued on the study of the hydrological characteristics of Palk Bay and Gulf of Mannar in relation to plankton. No noteworthy departures were noticed from the values obtained for earlier years. The data obtained were utilized for the calculation of the organic production in the inshore waters. Studies were made on apparatus and methods suitable for use on small vessels. These included: (1) the assembly of a current meter for use in shallow waters and a field unit for comparison of intensities of colours; (2) adaptation of the standard method for estimation of salinity; (3) reinvestigation of the diphenylbenzidine method for nitrate estimation; and (4) the use of the sensitive reaction of phosphomolybdate complexes with certain dye-stuffs for the estimation of total phosphorus in sea-water.

47. *Studies on Fish Eggs and Larvæ.*—Eleven new types of eggs were recorded this year from inshore waters. There was a fall in the total number of eggs in the plankton this year as compared to last year's. Clupeoid eggs alone, however, occurred in greater numbers, especially in December. Carangid eggs were present throughout the year, with maximum intensity between November and March. It was also seen that there is greater variety and concentration of fish eggs in the Gulf of Mannar than in the Palk Bay. Young fry of *Sillago sihama* ranging from 1.8 to 50 cm. were collected from the shallow sandy tidal pools along the beaches of Gulf of Mannar, Pamban and Kilakarai from October–January.

48. *Hydrological Studies at Bombay.*—The hydrological conditions in area 43-A, just outside the Bombay Harbour, were investigated in the month of May 1954. The salinity here ranged between 36.29‰ and 35.93‰ and inorganic phosphate between 4.0 and 10.0 mg. per c. metre. The surface temperature showed no appreciable variation, being steady at 30.4 *plus/minus* 0.05° C. Water samples collected from a few selected stations were found to have salinity values ranging between 35.2 and 35.7‰. No variations were observed in the surface temperature (30.1–30.4) in this period, except near Ratnagiri where the temperature was 29.8° C. Additional information on temperature and salinity was also obtained from samples collected and supplied by the Indian Navy.

49. *Planktological and Hydrological Studies at Karwar.*—The volume of the plankton of Karwar Bay fluctuated between 0.2 c.c. and 80.0 c.c. per cubic metre. Diatom blooms were obtained in April–June, August–October, January and March, the period August–October forming the peak period when

the blooms were chiefly of *Fragilaria oceanica*. Dinoflagellate abundance was observed in May (chiefly due to *Ceratium furca*), in October (mainly composed of *Ceratium massiliense* and *C. fusus*), and in December (due to swarms of *Dinophysis* sp.), the last one representing the peak which succeeded the diatom maximum in October. The peak period for zoo-plankton was May, which was largely due to swarms of *Noctiluca*. A secondary maximum was noticed in September largely contributed by cladocerans, and if *Noctiluca*, which is known to form the "inedible" part of the plankton, is excluded, the real peak for zoo-plankton ("edible") occurred in September. March-June represented the period of zoo-plankton abundance. The swarming of *Noctiluca*, however, brought in its wake a diminution of the other zoo- and phyto-plankton populations. Subsequently, both copepods and phyto-plankton were found almost excluded from the collections. Chætognaths appeared in maximum numbers in April. Appendicularians were most common during October-December. Fish eggs were met with in considerable numbers during September-December, the peak of occurrence being in September. Copepods were most abundant during June-August (with the peak in July), their fluctuations during monsoon being closely related to those of salinity.

In Kali River, the volume of plankton fluctuated between 0.2 c.c. to 120.0 c.c. per cubic metre. Mean volume was at its maximum in May, which was due to diatom blooms, with a secondary peak in September due to swarms of diatoms and dinoflagellates. Diatom blooms were observed in May (*Chaetoceros* being the most common diatom) and during August-September (*Fragilaria oceanica*—the commonest diatom), August representing the peak of occurrence of diatoms. Swarms of dinoflagellates were noticed only in September, succeeding the diatom maximum in August, the important dinoflagellates being *Ceratium fusus*, *C. massiliense*, *C. brevis* and *C. furca*. The maximum for 'edible' zoo-plankton was recorded in April (mainly composed of copepods) since the peak in May was largely contributed by the 'inedible' *Noctiluca*. Zoo-plankton was again abundant during August-October which was due to copepods, cladocerans, copepod-nauplii and gastropod larvæ. Chætognaths occurred in maximum numbers in April. Fish eggs appeared in considerable numbers in April and were less common in September.

In Binge Bay volume of plankton fluctuated between 0.2 c.c. to 30.0 c.c. per cubic metre, attaining its peak in July with a secondary maximum in October and December. Diatom outbursts were noticed during August-September representing the diatom peak and during December and March. August-



September blooms were composed of *Fragilaria oceanica*. In December, *Chaetoceros*, *Rhizosolenia* and *Bacteriastrum* were most common. In March, *Chaetoceros*, *Bacteriastrum*, *Schröderella* and *Rhizosolenia* were the important diatoms. *Trichodesmium* sp. was common in December–January. The peak of occurrence was in October, when copepods and cladocerans, besides *Noctiluca*, were very common. Even barring *Noctiluca*, this month represents the peak period for zoo-plankton. The other maximum was noticed in July. It is probable that February–July represents a period of zoo-plankton increment here.

50. *Studies on Hydrology and Plankton at Calicut*.—Investigations on the total phosphorus and dissolved organic matter in the inshore waters, as also hydrochemical studies in the bottom mud of Quilandy Bay were continued, along with routine hydrological observations. Preliminary studies on chemical constituents of mixed plankton were initiated this year. The zoo-plankton trends were similar to last year's except that the characteristic outburst of siponid polychæte larvæ during June has been delayed till August–September. Large numbers of white-bait (*Anchoviella* spp.) eggs occurred in the 20-fathom off-shore plankton during December and January when the fish are not encountered in the coastal waters, indicating off-shore breeding habits.

Work on the quantitative, qualitative, taxonomical, ecological and life-history aspects of phytoplankton was continued. The pattern of quantitative fluctuation was more or less similar to that of earlier years except that the lowest values were recorded in October. *Fragilaria*, as usual, appeared to dominate the plankton during the peak period. Water samples from different depths were centrifuged and its plankton was studied in comparison with net collections. The life-history of a new chrysophycean has been worked out.

51. *Ecological Studies at Calicut*.—The main lines of research carried out during the year under review were the investigations on the fishery and ecology of the Quilandy Bay, with special reference to the sole fishery, routine zoo-plankton studies of Calicut coast and certain investigations as part of the team-studies on the fishery resources of the Elathur estuary. A preliminary survey of the various fish landing centres of the south-west coast was completed to ascertain the nature and extent of the inshore fishery with special reference to soles.

#### PHYSIOLOGY

52. *Studies on the Milkfish, Chanos*.—*Chanos-fry* were collected in small numbers in May 1954 from the mudflats on the Vypeen coast (Cochin). Besides locating a centre from where fry can be collected, a possible source

of entry of the fish from the sea into the backwaters has also been observed. The secondary season for *Chanos-fry* (November–December) was a failure this year also. A considerable lowering of the salinity of water in the tidal creeks at this time, caused by the monsoons, is believed to be one of the factors for the absence of fry during this period. Adult fish were not recorded from the vicinity of Mandapam. Analysis of all available data on the food of *Chanos* during different stages indicates that the fish, at least in their adult stage, is not such a selective feeder as formerly believed. A paper discussing the practical implications of this aspect of fish culture has been prepared. General ecological studies at the fry-collecting centres at Pamban, together with data gathered this year on the movement of the fry, their feeding habits, etc., were helpful in laying down lines of possible future study on these fish fry.

#### BACTERIOLOGY

53. Studies on bacteria of the marine environment have provided much information on the marine bacterial flora which is of basic importance in the study of fish preservation problems. The production of trimethylamine and total volatile nitrogen during spoilage was investigated. The relation between the TMA and TVN levels and bacterial counts, as well as the qualitative composition of the bacterial flora, were studied with a view to defining standards for freshness of fish. Over 300 bacterial strains, isolated during the spoilage studies, were classified. The bacterial flora of fish-muscle spoilage at 3°–5° C., at 0° C. (in ice) and at room temperature (27°–30° C.) differed qualitatively. Spore-forming rods, *i.e.*, *Bacillus*, were present almost exclusively at room temperature, while at 3°–5° C. the flora consisted of *Bacillus*, *Micrococcus* and Gram-negative asporogenous rods. At 0° C. *Pseudomonas* predominated. Evidence of a generic succession in the bacterial type during spoilage at 3°–5° C. and 0° C. was obtained. Among the *Pseudomonas* isolates some produced greenish fluorescence and a few produced gas from glucose. Coliforms belonging to intermediate types were occasionally found in spoiling fish muscle. A correlation between the TMA and TVN concentrations and the bacterial count was usually observed. The flora of shark spoilage occurring at room temperatures differed from that of teleost spoilage (at room temperature) in that Gram-negative rods predominated in the former. A majority of the isolates from shark spoilage required, for satisfactory growth, media prepared with sea-water or with freshwater containing 3% NaCl. Whether any basic differences exist in the character of the bacterial flora associated with elasmobranch and teleost spoilage is being investigated. During storage at – 5° C. fish remained in good condition for over three months, the TMA, TVN and bacterial count

being negligible throughout the period. Bacteriological investigations on fish curing were resumed towards the end of this year. Observations were made at different stages in the salting and drying of sardines carried out experimentally.

#### ALGOLOGY

54. The pulp method of agar manufacture worked out for *Gracilaria lichenoides* was applied to many other Indian agarophytes, with considerable success. Milling of the sea-weeds (after thorough cleaning) in powered rice-flour mill was found to simplify agar manufacture from these algae since the flour is more easily handled than bulky sea-weed, and also since diffusion of soluble compounds from cells is facilitated.

#### FISH CURING

55. The Fish Curing Section was started at Mandapam in September 1954 and during the six-month-period under report an extensive survey of the fish curing yards along the Travancore and Bombay coasts was undertaken to study the different methods of fish curing practised in these areas. Samples of cured fish were collected from each area for detailed analytical study in the laboratory. These analyses clearly showed that the products do not conform to any fixed standards. The moisture content of the sun-dried samples varied between 13.8 and 42.5% and the salt content between 0.6 and 15.4%, while that of dry salted fish between 23.3 and 51.0% and 10.5 and 27.0% respectively and that of wet salted fish between 33.0 and 55.6% and 12.0 and 19.3% respectively. The total volatile nitrogen content (100 mg. N/100 g. to 450 mg. N/100 g.) of many of the samples collected from the curing yards was far above the maximum limits ordinarily allowed for salted fish. Since, generally the cured products are stored in the markets for months together before reaching the consumers, chemical analyses were also conducted with samples from important fish markets like Sewri in Bombay, and Kovilpatty and Paramakudy in Madras State. It was found that, excepting in some of the sun-dried specimens whose moisture content is well below 15%, most material was in a spoiled condition. Samples of salt, taken for analysis from the curing yards, were also found to differ widely in their NaCl, moisture and insoluble matter contents. The samples were also analysed for their Ca, Mg, SO<sub>4</sub> and CO<sub>3</sub> contents and correlated with the water-soluble Ca, Mg, SO<sub>4</sub> and CO<sub>3</sub> of the fish samples collected from the respective places. Another important work undertaken by the Fish Curing Section during the year was the investigation connected with the processing and preservation of *Choodai* which is a major fishery around the Rameswaram Island. Samples of *Choodai*

(sardines) cured by different methods were collected and analysed in the laboratory. Based on these results a series of planned experiments were conducted with a view to working out an economic method for the preservation of this fish. The method, which is being developed, involves the following steps: (1) washing the fish in sea-water before salting; (2) salting the fish with a fixed proportion of salt (the proportion of salt is different for gutted and un-gutted fish); (3) keeping the fish in the salting vessel with alternating layers of salt for a period of 18 to 24 hours; (4) the application of pressure to the fish from the top, or in cases where pressure could not be applied the level of the self-brine to be raised to the top after 6 hours of salting; (5) washing fish in self-brine followed by thorough washing in sea-water; and (6) drying the fish in the sun for 1½ days or until the moisture content comes down to about 35%.

Side by side with the above, investigations were started on the possibility of improving the quality and appearance of pit-cured fish. The effect of washing the fish in different solutions on its quality was studied in detail. The data collected so far indicate that washing of the pit-cured fish, either in sea-water or in a 6% NaCl solution for a fixed period, improves the quality and the appearance considerably and that the samples keep for a longer time without producing the characteristic bad odour.

During the period under report a comparative study of the different methods of estimating the total volatile nitrogen in cured fish samples was initiated. The efficiency of different solvents in extracting the volatile nitrogen compounds from the fish, the relationship between the quality of the sample taken and the TVN values, the efficiency of boric acid as an absorbent medium for ammonia, and the effects of increased periods of distillation on the TVN values are a few of the problems which have been studied in detail so far. Work on the estimation of the total-reducing substances in the cured products and the use of such a factor as an index of spoilage, is now in progress.

CENTRAL MARINE FISHERIES  
RESEARCH STATION,  
*Mandapam Camp P.O., S. India,*  
24th September 1955.

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

The following scientific papers based on the work at the Research Station have been published during 1954-55.

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APPENDIX

Zonewise figures of total catch of marine fish and composition of such catch in 1954

Name of zones	Total catch (tons)	Composition of catch (figures in tons)
(1) West Bengal and Orissa	9,356	<i>Sardinella fimbriata</i> 5,741; <i>Dussumieria hasselti</i> 632; <i>Rastrelliger canagurta</i> 5; Prawns and Crustaceans 545; <i>Thrissocles</i> spp. 200; <i>Anchoviella</i> spp. 104; <i>Sciæna</i> spp. 118; <i>Otolithus</i> spp. 55; Elasmobranchs 294; <i>Trichiurus savala</i> 148; <i>Hilsa</i> spp. 171; <i>Pellona</i> spp. 29; <i>Coilia dussumieri</i> 64; <i>Equula</i> spp. 46; <i>Lactarius lactarius</i> 8; <i>Harpodon nehereus</i> 10; <i>Sillago</i> spp. 84; <i>Caranx</i> spp. 7; <i>Cybium</i> spp. 269; Pomfrets 52; <i>Chirocentrus dorab</i> 245; <i>Polynemus</i> spp. 61; Tunnies 43; <i>Mugil</i> spp. 1; Miscellaneous 422.
(2) Andhra coast (south of Gopalpur to north of Visakhapatnam)	5,447	<i>Sardinella fimbriata</i> 526; <i>Dussumieria hasselti</i> 17; <i>Rastrelliger canagurta</i> 29; Prawns and crustaceans 169; <i>Thrissocles</i> spp. 171; <i>Anchoviella</i> spp. 108; <i>Sciæna</i> spp. 162; <i>Sciænoides</i> spp. 8; <i>Otolithus</i> spp. 1; Sharks 502; <i>Trichiurus</i> spp. 217; <i>Pellona</i> spp. 117; <i>Hilsa</i> spp. 38; <i>Arius</i> spp. 659; <i>Equula</i> spp. 163; <i>Lactarius lactarius</i> 99; <i>Saurida tumbil</i> 131; <i>Harpodon nehereus</i> 1; <i>Lutjanus</i> spp. 151; <i>Synagris</i> spp. 38; <i>Serranus</i> spp. 12; <i>Pristipoma</i> spp. 8; <i>Sillago</i> spp. 4; <i>Caranx</i> spp. 135; <i>Chorinemus</i> 130; <i>Cybium</i> spp. 1, 184; Pomfrets 62; <i>Chirocentrus dorab</i> 63; <i>Cypselurus</i> spp. 69; <i>Upeneus</i> spp. 9; <i>Polynemus</i> spp. 25; Tunnies 14; Miscellaneous 425.
(3) Andhra coast (Visakhapatnam to Masulipatnam)	19,840	<i>Sardinella fimbriata</i> 516; Prawns and crustaceans 234; <i>Thrissocles</i> spp. 1,073; <i>Anchoviella</i> spp. 306; <i>Sciæna</i> spp. 681; <i>Otolithus</i> spp. 365; <i>Umbrina</i> spp. 105; <i>Pseudosciæna</i> spp. 8; Sharks 431; <i>Trichiurus</i> spp. 77; <i>Kowala coval</i> 4, 194; <i>Anodontostoma chacunda</i> 3,002; <i>Pellona</i> spp. 1,415; <i>Hilsa</i> spp. 641; <i>Coilia dussumieri</i> 214; <i>Arius</i> spp. 214; <i>Lactarius lactarius</i> 544; <i>Equula</i> spp. 179; <i>Harpodon nehereus</i> 50; <i>Saurida</i> spp. 6; <i>Sillago</i> spp. 99; <i>Cynoglossus</i> spp. 22; <i>Caranx</i> 38; <i>Cybium</i> spp. 157; Pomfrets 10; <i>Chirocentrus dorab</i> 1,869; <i>Upeneus</i> spp. 10; <i>Polynemus</i> spp. 341; Miscellaneous 3,038.

## APPENDIX—Contd.

Name of zones	Total catch (tons)	Composition of catch (figures in tons)
(4) Andhra coast (south of Masulipatnam to north of Pulicut Lake)	6,330	<i>Dussumieria</i> spp. 275; <i>Rastrelliger canagurta</i> 34; Prawns and crustaceans 2,036; <i>Anchoviella</i> spp. 373; <i>Thrissocles</i> spp. 329; <i>Sciæna</i> 629; Sharks 125; Rays 92; Skates 59; <i>Trichiurus</i> spp. 944; <i>Pellona</i> spp. 189; <i>Hilsa</i> spp. 28; <i>Raconda</i> spp. 7; <i>Equula</i> spp. 161; <i>Lactarius lactarius</i> 4; <i>Harpodon nehereus</i> 141; <i>Saurida</i> spp. 35; <i>Therapon</i> spp. 14; <i>Drepane</i> spp. 4; <i>Caranx</i> spp. 128; <i>Cybium</i> spp. 52; Pomfrets 409; <i>Chirocentrus dorab</i> 87; <i>Upenoides</i> 34; Miscellaneous 141.
(5) Coromandel coast (Pulicut Lake to Cuddalore)	24,245	<i>Dussumieria</i> spp. 861; <i>Sardinella</i> spp. 851; <i>Rastrelliger canagurta</i> 293; Prawns and crustaceans 960; <i>Thrissocles</i> spp. 2,446; <i>Anchoviella</i> spp. 1,123; <i>Sciæna</i> spp. 1,486; Sharks 897; Rays 12; Skates 2; <i>Trichiurus</i> spp. 868; <i>Pellona</i> spp. 558; <i>Chatassus</i> spp. 211; <i>Opisthopterus</i> sp. 7; <i>Raconda</i> spp. 2; <i>Elops</i> spp. 2; <i>Arius</i> spp. 364; <i>Equula</i> spp. 2,517; <i>Lactarius lactarius</i> 548; <i>Gazza</i> spp. 17; <i>Gerres</i> spp. 2; <i>Saurida</i> spp. 303; <i>Synagris</i> spp. 548; <i>Lutjanus</i> spp. 366; <i>Serranus</i> spp. 160; <i>Scolopsis</i> spp. 109; <i>Therapon</i> spp. 107; <i>Pristipoma</i> 80; <i>Sillago</i> spp. 78; <i>Echeneis</i> spp. 75; <i>Teuthis</i> spp. 5; <i>Diagramma</i> spp. 2; <i>Cynoglossus</i> 19; <i>Caranx</i> spp. 3,467; <i>Chorinemus</i> spp. 519; <i>Cybium</i> spp. 1,229; Pomfrets 419; <i>Chirocentrus dorab</i> 366; <i>Sphyræna</i> spp. 325; <i>Cypselurus</i> spp. 87; <i>Upeneus</i> spp. 269; <i>Upenoides</i> spp. 32; <i>Polynemus</i> spp. 240; Miscellaneous 1,413.
(6) Coromandel coast (south of Cuddalore to Devipatnam)	23,589	<i>Dussumieria acuta</i> 107; <i>Sardinella fimbriata</i> 92; Prawns and crustaceans 151; <i>Thrissocles</i> spp. 548; <i>Sciæna</i> spp. 2,486; <i>Otolithus</i> spp. 1,891; Sharks 828; Rays 2,896; Skates 590; <i>Trichiurus</i> spp. 205; <i>Pellona</i> spp. 484; <i>Hilsa</i> spp. 408; <i>Coilia dussumieri</i> 236; <i>Dorosomids</i> spp. 44; <i>Arius</i> spp. 4,296; <i>Equula</i> spp. 1,846; <i>Gerres</i> spp. 11; <i>Harpodon nehereus</i> 22; <i>Sillago</i> spp. 535; <i>Lates calcarifer</i> 11; <i>Therapon</i> spp. 11; <i>Serranus</i> spp. 2; <i>Caranx</i> spp. 240; <i>Chorinemus</i> spp. 11; <i>Cybium</i> spp. 797; Pomfrets 601; <i>Chirocentrus dorab</i> 1,830; <i>Cypselurus</i> spp. 1,748; <i>Upenoides</i> spp. 31; <i>Polynemus</i> spp. 607; Miscellaneous 24.



- (7) Palk Bay and Gulf of Mannar (south of Devipatnam to north of Cape Comorin) 9,298 *Sardinella* spp. 1,058; *Dussumieria* spp. 128; Prawns and crustaceans 7; *Anchoviella* spp. 2,005; *Thrissocles* spp. 119; *Sciaena* spp. 68; *Otolithus* spp. 1; Sharks 145; Rays 97; Skates 33; *Trichiurus* spp. 1,914; *Pellona* spp. 4; *Elops* spp. 2; *Arius* spp. 812; *Lactarius* spp. 269; *Equula* spp. 69; *Saurida* spp. 2; *Serranus* spp. 417; *Lethrinus* spp. 247; *Lutjanus* spp. 173; *Aprion* spp. 26; *Diagramma* spp. 18; *Teuthis* spp. 4; *Therapon* spp. 2; *Caranx* spp. 204; *Chorinemus* spp. 71; *Cybium* spp. 463; Pomfrets 26; *Chirocentrus dorab* 297; *Sphyrana* spp. 17; *Cypselurus* spp. 31; *Upenoides* spp. 9; *Euthynnus* spp. 164; Miscellaneous 396.
- (8) Travancore-Cochin (Cape Comorin to Ponnani River) 78,786 *Sardinella longiceps* 3,013; *Sardinella* spp. 6,252; *Dussumieria hasselti* 362; *Rastrelliger canagurta* 693; Prawns and crustaceans 3,144; *Anchoviella* spp. 18,381; *Thrissocles* spp. 575; *Scianoides* spp. 2,482; *Sciaena* spp. 2,364; *Otolithus* spp. 1,324; Sharks 2,041; Rays 607; Skates 39; *Trichiurus* spp. 11,062; *Kowala coval* 552; *Anodontostoma chacunda* 197; *Opisthopterus* spp. 118; *Ambassis* spp. 95; *Pellona* spp. 55; *Arius* spp. 3,199; *Lactarius* spp. 3,829; *Equula* spp. 1,331; *Lethrinus* spp. 165; *Lutjanus* spp. 16; *Sillago* spp. 8; *Cynoglossus* spp. 748; *Caranx* spp. 5,247; *Chorinemus* spp. 386; *Cybium* spp. 819; Pomfrets 630; *Chirocentrus dorab* 221; *Sphyrana* spp. 3,569; *Upenoides* spp. 386; *Upeneus* spp. 16; *Polynemus* spp. 8; Tunnies 2,017; Miscellaneous 2,835.
- (9) Malabar and South Kanara (north of Ponnani River to Mangalore) 79,304 *Sardinella longiceps* 30,099; *Sardinella* spp. 1,266; *Dussumieria hasselti* 373; *Rastrelliger canagurta* 7,732; Prawns and crustaceans 3,394; *Anchoviella* spp. 2,030; *Thrissocles* spp. 603; *Pseudociaena* spp. 1,372; *Sciaena* spp. 134; *Otolithus* spp. 8; Sharks 1,911; Rays 1,126; Skates 24; *Trichiurus* spp. 56; *Kowala coval* 611; Dorosomids 278; *Opisthopterus* spp. 238; *Hilsa* spp. 143; *Ambassis* spp. 127; *Pellona* spp. 119; *Arius* spp. 7,732; *Equula* spp. 7,907; *Lactarius lactarius* 190; *Saurida tumbil* 8; *Therapon* spp. 56; *Serranus* spp. 8; *Cynoglossus* spp. 745; *Caranx* spp. 4,592; *Chorinemus* spp. 159; *Cybium* spp. 254; Pomfrets 5,670; *Chirocentrus dorab* 8; *Sphyrana* spp. 71; *Polynemus* spp. 8; Miscellaneous 252.
- (10) Konkan coast (north of Mangalore to south of Ratnagiri) 28,858 *Sardinella longiceps* 316; *Sardinella* spp. 183; *Dussumieria* spp. 12; *Rastrelliger canagurta* 19,026; Prawns and crustaceans 177; *Thrissocles* spp. 164; *Anchoviella* spp. 17; *Sciaena* spp. 2,470; *Otolithus* spp. 167; *Scianoides* spp. 115; *Pseudo-*

APPENDIX—Contd.

Names of zones	Total catch (tons)	Composition of catch (figures in tons)
		<i>sciana</i> spp. 46; Sharks 1,414; Rays 216; Skates 81; <i>Trichiurus</i> spp. 141; <i>Opisthopterus</i> sp. 78; <i>Pellona</i> spp. 29; <i>Ambassis</i> spp. 6; Dorosomids 3; <i>Elops</i> sp. 6; <i>Arius</i> spp. 1,596; <i>Equula</i> spp. 283; <i>Lactarius</i> spp. 118; <i>Gerres</i> spp. 43; <i>Harpodon nehereus</i> 3; <i>Lates</i> sp. 61; <i>Therapon</i> spp. 29; <i>Serranus</i> spp. 32; <i>Lutjanus</i> spp. 12; <i>Sillago</i> spp. 6; <i>Cynoglossus</i> spp. 40; <i>Caranx</i> spp. 378; <i>Chorinemus</i> spp. 263; <i>Cybius</i> spp. 687; Pomfrets 124; <i>Chirocentrus dorab</i> 92; <i>Sphyrana</i> spp. 6; <i>Polynemus</i> spp. 17; Tunnies 46; Miscellaneous 355.
(11) Bombay and Gujarat coasts (Ratnagiri to Broach)	275,820	Prawns and Shrimps 140,972; <i>Thrissoctes</i> spp. 634; <i>Sciana</i> spp. 52,875; <i>Sciaenoides</i> spp. 303; Elasmobranchs 359; <i>Trichiurus</i> spp. 13,267; <i>Coilia dussumieri</i> . 11,005; <i>Pellona</i> spp. 1,048; <i>Hilsa</i> spp. 28; <i>Arius</i> spp. 2,262; <i>Equula</i> spp. 138; <i>Harpodon nehereus</i> 21,900; <i>Lutjanus</i> spp. 745; <i>Cynoglossus</i> 83; <i>Caranx</i> spp. 165; <i>Cybius</i> spp. 28; Pomfrets 9,240; <i>Chirocentrus dorab</i> 165; <i>Bregmaceros</i> sp. 9,599; <i>Upenoides</i> spp. 717; <i>Polynemus</i> spp. 772; Miscellaneous 9,515.
(12) Kathiawar coast	17,121	<i>Sciana</i> spp. 152; Sharks 335; Rays 265; Skates 255; <i>Trichiurus</i> spp. 190; <i>Hilsa</i> spp. 555; <i>Coilia dussumieri</i> 330; <i>Pellona</i> spp. 75; Dorosomids 9; <i>Arius</i> spp. 144; <i>Harpodon nehereus</i> 12,870; <i>Lutjanus</i> spp. 43, <i>Sparrus</i> 27; <i>Sillago</i> spp. 5; <i>Chorinemus</i> spp. 10; <i>Cybius</i> spp. 217; Pomfrets 1,077; <i>Chirocentrus dorab</i> 51; <i>Polynemus</i> spp. 9; <i>Mugil</i> spp. 39; Miscellaneous 464.
(13) Mechanised vessels	972	<i>Sciana</i> spp. 180; Elasmobranchs 91; <i>Arius</i> spp. 75; Perches 110; <i>Polynemus</i> spp. 160; Miscellaneous 356.
TOTAL ..	578,966	Prawns and crustaceans 151,789; Sardines 52,680; Mackerel 27,812; White-bait 31,309; Sciaenids 72,055; Elasmobranchs 15,767; <i>Trichiurus</i> 29,089; Other clupeids 27,773; Cat-fish 21,354; Silver-bellies and <i>Lactarius</i> 20,322; Bombay duck 35,482; Perches 4,713; Soles 1,657; Carangids 16,150; Seer-fish 6,156; Pomfrets 18,320; <i>Chirocentrus</i> 5,294; <i>Bregmaceros</i> 9,599; <i>Sphyrana</i> 3,988; Flying-fish 1,935; Red mullets 1,513; Polynemids 2,284; Tunnies 2,284; <i>Mugil</i> spp. 40; Miscellaneous 19,637.