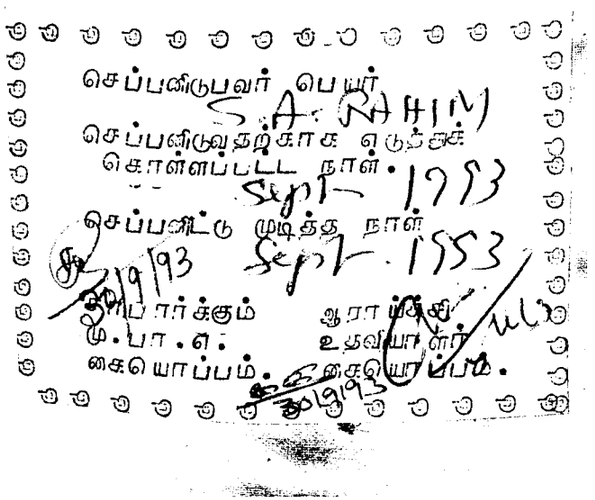
DEPARTMENT OF FISHERIES

FISHERIES STATION REPORTS AND YEAR BOOK

APRIL 1955 — MARCH 1956

PRINTED AT
SRI RAMAKRISHNA PRINTING WORKS
WOODS ROAD, MADRAS-2
1959



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FOREWORD

The present issue is the second in the series of Publications containing the annual administration reports of the Research Stations together with the research papers published from the various Research Stations during 55-56. The Publication of the year Book is an effort to make available to the public in a consolidated form the results of work done at the various Research Stations maintained by the Department in the State.

4

CONTENTS

CONTENTS

5

FISHERIES STATION REPORTS AND YEAR BOOK

I. ANNUAL REPORT OF THE MARINE BIOLOGICAL STATION, WEST HILL, MALABAR COAST FOR THE YEAR 1955-56 BY P. I. CHACKO

1. Meteorology and Hydrography of the Calicut Coast

The maximum atmospheric temperature of 87°F was reached in April and May and the minimum of 63°F in December. The south-west monsoon burst out on 16th May and the rains were fairly heavy with a total rainfall of 136.57 inches as against 138.85 inches in the previous year. During the last five days of September, the rainfall was 15.77 inches, a record for the last 50 years for the month. The month of May recorded the heaviest rainfall it being 19 per cent of the total rainfall for the year. The maximum atmospheric humidity of 89 per cent was in the months from June to September and the minimum was 78.5 in January. The direction of the wind was from north-west to south-east from April to September and in the reverse direction from October to March. The prevailing current was from north to south except during the months of November, December and January when the flow of current was from south to north. The surface temperature of the coastal waters was maximum in April being 29·37°C and the lowest average surface temperature was 25.4°C in August. The maximum and minimum specific gravity were 1.027 in April and 1.021 in February. The PH was high (8.4 to 8.6) from February to May and low (8.25 to 8.3) in other months. Salinity of sea water was high (36.31 to 33.98 per mille) from December, to May and low (29.72 to 32.9 per mille) from June to November. Phosphate content was greater in June and from August to October (63.0 mgm. per cubic metre to 43.5 mgm. per cubic metre) and was lowest in May (13.8 mgm. per cubic metre). Maximum carbonate content was 10.5 mgm per thousand in May and minimum was 5.7 mg per thousand in March. Silicate content showed high value of 420 mg per cubic meter in March and low reading of 9.8 in June.

2. Plankton Investigation of Calicut Coast

Surface plankton was collected and analysed on 49 days. The average sedimentation per litre reached 146cc in December and 128cc in May and dropped down to 11cc in April and 12cc in October.

An important feature was the predominance of phyto-planktonic organisms over zoo-plankters in all the months of the year, the heaviest outburst of this group being in the months of May and November. During these months 90 per cent of the plankton consisted of phyto-

plankters. The seasonal distribution of the important organisms were as follows :—

Coscinodiscus was the most common diatom in the sea found throughout the year. It reached the maximum of 67 per cent in August. In February and April, its frequency came down to 2 per cent. During the other months it occured in Proportions of 23 per cent to 5 per cent.

Fragillaria was a major diatom in the coastal plankton and occurred throughout the year with 2 peaks from June to August (23 per cent to 41 per cent) and November (35 per cent). It was found in trace in March, 2 per cent in January and April.

Chaeloceras was another common diatom. The peaks were reached in May and December when it formed 38 per cent and 29 per cent respectively of the total plankton. It was only 1 per cent in July and August.

Thalassiothrix was absent in July and September, but was present in other months with a peak period in May and June (12 per cent to 22 per cent.)

Biddulphia occurred with 2 maximal periods of 5 per cent in May and in October and in other months fluctuated from trace to 2 per cent.

Rhisosolenia dominated plankton in January when it reached 37 per cent and then declined to 13 per cent and 14 per cent in February and March. It was almost absent in June and October.

Nitzschia had the peak in November (22 per cent.) They were almost absent for 6 months from April.

Asterionella had one peak in May (12 per cent).

Trichodesmium contributed 40 per cent in April and occurred 2 per cent to 8 per cent from January to March.

Planktionella, Melosira, Pleurosigma, Bascteriastrum, Lauderia, Hemidiscus were observed occasionally.

Among Zoo-plankters, copepods were the most common with peak period in March and April when they formed 19 per cent to 22 per cent of the hauls. Their larval forms had the maximal period of 27 per cent in July and 13 per cent in October. During the other months it contributed from 9 per cent to traces. Ceratium were prominent in July (14 per cent), February (8 per cent) and in September (7 per cent). Other flagellates, *Peridinium, Dinophysis, Gymnodinium, Tintinnus* and *Prorocentrum* were occasionally found in the Plankton. The peak months for Evadne were August and September when it formed 5 per cent of the plankton.

Other forms like bivalve larvae, spionid larvae, Frittilaria, Acanthometron, Sagitta and Mysis occurred scarcely at various times. Fish eggs were noticed in December and January and fish larvae in February and March.

3. Investigation on Mackerel Fisheries

Improvement in mackerel landings were noticed during the year, the total landings in Malabar and South Kanara coasts being nearly 11 lakhs maunds as against 5½ lakhs maunds in the previous year. The maximum landings of nearly 5 lakhs were in November.

In June baby mackerels, 49 per cent in zero year and 51 per cent in one year appeared along with miscellaneous fishes. In July also they were caught along with miscellaneous fishes but zero to four year groups formed the catches, the majority being two, three and four year old ones forming 48 per cent, zero year 22 inches, 2 year old ones 26 per cent and three year old 4 per cent. In the month of April, the fishery was mainly composed of three year old ones, 83 per cent. In May 15 per cent were two year groups, 70 per cent three year groups and 15 per cent four year groups. The size of the shoals ranged from 8 cms. to 26 cms. 23 per cent of mackerel examined in May were fully gravid, indicating commencement of spawning. Individuals with ripe gonads were also noticed in July. Those born in June 1954 have entered in the fishery of August and September 1955 when one year group formed 48 per cent and 55 per cent respectively. There was no fresh recruitment of zero year group except in June, July and August of 1955 and the size groups appearing in these months suggest protracted spawning that had taken place in 1954. The very large percentage of 2 year groups appearing in the fishery from October 1955 right upto February 1956 and the spawning from June to August 1955 with one year recruits in June, August and September gave sufficient indication of a prospective mackerel fishery in the ensuing season.

The rate of feed of mackerel was one to two c c in May, September, January and March. In juvenile forms in June and July, the rate was as low as ·2 cc. Zoo-plankters formed the major portion of the food except in a few months. This group formed 80 per cent in May, 75 per cent in July, 62 per cent in January and 60 per cent in March. The Chief organism composing the food were copepods, larval bibalves, flagellates and Evadne and among phytoplankters, *coscinodiscuss, pleurosigma, Trichodesmimum, Fragillaria, Biddulphia, Rhizosolenia, Thalassiothrix* and *Chaetoceras*. The juvenile forms seemed to prefer *Fragillaria*.

4. Investigations on Oil Sardine Fisheries

The oil sardine fishery was not very favourable during the year, the total landing being only about 5½ lakhs of maunds of which nearly three lakhs maunds were landed in the months of November and December. The commercial catches were chiefly composed of 14 to 16 cms. groups in April, 14 to 19 cms. group in May, 13 to 16 cms. in June, 17 cms. in July, 6 to 12 cms. in August, 11 to 14 cms. (first year

groups) and 18 to 20 cms. (third year groups) in September, 12 to 16 cms. in October, 14 to 22 cms. in November, 13 to 21 cms. in December and 15 to 20 cms. in January. There were no landings in February and March. From second fortnight in May upto the end of July, the oil sardines with fully mature gonads formed major part of the catches, Spawning had commenced in early June and continued till the end of July. From August onwards upto October Zero year and first year groups formed the main catches and the exploitation of such juvenile forms is bound to have a serious set back in the c sardine fishery in the ensuing season. Unlike mackerels, oil sardine i predominantly a vegetable consumer. In April, phytoplankters forme 64 per cent of stomach contents, 76 per cent in May, 88 per cent i November and 85 per cent in December. The predominant diatom tha entered into the diet of oil sardine were *Fragillaria, Thallsiothrix Rhizosolenia, Biddulphia, Coscinodiscus, Nitzschia, Pleurosigma* an *Planktoniella.* Zoo-plankters like Copepods, Peridinium, Larva bivalves and spinoids, ceratium and dinophysis, also have formed par of the diet of oil sardines. Very often there was close confirmity between the items noted in the gut of sardines and the organisms in the plankton of inshore seas.

5. Studies on Other Food Fishes

Studies on binomics of other food fishes of west coast were continued. Synaptura commersoniana, a specimen of 17·5 cms. in length examined in May was found to be a female in third stage of maturity with hippa as stomach contents.

Cynoglossus Sidensis. — This forms the Chief "padamanthal fishery" of west coast. Specimens examined in May, June and October were found to have fed on hippa and bivalves.

Cynoglossus Dubius. — Main food consists of mainly bivalves.

Cynoglossus Punctipus and Pseudorhambus Arsius examined in May and July had hippa and mysids in their stomach.

Synagris Japonicus is a plankton feeder.

Sphyraena Obtusata, Teuthis Virgata, Trichiurus haumela and *Rhinobatis Halabi* were other species examined.

6. Fish Sampling Studies at the Kozhicode Landing Centre

This item of interesting study was commenced in June. These studies consist of investigations at the landing centre on the magnitude of the fishery by analysing the variety composition of catch by different tackles. This study is now in progress and it is certain to throw much light on the season of occurrence and bionomics of fishes and of the economic condition of fishermen.

7. Ecological Study at Kaup Fishing Centre

In South Kanara, Kaup is a major cat fish landing centre. A preliminary investigation on the ecological aspects of Kaup revealed that a wide stretch of comparatively shallow area was found protected by a rocky barrier in the West lying 8 miles off. In this stretch from Kaup to Polippu which is a neighbouring fishing centre in the north, the beach was strewn with beautiful tusk shells, Dentalium. The plankton from the sea on examination was found rich with crustacean larvae, molluscs and tunicates. The relationship of Dentalium and cat fish fiishery offers a new field of interesting studies.

8. Estuarine Survey

The fisheries survey of Nileshwar and Cheruvathur estuaries was taken up to find out if there is any adverse effect in the Etroplus fishery in the region by the use of close meshed fixed gear for which licences are being issued. On analysing the catches in the stake net it was noticed that prawns formed very large percentage of catches and that not a single fry of Etroplus was met with. A special kind of drag net used only in very small number in the estuary entraps Etroplus breeders. But this method of destruction of Etroplus breeders is negligible.

9. Statistical Survey of the Trend of Fisheries of the West Coast

Statistics of fish landings along the coast as obtained from the staff of fish curing yards were tabulated and maintained correctly. The fish landings being nearly 40 lakhs maunds as against over 31½ lakhs maunds in the previous year. The mackeral fishery occupied the first rank, the total yield being about 10½ lakhs maunds whereas in the previous year the oil sardine fishery occupied the first rank. The peak period for mackeral fishery was October, November, and December. The total landings of oil sardines was 4½ lakhs maunds, nearly half of last years catches, of which nearly 3 lakhs maunds were caught in November and December. The manthal (sole fish) fishery had its peak in September when about 1½ lakhs maunds were landed. Mullan (silver bellies) fishery was the major monsoon fishery in July. October was the peak period for catfish fishery when landings were high both in Malabar and South Kanara. In November heavy catches of sharks were reported in central and northern sections of Malabar Coast. Seer fish fishery was fairly good in southern section of Malabar coast in November. Ribbon fish fishery was prominent in the northern section of Malabar coast in October. Prawn fishery had its peak from July to September.

Marine fish survey was conducted in Malabar and Southern section of South Kanara coast under the guidance of the Indian Council of Agricultural Research and the data gathered were forwarded to the Council for drawing inferences.

10. Publications

The following publications were made during the year.

1. The 1953-'54 bumper fishery of the oil-Sardine (Sardinella longiceps) of the West Coast of Madras State By P.I Chacko and M.J. Mathew. Ind-Com. Journal, 10, 190-191, 1955.

2. Prawn fisheries of Madras State. By P. I. Chacko. *Contrib Marine Biological Station, West Hill*, 3, 1-14, 1955.

3. A review of the 1953-54 fishery of the Mackerel, **Rastrelliger** Hanagunta of the West Coast of Madras State. **By P. I. Chacko and** M. J. Mathew. Ind-Com. Journal, 10, 288-190, 1955.

4. Age and length composition of the catches of the **macherel** Rastrelliger kanagurta of the calicut coast in 1954-55. By P.I. **Chacko,** and M. J. Mathew. Proc. 43rd Indian Sci. Congr., 3,309-310, 1956 (Abstract).

5. Programme of oil-sardine research in Madras State Fisheries Department in 1954-55 by P. I. Chacko and **M. J. Mathew, ibid, 3, 310,** 1956 (Abstract).

6. Meteorology, hydrography and plankton of the inshore **sea** opposite the marine biological Station, West Hill, Malabar **coast, in** 1954-55 by P. I. Chacko, ibid, 3,319, 1956 (Abstract).

7. Shoaling of oil-sardine, mackerel and catfishes **By P. I.** Chacko, ibid, 11,82-83, 1956.

8. Surface temperature of the coastal waters of Madras State during 1949-54. By P. I. Chacko, Sci. and cult. 21, 458-459 1956.

11. Programme of Work for 1956-57.

1. Studies on meteorology and hydrography of West Hill sea and their correlation with plankton cycle of Calicut coast.

2. Application of both inshore and offshore plonktological studies in fluctuations of plankton-feeding food fishes.

3. Shoaling, length and age frequency, feeding, maturity and spawning of oil sardines with a view to forecast its fishery.

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5. Racial studies of mackerels and oil sardines.

6. General biological and ecological studies of other important food fishes.

7. General survey of fisheries of West Coast with reference to seasonal trends.

8. Occurrence of the red water phenomena of the sea and its effects on the fishery.

9. Compilation of inland and marine fish statistics for West Coast of Madras State.

II. ANNUAL REPORT OF THE MARINE BIOLOGICAL STATION, KRUSADAI ISLAND, GULF OF MANNAR FOR 1955-'56. BY P. I. CHACKO.

1. Meteorology and Hydrography of Kundugal Channel

The atmospheric temperature was at maximum of 88.6 °F in March and minimum of 77.54 °F in December. The atmospheric pressure was low from May to October and maximum from November to March. The pressure fluctuated between 29.734 inches and 30.125 inches. The maximum speed of the wind was nearly 15 miles per hour in December. The north-east monsoon brought nearly 81¾ inches of rainfall and South-west monsoon 8½ inches. Humidity was maximum (86.4 per cent) in December and minimum (78 per cent) in June. Double oscillation in humidity was noticed. The surface temperature of sea water was maximum (29.7 °C) in April and minimum (25.37 °C) in January. The specific gravity was maximum (23.38—24.16) from July to October and minimum (13.6) in December and pH ranged between 8.20 and 8.45. Salinity was maximum (35.70 per mille and 36.23 per mille) from July to September and minimum (30.16 per mille) in November. Dissolved oxygen content varied between 3.07 c.c. per litre and 4.40 c.c. per litre, the maximum being in November. The average residual alkalinity (carbonates) ranged from 0.0534 gm. litre in December to 0.0705 in April and October, Calcium content varied from 0.2851 gm. litre in December to 9.4875 gm. litre in July. Silicates content was maximum (108 mgm. cubic metre) in December and minimum (50.0 mgm. cubic metre) in July. Phosphate content varied from 1.0 mg. cubic metre in December to 36.0 mg. cubic metre in April. Nitrates were nil in December and January and showed the maximum of 30 mg. cubic metre in April.

2. Plankton Stuides of Kundugal Channel

The average plankton sedimentation was high in the months of April and from August to November (142 c.c. 118.6, 247.5 and 169.2 c.c.), the maximum (247.5 c.c.) being in September. The plankton was very poor in July, the sedimentation being only 4 c.c. The phyto-planktonic organisms were predominant over zoo-plankters during the entire period. The phyto-plankters formed 99.7 per cent of the total in November and in the other months from 8 per cent to 97.7 per cent except in the month of July when they formed 90 per cent only. The large percentage of phyto-plankters was caused by swarming of diatoms, Oscillatoria, Trichodesmium, Fragillaria, Rhizosolenia, Chaetoceras and Coscinodiscus. The other diatoms Biddulphia, Pleurosigma and Nitzchia were also present in the plankton. Zooplankters were at their maximum in the months of August, October, February and March. Among the zoo planktonic organisms the important ones that contributed to the volume were Copepods, Crustacian larvae, molluscan larvae, flagellates and Oikopleura.

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Fish eggs and larvae were noticed only in small numbers. Except ing for the occurrence of brown water phenomena during the calm days in the close of north-east monsoon due to putrefaction of large swarms of Trichodesmium no other peculiar planktonic phenomena were noticed

3. Studies on Fishery of Rameswaram Island

At the fishing centres in the Palk Bay side of Rameswaram island good catches were reported during the south-west monsoon period and at the centres on the gulf of Mannar side of the island, heavy landings were made during the north-east monsoon period. Only the Dhanushkodi centre by virtue of its location at the eastern tip of the island enjoys good fishing throughout the year. The tackles that were operated at the different centres are as follows :—

Dhanushkodi.—Dunlop twine net, ola valai, shore seine net and hooks and lines.

Rameswaram.—Ola valai, shore seine net, perch and crab traps.

Thangachimadam.—Madi valai and Dunlop twine net.

Kundugal.—Dunlop twine net and hooks and lines.

Kadarsapad.—Shore seine net.

Rameswaram Rd.—Shore seine net and ola valai.

Fish landings were maximum at Dhanushkodi centre and next best is Thangachimadam. The important species of fish caught in the various centres are as follows :—

DHANUSHKODI.—Sardinella spp., Dussumeria spp., Equala spp Chirocentrus dorab, Cybium spp., Caranx spp. Sciaenids, sharks and rays.

Rameswaram.—Caranx spp., cybium spp., Lethrinus spp., Lutjanus spp., crabs and sepia.

Thangachimadam.—Sardinella spp., Dussumieria hasselti, Equula spp., Lactarius lactarius, Sciaenids, Stolephorus spp., sharks and rays.

Kundugal point.—Sardinella spp., Chirocentrus dorab, cybium spp Lutjanus spp., Serranus spp., and Lethrinus spp.

Kadarsapad.—Sciaenids, Arius spp. and Caranx spp.

Rameswaram Rd.—Sardinella spp., scienids, Arius spp., Sharks and Rays.

The total landings of all fishes are estimated to be 44,000 maunds of which nearly 30,000 maunds were landed at Dhanushkodi centre.

4. Departmental Deep-Sea Fishing Operations in Rameswaram Island

The deep-sea fishing unit at Pamban operated around Rameswaram island nylon bottom nets from motor fishing luggers and Tuticorin type of canoes to demonstrate to local fishermen the efficiency of this type of net in enhancing the catches. Operations were conducted both in Palk Bay and Gulf of Mannar according to monsoonic conditions. The departmental operations were confined to fishing areas lying about 8 to 10 miles off-shore at depths varying from 6 to 10 fathoms. Of fishes caught sharks, Carcharias spp. occupy the first rank the catches being nearly 20,000 pounds. Next comes rays the catches being nearly 13,000 pounds. Chirocentrus dorab, Cybium spp. and Rhyncobatus occupied third, fourth and fifth ranks. The other important fishes caught are Pristis Cuspidatus, Rays, Arius spp., Serranus spp., Caranx spp., Polynemus spp., Chorinemus spp., Lates calcarifer, Strongmateus spp., Chanos chanos, Hilsa spp., Sillago sihama, Elacate niger, Diagramma griseum, Sardinella spp., Lethrinus spp., Lutjanus spp., Sphyraena obtusata, Equula spp. and miscellaneous ones. Dolphins, dugongs and turtles were also occasionally caught. The total catches are estimated to be nearly 76,000 pounds.

5. Marine Fish Farming

The marine fish farm for culture of milk fish, Chanos chanos was in disuse for some time past and steps have now been taken to renovate the farm and conduct fish farming in a systematic way. The renovation work was commended by the end of 1955. It has not yet been completed and the delay was due to damage to the work already done by the cyclone and floods.

6. Pearl Oyster Farming

Pearl oysters, Pinctada vulgaris brought from the pearl banks, off Tuticorin were reared in iron cages and wooden cages with cubicles at the pearl oyster park. The oysters were regularly cleaned and released back in fresh cages at intervals. Culture pearl experiments were conducted with nacre balls for production of free culture pearls. But these experiments did not produce free pearls, but the pearls formed were very often found attached to the shell. Improvements in the technique of culture pearl experiments are now being made. A portion in the Galaxea reef near the island has been selected for planting pearl oysters brought from pearl banks off Tuticorin, so as to study their rate of growth, feeding habits, gonadial maturity, parasitical attack etc., under natural conditions.

7. Studies on Sea Weeds around Rameswaram Island

A preliminary study on the population of sea weeds especially the brown algae, Phaeophyceae around the Rameswaram and nearby islands was taken up and valuable data were collected. The other two classes represented are Chlorophyceae with 48 species and Rhodophyceae with 38 species.

Experiments were conducted to ascertain the percentage of yield of agar from certain red algae. (*Rhodophyceae*) such as *Gelidium, Micropterum, Gracilaria spp., Hypnea musciformis* and *Sarconema Filiforme,* and it was found that *Gelidium micropterum* yielded about 43 percent of agar. The yield of other products of commercial importance such as algin and mannitol from brown algae (*Phaeophyceae*) was also ascertained and it was found that *Sargassum spp , Turbinaria spp., Cystophyllum, muricatum, Hormophysa, triquetra, Padina australis, Steochespermum marginatum, Dictyota* and *Colpomena sinuosa* yield from 13 to 32 per cent of algin. A scheme to set up a pilot plant to produce 200 pounds of agar-agar, 100 pounds of algin and 20 pounds of mannitol per month was prepared.

8. Publications

The following publications were made during the year :—

1. Observations on an interesting method of stake-net fishing in the northern sector of the Gulf of Mannar.—By S. Mahadevan and P. I. Chacko, *Contrib. Marine Fish Biological Station, Krusadai Island, 2, 1-4-1955.*

2. A guide to the field study of the fauna and flora of Krusadai Island, Gulf of Mannar. By P. I. Chacko, S. Mahadevan and R. Ganesan *Ibid.*, 3, 1-16, 1955.

3. Annual variations in the hydrobiological elements of the waters around Krusadai Island, Gulf of Mannar, from April 1954 to March 1955. Proc 43rd Indian Science Congress, 3, 318, 1956 (Abstracts).

4. Production of agar agar, algin and mannitol. By P. I. Chacko and Malu Pillai. *Ind-Com. Journal,* 11, 80-81, 1956.

9. Programme of Work for 1956-57

1. Meteorological, hydrographical and planktological investigation of the pearl park.

2. Studies on pearl oysters, such as farming of pearl oysters and cultching experiments, studies on growth and breeding habits of pearl oysters and on associated flora and fauna, pearl culture experiments, plantation of oysters in Galaxea reef and studies on biology of oysters under natural conditions.

3. Ecology of chank beds off Ramnad coast, bionomics and development of chanks, racial studies and marketing experiments to study migration and growth of chanks.

4. Statistics of trend of fisheries of Rameswaram island.

5. Marine fish farming especially of chanos and studies on ecology of lagoons and growth of fish.

6. Systematics of sea-weeds of economic importance and their distribution in different regions. Studies on the rate of cropping and replenishment of different species of algae.

III. ANNUAL REPORT OF THE MARINE BIOLOGICAL STATION, TUTICORIN, FOR 1955-'56 BY P. I. CHACKO.

1. Meteorology and Hydrography of Tuticorin Bay.

The north-east monsoon was in full vigour from October to January and brought a total rainfall of 59.30 cms. out of a total of 61.33 cm. of rainfall. The closing phase of south-west monsoon brought 2.03 cm. of rain in September. The atmospheric pressure exhibited a single oscillation with the maximum (76.553 cms.) in December and the minimum (76.133) in July. The atmospheric temperature varied from 25.6°C in January to 31-16°C in June. The humidity was maximum (79 per cent) in December and minimum (52 per cent) in June. The surface temperature showed double oscillation with maxima of 28.3°C, 28.6°C, 28.4°C in May, September and October respectively. The minimum of 25.0°C was observed in January. The specific gravity fluctuated between 22.0 in December to 25.0 in July, August, October, November and February. PH value was between 8.30 to 8.45. Sudden rises and falls were noticed in salinity. The maximum (5.7 c.c. per litre) and during the rest of the period the oxygen content was more or less constant in the region of 3.1 c.c. per litre to 3.4 c c. per litre except in December when it was 4.1 per litre. The silicate content was fairly high (132 to 253 mg./cubic metre) from July to December and the minimum of 75 mg./cubic metre was noticed in January. The carbonate contents showed little variation, the range being 0.0695 gms./litre in March to 0.096 gms./litre in December. The phosphate content was poor ranging from 6 mg./cubic metre in November to 18 mg./cubic metre in August.

2. Plankton Investigation

Surface plankton was collected and analysed on 35 days (25 inshore and 10 offshore). The sedimentation per litre was maximum (60 c.c.) in February and minimum (10 c.c.) in June and August. Throughout the period, the zooplanktonic organisms were greater in percentage than phytoplanktonic organisms except in April when phytoplankters formed 52 percent of the total plankton. The pronounced peak of zoo-plankters in December (78 percent) and again in June (81 per cent) were mainly due to swarms of copepods and their nauplii. The larvae of invertebrates occurred throughout the year, the most important of them being larvae of bivalves and gastropods. Polychaete larvae were seen from October to February. Maximum number of Chaetognathae were obtained from January to March. Fish eggs appeared from November to March with their maximum in January. Leucifers, medusoids, Doliolum, Noctiluca and Ceratium also occurred in small numbers.

Diatoms constituted the main elements of phytoplankton. The maximum occurrence of diatoms was from June to August and again from January to April with August and April as peaks. These peaks were due to swarming of *Coscinodiscus, Rhizosolenia* and *Biddulphia. Planktoniella, Bacteriastrum, Chaetoceros, Hemidiscus, Fragillaria, Thalassiothrix, Asterionella, Navicula, Pleurosigma, Bacillaria, Nitzschia, Oscillatoria* and *Melosira.*

3. Trend of Fisheries of Tuticorin

The total landings of fish at Tuticorin during the year was estimated to be over 35,000 maunds of which nearly 8,000 maunds were entirely formed by *Sardinella fimbriata.* The tackles used were Kolavalai, Dunlop twine net, hand lines, R.C. lines, vala valai, Madi valai, whiffing and long lines. Sardines, consisting of *Sardinella fimbriata, Sardinella gibbosa* and *Sardinella sirm* constituted the richest fishery in the year. The second in rank was *Chirocentrus dorab* which accounted for 2540 maunds, the third was *Dussumeria hasseltii,* the fourth *Engraulis spp.*, the fifth *Epinephelus spp.*, and the sixth *Scomberomorus guttatum.*

The following were the monthly details of the trend of the fisheries at Tuticorin :—

Month	Weight in mds.	Chief Fisheries
April, 1955	1810	Sardinella gibbosa, S. fimbriata and Dussumeria hasseltii.
May	2350	Chirocentrus dorab, Sardinella gibbosa, S. fimbriatia and Serranus undulosum.
June	4100	Chinocentrus, Scomberomorous, Sardinella fimbriata and sharks.
July	5600	Engraulis, Sardinella gibbosa, S. firmbriata, Chirocentrus & Sharks.
August	2760	Sardinella fimbriata, S. gibbosa and sharks.
September	2630	Sardinella fimbriata, S. sirm, S. gibbosa and Pellona.
October	3440	Sardinella fimbriata, S. sirm and S. gibbosa.
November	1530	Sardinella sirm, S. fimbriata and Engraulis.
December	3020	Sardinella fimbriata and S. Sirm.

Month	Weight in mds.	Chief Fisheries
January, 1956	1580	Sardinella fimbriata, S. gibbosa and Engraulis.
February	2400	Dissumieria hasseltii, S. fimbriata, S. gibbosa and S. sirm.
March	3970	Sardinella fimbriata, S. gibbosa and Dussumieria hasseltii.

The seasonal catches of the various tackles used in Tuticorin were noted as follows :—

Tackle	Season	Catches
Long lines	March-July	Sharks, rays, catfishes, Serranus, Diagramma, Gerres & Pristipoma.
Pachuvalai (drift net)	Throughout the year	Plough fishes, sharks, rays, catfishes, Jew fishes, Hilsa toli, porpoises, dolphins and turtles.
Karavali (Shore seine)	do	Seer, pomfrets, Lates, Pellona, mullets, sharks, Teuthis and chanos.
Madivalai (Boat seine)	do	Silver-bellies, Lactarius, Upeneus, Chirocentrus & Sphyraena.
Valavalai (drift net)	April to August	Chiefly Chirocentrus.
Veechuvalai (cast net)	Throughout the year	Therapon, Sillago, Gerres, Elacate, Anchoviella, mullets and catfishes.
Kolavalai (drift net)	September to March	Sardinella fimbriata, S. gibbosa, S. sirm, Dissumieria hasseltii, Leiognathus, Anchovella and Pellona.
Handlines	Throughout the year	Diagramma, Balistes, Serranus, Gerres, Lethrinus, Lutjanus, Caranx and Aprion.
Whiffing line	June to August	Scomberomorus, Sphyraena, Caranx, Chorinemus, Thynnus, Elacate.

4. Study of Pearl Fisheries

Tholayiram par and the other pearl banks south of it were inspected in a detailed manner in November and December. Tholayiram par (South area) was found to contain an estimated population of only 8½ lakhs of oysters of which more than 6¾ lakhs were over 3 years of age and mature for a fishery. The northern area of the par was found to consist of oysters less than 3 years of age, the major percentage being formed by oysters of 1 to 2½ years of age. Out of other ten pearl banks (pars) situated to the south of the Tholayiram par, all

banks except Sultan par, were found to have had heavy spat-fall about a year back. Those oysters of one to two years of age and thickly populated throughout the entire banks will be ripe for a large fishery in February– March 1957. To exploit the estimated population of 6¾ lakhs of oysters of over 3 years of age in the southern area of Tholayiram par, a pearl fishery of small scale was commenced from 29-2-1956. The estimated quantity of oysters in the southern section of the Tholayiram par was fished out almost fully in the first week of the fishery. A fairly strong northerly wind set in in the beginning of next week and this resulted in a fairly strong current from the north which washed away the overgrowth of thick sea weeds on the oysters in the northern portion of the par and it was found that this bed also contained large number of oysters over 3 years though to a less percentage. Therefore the exploitation of the oysters in this portion was also resorted to. Fairly large number of oysters was fished out every day from this region. The fishery was thus continued upto 18th March 1956 when it was closed due to the fact that the Divers Union passed a resolution against the continuance of the fishery any further and it was observed that a major portion of the large sized oysters had already been fished out. There were 18 fishing days and 325 boats were sent for fishing. The average number of boats which participated was 16 per day. A total of 21,29,058 oysters were lifted of which Government share of oysters came to 1,419,371. The fishery was quite successful in all respects and both the merchants and the divers expressed their satisfaction of the results of the fishery.

5. Studies of Chank Fisheries

The chank fishing season commenced on 9-11-1955 and was in progress even in the end of the year under review. Upto the end of March 1956, 385,035 chanks were landed of which only 38,665 were wormed and undersized. The percentage of undersized chanks happened to be less than 7 percent and wormed 3½ percent.

Of the marked chanks released, six chanks were recovered in December, January and February from Pasipar, Vaduombathu par, Pattram par, Vadavalipattru par and Aluva par respectively.

6. Publications

The following publications were made during the year :—

1. The first pearl fishery in Independent India. By P. I. Chacko, *Proc-43rd. Indian Sci. Congr.*, 3, 303, 1956 (Abstract).

2. Fodd and Feeding habits of fishes of the pearl-bank. Thollayiram Par in the Gulf of Mannar. By P. I. Chacko, *ibib.*, 3,309, 1956 (Abstract).

7. *Programme of work for1956-57.*—1. Meterological and hydrographical studies pertaining to pearl banks and chank beds.

2. Studies on bottom strata of pearl bank and chank beds and the influence of bottom strata on the hydrography of the water immediately above.

3 Studies on the surface and bottom plankton of the pearl banks and chank beds.

4. Studies on growth, feeding habits, breeding habits, gonadial maturity and parasitism of pearl oyster.

5. Studies on the biology of important perches and Balistes inhabiting pearl banks.

6. Studies on enemies of pearl oysters and on the bottom fauna in association with pearl oysters.

7. Drift bottle experiments to study the drifting away of oyster larvae according to prevailing currents.

8. Evolution of a technique to estimate the population of oysters in different pearl banks.

9. Detailed inspection of the pearl banks to find out the possibility of a pearl fishery by the end of the year.

10. Studies on chank fisheries off Tuticorin.

IV. ANNUAL REPORT OF THE MARINE BIOLOGICAL STATION, ENNUR, FOR 1955-56. BY P. I. CHACKO.

1. Meteorological and Hydrographical Investigations at Ennore Estuary

The maximum atmospheric temperature of 98°F was reached in June and the minimum of 84°F in December, Humidity was maximum (91 percent) in May, November and December and minimum (83 per cent) in July, August, October, January and February. The atmospheric pressure was 30.1 inches and 30.2 inches from April to October and 30.4 inches from November to March. The maximum surface temperature of 87°F was reached in April and July and the minimum of 82°F was recorded in August and February. The highest specific gravity of 1.025 was recorded in March and the lowest of 1.022 in October. The maximum PH value recorded was 9.6 in September when a phytoplanktonic bloom causing green water phenomena appeared Turbidity of water ranged from 23 cms. in October to 130 cms. in February. Salinity was lowest in October being 9.0 parts per thousand and highest in February being 33.0 parts per thousand ; oxygen content was fairly constant ranging from 5.4 c.c. per litre to 6.5 per litre.

2. Plankton of Ennur Estuary and the Sea Off Ennore

The following zoo-planktonic organisms were present in the estuarine plankton throughout the year ;--

Copepods like Pseudocalanus, Acartia and Calanus and Nauplii, Polychaete larvae, larval bivalves, Gastropod larvae, daphnids like Canthocamptus and Evadne, Pleurobranchia, Arcella, Tintinnus, Ceratium tripos, Peridinium, Noctiluca. Echinopluteus larvae, Mysis, Leucifer Megalopa and Zoea larvae, Rotifers, Sagitta, Cresis acicula, Doliolum, Medusoids, water mites and cypiris.

Among the phytoplanktonic organisms the following are more common :

Chaetoceras, Spirogyra, Coscinodiscus, Navicula Pleurosigma, Rhizosolenia, Microcystis, Oscillatoria, Asterionella, Nitzchia, Biddulphia, Hemidiscus, Thalassionema, Bacillaria and Halosphaera.

All the organisms present in the estuary except the fresh water forms were found in the sea also. But most of the forms appeared first in the sea and then were noticed gradually in the estuarine plankton. Freshwater forms were noticed in the estuary during floods only. Quantitatively each form present in the plankton from the sea is five times more than in the estuarine plankton and copepods sometimes 10 times. The sedimentation is also correspondingly more in case of plankton taken from the sea.

3. Edible Oyster Research

The oyster boxes and oyster cage with crates were laid in the oyster beds in the estuary to study the intensity of spat fall for the various months of the year. Tiles coated with lime and plain tiles were used as cultch to find out the suitability of each for the purpose. Tiles coated with lime were found to be more suitable as more spats were found attached to them than in the case of plain tiles. The growth rate of oyster spat and the estuarine fouling organisms of oyster cultch were studied. The maximum growth rate observed was 12 cms. in a fortnight and the minimnm 3 cms. The fouling organisms were Modiola undulatus, Hydroides, Balanus amphitrite, Neries, Cerolan, and Nucularia mauritiana.

Oysters were measured, weighed and examined for their gut contents until September when fresh waters flooded into estuary from upper reaches completely annihilating the oyster population. The gut contents of oysters examined consisted of diatoms like Coscinodiscus, Rhizosolenia, Thaiassiothrix, Melosira, Bacillaria, Navicula, Pleurosigma and Nitzchia.

4. Bionomics of Mullets of Ennur Estuary

Three common species of mullets are Mugil oeur, Mugil dussumeri and Mugil parsia. Mugil oeur ranging in size from 25 cms. to 50 cms. were available up to September though in very small numbers. Mugil parsia ranging in size from 8 cms. to 14 cms. were the most common though Mugil dussumeri ranging in size from 10 cms. to 20 cms. were also fairly common in the estuary.

Females and males of all the three species in breeding condition were found in January. Larvae in abundant numbers were seen in shallow waters. The fry and fingerlings of mullets are quick in their movements, have a characteristic way of leaping above water when disturbed, are elongate and spindle shaped, silvery on the abdomen and on the sides and greenish dorsally. The caudal fin is black tipped making it easily identifiable while in the water. Stomach contents consisted of zoo plankters such as Tintinnus, Copepods, Polychaetes, and Daphnids and Phytoplankters such as Navicula, Nitzchia, Pleurosigma, Rhizosolenia, Oscillatoria, Cocinodiscus, Pediastrum, Suriella and Merismopedia.

5. Bionomics of the Ribbon Fish, Trichiurus Savalai

Trichirrus Savalai appeared in fishermen's catches from May onwards and reached their peak in September after which month they declined. Young ones, 23.31 cm. in length and 3.12 gm. in weight, appeared in October. It was found that weights were not directly proportional to the growth in length. Growth in length was rapid

whereas the increase in weight was a slow process. Fish of more or less the same length varied in width and weight, the heavier and wider ones probably being older ones. In younger fish the tail portion constituted half the body length whereas in older ones, it is only one-third. That is a carnivorous form feeding on smaller fishes.

6. Studies on Prawn Fishery

Prawns available in the estuary were Palaemon lamarrei, Metapeneous monoceros and Penaeus indicus. Penaeus indicus which enter the estuary from the sea were the most common. They continued to be found in the estuary even after the closure of the bar and the mysid larvae noticed in the estuarine waters when the bar remained closed proving that they breed in the estuary. Metapeneous manoceros which is blackish green in colour, in contrast to the pinkish youngs of Penaeus indicus and bluish black adults of the same were found rarely along with Penaeus indicus. Stomach contents of Peneus indicus were comprised of sand grains and insect parts. Sizes examined ranged from 6 to 14 cms.

Palaemon lamarrei ranging in size from 7 cms. to 12 cms. were available in the estuary from September to November after the floods in the river. Stomach contents consisted of bottom debris, digested vegetable matter, sand grains, Navicula, Fragillaria and the like.

7. Studies on the Green Crab, Scylla Serrata

A good fishery of green crab, Scylla serrata was observed in June. On an average about 10 small catamarans took part in the fishery. Crabs were caught by hooks tied by small pieces of dyed cotton twines to a long line. Bait used were Hippa or Meretrix flesh the flesh of shark, ray or eels. A triangular bag net was used to haul up the crabs by inserting it below the crabs soon after they had taken the bait and shaking them into the net.

The female ones were found to be fewer in number than males in June whereas in August the females in advanced stage of maturity were more in number. The stomach contents consisted of digested flesh of Hippa or Albunea and occasionally pieces of Oscillatoria and green scum. They were found to be hardy and not affected by sudden hydrographical changes. They lived for 20 days without food or water.

8. Publications

The following publications were made during the year:—

(1) An unusual crab fishery in the sea off Ennur, near Madras. By P. I. Chacko and E. Palani. *Journ. Bombay Nat. Hist, soe.*, 52, 946-947, 1955.

(2) Report No. 1 on the Madras Edible Oyster (*Ostrea Madrasensis*). By D. W. Devanesen & P. I. Chacko. *Contrib. Fish. Biological Station, Ennur*, 2, 1-60, 1955.

(3) Hydrobiology and fisheries of the cortalliar estuary, Ennur near Madras, in 1954-55. By P. I. Chacko. *Proc-43rd Indian Science Congress*, 3, 308, 1956 (Abstracts).

9. Programme of Work for 1956-57

(1) Meteorology, Hydrography & Planktology of Ennur estuary particularly of edible oyster beds.

(2) Studies on the biology of estuarine fishes one after another. Mullets will be taken first.

(3) Catch-effort statistics of fisheries of Ennur estuary with a view to assess the fluctuations in the different fisheries.

(4) Studies on farming of edible oysters, destruction of oyster beds by pollution, by enemies such as boring nolluses, bivalves, starfishes, barnacles, etc., cultching oysters by use of various types of cultch.

(5) Investigations in Pulicat lake when a new research Assistant is appointed.

V. ANNUAL REPORT OF THE FRESHWATER BIOLOGICAL STATION, BHAVANISAGAR, FOR THE YEAR 1955-'56.

BY M. DEVIDAS MENON AND S. T. CHARI.

INTRODUCTION

The Fresh Water Biological Research Station continued to work at Bhavanisagar. Due to non-availability of a large building the various sections of the Station worked in four separate but adjacent buildings. The Public Health Fish Officer and Unit continued to work at Chetput, Madras.

STAFF PERSONNEL

1. *Assistant Director of Fisheries (Fresh Water Biology).*—Sri M. Devidas Menon, continued throughout the year.

RESEARCH STAFF

2. *Hydrologist.*—(a) Sri R. Srinivasan, 1-4-1955 to 14-11-1955.
   (b) Sri K. A. Dorai Rajah, (15th to 30th November 1955 (held charge)]
   (c) Sri M. Devidas Menon, [1st December 1955 to 5th March 1956 (Full Additional charge)]
   (d) Sri S. T. Chari, (6th March 1956).

3. *Research Assistant (Fresh Water Biology).*—(a) Sri M. Nelliyandar, (1st April to 31st May, 1955).
   (b) Sri T. B. Ramachandran, (1st June 1955 to 13th February, 1956).
   (c) Vacant (14th February to 31st March 1956)

4. *Research Assistant (Fluviatile).*—Sri B. Krishnamurthi, (1st April, 1955 continuing).

5. *Research Assistant (Hydrology).*—(a) Sri K. A. Dorai Rajah, (1st April, to 3rd September, 1955).
   (b) Sri M. V. Natarajan, (4th September to 14th October 1955).
   (c) Sri K. A. Dorai Rajah, (15th October 1955 continuing).

6. *Research Assistant (Soil Analysis).*—(a) Sri N. Narayana Hande, (16th May, to 5th October, 1955).
   (b) Vacant (6th October 1955 to 31st March, 1956).

7. *Algologist.*— (a) Kumari N. Pankajam (1st April to 18th July 1955.
   (b) Vacant (19th July to 8th August 1955).
   (c) Sri A. D. Venkataswami (9th August 1955 continuing).

8. *Public Health Fish Officer.*—(a) Srimathi J. G. Abraham, (1st April to 7th June 1955).
   (b) Sri T. M. Arumugam, [8th June 1955 to 16th June 1956 (held charge)].
   (c) Sri M. Nellayandar (17th June 1955 to 11th January, 1956).
   (d) Srimathi J. G. Abraham (12th January 1956 continuing).

9. *Fisheries Overseer under Research Assistant (Fluviatile).*—Sri V. Madhavan Nair, (1st April 1955 continuing).

10. *Fisheries Overseer under Research Assistant (Soil Analysis).*—Sri N. Muthuswami (21st June 1955 continuing).

The Fresh Water Biological Research Station records with deep regret the sudden death of Sri T. B. Ramachandren, Research Assistant on 14—2—1956 at the Head Quarters Hospital, Coimbatore.

PROGRAMME OF WORK

1. Limnology of the Bhavanisagar Reservoir.
2. Further Studies on the Blue Green Algae Microcystis sp.
3. Studies on River and Reservoir Pollution.
4. Investigations on the Fish Poisons.
5. Aquatic Manuring Experiments.
6. Analysis of Pond Bottoms.
7. Studies on Food Value of Fresh Water Fishes.
8. Studies on the Oxygen requirements of Fresh Water Fishes.
9. Investigations on the Fish Population of Bhavanisagar Reservoir with reference to efficiency of different gears.
10. Experiments on the seggregation of carp fry.
11. Studies on Rasbora daniconius.
12. Studies on the White carp, *Cirrhina cirrhosa.*
13. Investigations on *Tilapia mossambica.*
14. Studies on spawning of Mirror carp.
15. Miscellaneous.

1. Limnology of Bhavanisagar Reservoir

A detailed report on the preliminary studies on the surface waters has already been completed for publication in the Departmental bulletin. Detailed studies on the Limnology of the sub surface layers at various depths at four stations in the reservoir has been undertaken and continued during the year. The daily Meteorological conditions were also noted during the period as the studies of last year showed that the fluctuations in the meteorological conditions bear great influence on the physical and chemical changes in the reservoir.

Meteorological data :—Meteorological data were as usual collected from the daily recordings.

The highest average maximum temperature of 99.0°F was recorded during April, 1955 and the lowest average maximum temperature of 84.1°C being recorded in December 1955.

The highest average minimum temperature of 79°F was in April 1955. The lowest average minimum temperature of 64.6 ° F was in February 1956.

There was a total rainfall of 19 inches during the year as against 15.43 inches in 1954-55. The maximum rainfall of 5.5 inches occurred in September 1955. The level in reservoir was at its peak in the months of August and September 1955. The lowest level in the month of December 1955. The period from June 1955 to October 1955 was marked by strong winds. The maximum wind velocity of 18.6 miles per hour on the average was during July 1955.

Hydrological Conditions :—The difference between the surface and bottom water layers in the reservoir at all the four stations never exceeded 0.9 degree C during January 1956. The difference in the temparatures progressively increased during the months of February 1956 to a maximum of 1.5 degree C and to 2 degree C during March 1956.

Similarly the difference in average of the PH of the bottom and surface layers was only as much as 0.5 during January, 1956 increasing to 0.8 in February and March 1956.

The correlation between the other chemical data can be drawn only after the completion of the entire investigations.

Monsoon months were marked by the maximum production of phytoplankton. During the months of February to May *Melosira* was dominant in plankton. Microcystis became prominent during the months of June and July. By August *Microcystis* dwindled in numbers and *Synedra* played the dominant part in the phytoplankton and continued to be so till end of September. As *Synedra* decreased in number *Navicula* appeared on the scene in the month of October.

During the months of November, December and January *Ceratium* asserted itself into prominence.

A further work on this has been commenced from December 1955. Plankton samples from the four stations were collected twice in a week and analysed qualitatively and quantitatively.

(a) At the mouth of Moyar river.
(b) At the mouth of Bhavani river.
(c) Above the confluence.
(d) Below the confluence.

Ceratium continued to be prominent in the collections during December and January with *Melosira* and *Staurastrum* closely following. During February and March *Melosira* became dominant with *Staurastrum* next in population.

Fish :—The fish population continued to be mainly composed of fluviatile species. *Barbus dubius* contributed to 64% of the total population in the reservoir. The stocking of the reservoir with ecologically exotic fishes like *Catla catla, Cirrhina cirrhosa, Labeo fimbriatus* and *Etroplus suratensis* started being felt in the population as found from the experimental catches. The percentages of these species in the population were as follows :—

Labeo fimbriatus	..	0.18
Cirrhina firrhosa	..	0.07
Catla catla	..	0.20

Though *Etroplus suratensis* did not come into these experimental catches in the reservoir this has stabilised very well as is seen from the distribution of this fish in the Canal system and irrigation tanks connected with the Canal system. The reservoir has been stocked this year with Mirror carp and *Labeo rohita.*

The population of *Barbus dubius* composed of 6 year classes the I to VI groups forming the commercially expoitable classes. The population of *B. hexagonolepis* composed of, 8 classes with II to VIII groups forming the fishery.

The catch per unit effort was maximum in the period October to December. The relationship of the catches with sudden drops in wind velocities and reduction in surplussing was again noticed.

Observations on the seasonal and diurnal changes in the percentage composition of young fishes in the reservoir were commenced in January 1956. Weekly samples in the morning and evenings were collected at the mouth of river Bhavani and were examined for species composition and lengeh frequency. The data collected so far show that more than 80 % of the recruitment in the months of January to March composed of small varieties of fishes like *Amblypharyngodon, Perilampus,*

Danio, Rohtee cotio, Macrones vittatus, M. Oculatus, Rasbora, Chela B. chrysopoma, and *Ophicephalus marulius* were found in small proportions. There is a diurnal cycle in the relative abundance of the varieties, cat fishes being in greater percentage in the evenings than in the mornings. The work is being continued to get a picture of the seasonal variations and is expected to yield data on the rates and species composition of the recruitment of fish to the reservoir population through the river Bhavani.

2. *Further Studies on the Blue Green Algae Microcystis*

A detailed work on Microcystis was taken up. Experiments were again gone through with different culture media like Knops, Mohrlish, Pringsheim, Beijerinck and extracts of pond soil, garden soil, mud soil and sand soil. These revealed that the soil extracts with the soil as the substratum (especially pond soil and Garden soil extracts) gave the most encouraging results probably indicating the necessity of certain elements. In order to fix up these elements more detailed work will be carried out. It has also been found that the cultures require direct sunlight for their effective and quick growth.

3. *Studies on River and Reservoir Pollutions*

1. *The Mettupalayam United Bleacher's Factory.*—This factory is situated over an area of about 8 acres on the bank of River Bhavani at Mettupalayam on the Northern side of Nellithurai road. The factory is engaged in bleaching and processing of handloom cloth handling about 20,000 pounds of material per day. The waste liquors from the Bleaching, desizing and keir baling and grey souring processes at the rate of about 75,000 gallons per day are led into the river Bhavani through a drain in the northern bank of the river towards the upper reaches of the reservoir. Investigations as to the effect of these effluents on the fisheries of the river Bhavani and Bhavanisagar were undertaken during the year. Periodical samples of the effluents proper and the river water samples from 100 yards above the confluence of the effluents at the point of confluence and 100 yards below the confluence respectively were collected and analysed in detail.

It was found that the effluents of the Keir boil were dark brown in colour with a smell of burnt lime. The effluents were highly alkaline with a pH exceeding 11.0 on many occasions, with a total conductivity figure exceeding 30,000 reciprocal meghom indicating great quantities of dissolved impurities in the liquor.

Analysis of the wash wastes was also done and it also showed a high pH and high conductivity figures.

The River waters 100 yards above the confluence were well oxygenated and it had an average pH of 7.6 and low chloride figures of 0.8

to 1.0 pp. 100000. The total solids were 17 ppm. on the average and the Tidys and Ammonia figures were low being characteristic of river waters.

The effluents had the effect of raising the Bicarbonates, pH and the chloride content to a high degree at the point of confluence and to a fair extent at 100 yards below the confluence.

Taking 1,75,000 gallons as the waste out put of the factory for one shift of 8 hours the discharge would be about 3,50,000 gallons during a double shift day. Taking the average depth of the river to be 4 feet and width 200 feet and rate of flow at 2 feet per second, there would be an approximate dilution of over 1,750 to 2,000 times. As per laboratory investigations a dilution of over 1,000 times is needed to keep down the harmful effects of effluents

2. *Pollution of Vellar Estuary by Waste Waters of South Indian Starch Factory.*—This factory is situated on the banks of Vellar river near its estuary at Porto Novo, in the South Arcot district. The factory is engaged in the manufacture of crude starch from raw tapioca roots. Approximately 12,000 pounds of raw tapioca are processed daily yielding about 3,000 pounds of crude starch. About 5,000 gallons of the starchy wastes are let into the Vellar River daily.

The Vellar River originating from the Uttangarai hills in Salem District runs a course of about 300 miles through Salem and South Arcot districts and finally empties into the Bay of Bengal at Porto Novo. The Vellar Estuary is connected with the sea throughout the year and subject to diurnal tidal influence upto about 10 miles upstream.

The effluents were highly turbid and white in colour with starchy odour with an acidic pH of 4.0 the acidity being due to the fermentation and putrefaction of starch resulting in the formation of carbonic and other organic acids. The waste waters had a total solid figure of 18,000 pp. million of which 10,050 ppm. were organic matter. The organic matter is derived from the processing of raw tapioca into starch. The highly putrescible nature of the effluents was indicated by the high Biochemical Oxygen demand of 5,000 ppm. during 3 days test and 1,764 ppm. of oxygen absorbed in 4 hours (Tidys Test).

The free ammonia figure was nearly 3 times that of Albuminoid ammonia. This is due to the microbiological action and enzymatic digestion of the nitrogenous gluten and proteins present in tapioca tuber.

The effluents had the capacity of reducing the pH. of the river water from 8.5 to 7.2 and the dissolved oxygen by 2.0 mg/litre. There was an increase of Free carbondioxide, Bicarbonates organic matter and Biochemical Oxygen demand of the Vellar river waters. But the pollutional effect of the waste waters of the factory was felt only over

a small zone near the out fall of the effluents. This is due to the high degree of dilution effected naturally in the river due to the tidal influence which is reflected in its plankton characteristics.

At 100 yards above the discharge of effluents the phytoplankton was represented by Chlorophyceae (*Pediastrum*) Bacillariae (*Cyclotella, Navicula,* and *Coscinodiscus*), Myxophyceae (*Microcystis sp, Oscillatoria* and *Cylindrosphaerium*); and Dinophycease (*Ceratium*).

There was increase of 200% in the *Chlorophyceae* at the out fall of the effluents showing the pollutional characteristics of the effluents. This phytoplankton was totally absent at 100 yards below the point of confluence.

The increase in the diatom population 100 yards below the effluent outfall indicated the considerable dilutions of the effluents effected by the river waters.

No deleterious effects were reported to have been caused by the effluents on Vellar fishes. However laboratory experiments revealed that the starch factory effluent were harmful to fish life if not diluted to 8,000 times and over. It was found from a study of the rate of flow in the river and the quantity of effluents discharged, that a natural dilution of 33,300 times was effected on the effluents in the river. Since such a guaranteed dilution beyond the minimal dilution of 8,000 times is effected in the river at all periods of the year, neither mechanical nor chemical treatment was considered necessary.

3. *Pollution of Kalingaraya Channel* :—The Kalingarayan Channel is an irrigation channel running a course of about 28 miles in the Erode taluk on the southern bank of the river Cauvery. There are about half a dozen small bleaching firms located near the channel of which only one firm belonging to Sri S. Natchimuthu Gounder could be considered as a major bleaching firm.

This factory employed about 15 to 16 daily workers, bleaches 2,000 yards of hand loom fabrics discharging its waste waters at the rate about a gallon per hour. The total quantity of effluents that are let into the stream during a 6 hour shift would not be any way more than 100 gallons.

The low quantity of effluents is due to the fact that prior to entering the stream the effluents pass through the private garden of the owner irrigating the same, and as such only a trickling flow escapes out of the garden into the Kalingarayan channel.

The strong effluents collected was whitish in appearance with a pH ranging from 7.0 to 7.5. The total solids were present to the extent of 1,76,000 ppm. and a conductivity of 1975 Reciprocal meghom. The Free CO_2 content varied from 4.95 to 6 6 ppm. The Bicarbonates

showed great fluctuations ranging from 30.5 to 573.4 ppm. and chloride was also high.

Samples of water from the stream from three places, one at 100 yards above point of confluence, one at the confluence and one 100 yards below the confluence of effluents were collected and analysed. It was observed that the effluents had the effect of increasing the chemical factors of the stream as shown by the higher chemical values of water in the samples collected at the confluence and 100 yards below, The Dissolved Oxygen of the stream waters did not show any appreciable change due to the mixture of the effluents.

Detailed laboratory experiments revealed that fishes had no ill effects even in a dilution of 1:10 of the effluents.

The minimum rate of flow in Kalingarayan Channel is 80 cusecs. Taking the lowest rate of 80 cusecs it works out to 2,15,60,000 gallons of water per day of 12 hours during the shift hours of the factory. Hence the dilution works out to 1,18,000. Thus a natural dilution of over and above the 1800 times minimal requirements of 1:10 is ensured in the channel. In view of the guaranteed dilution of such magnitude special machanical and chemical treatments of the effluents prior to discharge into the channel is not considered necessary.

4. Investigation on Fish Poisons

In the upper reaches of various rivers of the state wholesale capture of fish in large stretches of the rivers are made by using different poisons. The detection of the mortalities of fishes as a result of such poisoning has been made necessary in the prosecution of various cases under Indian Fisheries Act. For this purpose the effect of various indigenous fish poisons on fish life has to be studied and this work has been undertaken. Besides, the eradication of predators forms an obligation and prerequisite of stocking and fishery development in a piece of water. To evolve a method of selective killing of predators with some indigenous poison, this study has a practical bearing. Preliminary work on collection of all the different indigenous varieties of poisons, their avilability, application and mode of use and their effects, etc., have been gathered after a detailed survey in various parts in the state. This problem is under further study.

5. Aquatic Manuring Experiments

Experiments were started in the Bhavanisagar Fish Farm to assess the utility of various organic and inorganic manures in increaseing fish production. At the Bhavanisagar Fish Farm superphosphate cow dung were treated in the ponds as follows :—

Pond 2—Superphosphate treated.
Pond 3—Superphosphate treated.
Pond 4—Cow dung treated.
Pond 5—Control (untreated).

Tilapia fish measuring from 45–55 mm. in length were stocked in each of the ponds. Periodical analysis of water, mud and plankton samples were analysed and assessed for their characteristics and correlated with the growth of the fish. The results of experiments so far conducted showed that in the ponds treated with superphosphate fertilizer, the reserve and available phosphorous of the bottom soil increased as compared to the control. The organic content of the bottom mud of the pond treated with cow dung was higher than any of the other ponds. The planktonic organisms were found in abundance in the manured ponds, the waters attaining a greenish hue within a fort night.

The fish *Tilapia mossambica* had grown very well in all the manured ponds, the maximum size attached being 200 mm. in the pond treated with cowdung in a period of 8 months. The fish bred very well in the cow dung manured pond and control pond. The breeding was very poor in the ponds manured with superphosphates.

Microcystis blooms were prominent during July to September and December in superphosphate-treated ponds and during August and September in cow dung treated pond. The control showed microcystis bloom throughout.

Melosira was present throughout the period in Ponds 1 and 2 with a maxima during July and September. It was present in Pond No. 4 during July, October and in Pond No. 5 during November, December, January and February. *Navicula* was present in all the four ponds throughout the period. *Euglenoid* blooms were noted in Pond No. 2 during October and November in Pond No. 3 during September, Pond No. 4 during July, August and September and in Pond 5 during September and October. *Pinnularia* was predominant in the plankton in Pond No. 1 during September. *Oscillatoria* was represented in the plankton in Pond No. 1 during January and February and in Pond No. 4 throughout the period with a maxima during December. *Pediastrum* was present in the plankton in fairly good numbers in all the ponds throughout the period. *Synedra* was very prominent during November and December in Pond No. 2, during October and November in Pond No. 4 and during October, November, January and February in Pond No. 5. *Staurastrum* was represented fairly in good quantities during September, October and November in Pond 3 and during December, January and February in Pond No. 5. *Cymbella* was present in Pond No. 3 during October and November, in Pond No. 4 during July, August and September and in Pond No. 5 during August, October, December, January and February.

6. Analysis of Pond Bottoms

A start on detailed study on the relationship of bottom muds and soils in relationship to fish production was made following the appoint

ment of a Research Assistant (Soil Analysis) but unfortunately due to the resignation of the candidate the work envisaged could not be pushed through. Subsequent to the date of resignation (5—10—1955) the post has been vacant.

The salient features of work so far done had been the classification of fish ponds in Madras, Chingleput and South Kanara districts. Ponds were surveyed and water and mud samples were suitably analysed and the productivity or otherwise of the ponds classified (vide Table appended.)

Besides the above, mud samples from Yercaud lake, Kodaikanal lake and from Mariamman Temple Tank were analysed for chemical nutrients.

7. Studies on Food Values of Fresh Water Fishes

Studies on Food Value of Fresh Water Fishes and,

8. Studies on the Oxygen Requirments of Fresh Water Fishes

Could not be undertaken as the various apparatus ordered were not delivered till the close of the year. These studies will be taken up intensively in the next year only.

9. Investigations on the Fish Population of Bhavanisagar Reservoir with Reference to efficiency of Different Gear.

The work could not be started in detail due to the non-receipt of the financial sanction till late in the year. Only preliminary work were carried out with Rangoon nets and No. 8 and 9 hooks. The nylon Rangoon nets showed 64 per cent better efficiency than Yarn Rangoon nets. The efficiency as per catch effort return showed a direct relationship with the mesh size. Preliminary observation showed relationship of the catch-effort return, with turbidity, colour of water, temparatures and wind velocity. The catch effort return in Rangoon nets showed an upward trend with the greater mixing up of the cooler Moyar waters. The work will be taken up intensively in 1956–57.

10 Experiments on Seggregation of Carp Fry

Further experiments carried out in the seggregation of carp fry have revealed that the fry react differently to different rates of water velocity. In relation to the velocity of water it was possible to seggregate a group of fry into the following three groups :—

1. *Barbus hexagonalepis, B. carnaticus* and *Cirrhina cirrhosa.*
2. *Rasbora daniconius, Nuria danrica* and *Danio spp*;
3. *Barbus filamentosus, B. ticto* and *B. vittatus.*

The first group of fish ascends first being probably more capable of withstanding the velocity of water. The other groups come up according to the succession given. Observations made in the field

indicate a probable relationship between the height of the body of fish and its capacity to swim against current, the higher the body, the slower the capacity to swih against current.

(*b*) Percentage composition of the carp fry collected at Bhavani as determined from Weekly samples was as follows :—

Name of fishes	November 1955					December 1955				January 1956		
	Weeks					Weeks				Weeks		
	I	II	III	IV	V	I	II	III	IV	I	II	III
Labeo fimbriatus	...	11	...	...	7	...	...	...	...	...	...	...	...
L. kontius	...	...	45	5	...	...	...	...	...	...	...	...	...
Cirrhina cirrhosa	...	...	...	...	15	60	20	10	...	...	...	...	...
C. reba	...	20	13	...	18	10	5	5	...	...	...	...	...
C. latia	...	15	...	...	...	...	...	...	...	...	...	...	...
Barbus hexagonolepis	...	2	6	80	2	6	...	10	...	...	...	10	...
B. carnaticus	...	...	23	...	49	2	...	5	...	...	...	15	...
B. Pulchellus	...	....	...	...	..	...	...	...	...	10	20	25	10
B. dorsalis	...	3	...	...	...	...	15	10	10	20	...	...	...
B. ticto	...	20	...	...	...	...	...	...	...	10	5	...	...
B. sarana	...	...	...	...	2	...	...	...	...	...	...	...	...
B. mahecola	...	...	...	...	...	7	...	...	...	...	...	...	...
B. chrysopoma	...	...	...	...	...	...	...	...	...	...	5	...	...
B. amphibius	...	...	...	...	...	...	...	...	...	...	20	...	...
Barilius spp.	...	4	...	...	...	8	5	5	...	10	5	5	85
Amblypharyngodon sp.	...	3	...	...	...	...	...	...	...	...	...	...	...
Danio spp.	...	...	...	...	5	7	10	...	...	...	...	15	...
Rasbora daniconius	...	6	13	...	...	...	...	40	70	30	25	5	5
Discognathus spp.	...	13	...	...	...	...	40	...	...	...	15	25	...
Lepidocephalus sp.	...	3	...	15	...	2	5	5	20	20	5	5	...
Etroplus maculatus	...	...	...	...	...	...	...	10	...	...	...	...	...

The earlier weeks of the collection were characterised by a higher concentration of economic carps.

11. *Studies on White Carp Cirrhina Cirrhosa*

Cirrhina cirrhosa :—The white carp, *Cirrhina cirrhosa* is the most abundant carp and forms the main bulk of the fisheries of Cauvery. Growing to over 1.5 feet in length it predominates in the large congregation of fish in Mettur Reservoir and its channels. The fish is a very active one. This fish is silvery in colour and every scale has a red spot in the centre. Because of its silvery white colour the fish is called **Venkendai** in Tamil meaning the White carp. The white carp is peculiar to Cauvery system alone. Even in the Bhavani river which is a tributary of Cauvery, *Cirrhina cirrhosa* is rare.

Food and Feeding :—Cirrhina cirrhosa is a plankton feeder throughout its life history. In the young stages, only planktonic organisms are ingested. The diet consists of 78 per cent Diatoms and unicellular algae and 20 per cent zooplankton, (*Copepods, Daphnids, Ostracod,* and *Nauplius larvae*). 2 per cent of fine sand also is noticed. This must be mostly from the suspended material in water. In the adult and adolescent stages the fish includes in its diet fair amounts (19 per cent) of filamentous algae also. But it is at this stage predominantly a plankton feeder also taking in 52 per cent diatoms and unicellular algae, and 29 per cent of zooplankton. The detailed list of organisms comprising its food is furnished below :—

Diatoms :—*Amphora, Fragillaria, Navicula, Nitzschia, Pinnularia, Rhopalodia, Surirella.*

Green Algae :—*Ankistrodesmus, Cosmarium, Pediastrum, Scenedesmus, Spirogyra.*

Blue green algae :—*Anabaena, Microcystis, Oscillatoria.*

Protozoans :—*Arcella, Difflugia, Euglena, Phacus.*

Rotifers :—*Brachionus, Salpina.*

Cladocenus :—*Ceriodaphnia, Diaphanosoma.*

Ostracode :—*Cypridopsis.*

Copepods :—*Microcyclops, Diaptomus, Eucyclops.*

Crustaceans :—*Nauplius larvae.*

Very rarely insect larvae and aquatic weeds also have been noticed to have been ingested by a few individuals. But predominantly the fish is a surface feeder. Its top feeding habit is perhaps indicated by the fact that it constitutes the majority of the catch in the surface drift nets (Rangoon nets) in the Mettur Reservoir.

Fecundity and breeding.—It becomes sexually mature when it reaches a size of 22 to 24 cms. The males have their first dorsal fin ray elongated.

A fully gravid female 403 mm. long and weighing 970 gms. had ovaries weighing 167 gms. and containing 1,70,340 eggs of the following diameter frequency.

Diameter mm.	Percentage	Diameter mm.	Percentage
0.8	22	1.2	31
0.9	47	1.3	

Another fully gravid female 425 mm. long and weighing 1100 gms had its ovaries weighing 171 gms and containing 1,78,978 eggs of the following diameter frequency :—

Diameter mm.	Percentage	Diameter mm.	Percentage
0.9	18	1.2	43
1.1	31	1.3	8

The ovarian condition indicates a quicker spending of the ovary unlike several other major carps.

The spawning season coincides with the south west monsoons and extends from June to September. During the breeding season, shoals of this fish have been noticed to undertake a spawning migration to the pools below the Hoggainakikal falls.

Growth :—*Cirrhina cirrhosa* is reputed to grow to a length of over 5 cms. in the rivers.

Specimens of 500 to 550 mms. are occasionally caught in the Mettur Reservoir. But the commercial catch comprises mostly of 400 to 500 gms. Its rate of growth in the ponds and rivers is given below :

Year	Ponds Length mm.	Rivers and Reservoirs
I	370	210
II	490	350
III	—	450
IV	—	540
V	—	610

Because of its rapid growth, and surface feeding and non carnivorous nature, it is an ideal fish for combined culture with Labeo fimbriatus or some other browsing and bottom feeding fishes and also in tanks that contain rich blooms of phytoplankton.

Collection and transport of fry and fingerlings.—Fry can be collected in large numbers in Cauvery from July to October. The fingerlings are available in thousands in the channels and canals of Cauvery river system from October to March. The fingerlings have a tendency to periodically jump and these have to be kept in nurseries for at least a

week to get acclimatised to confined conditions and then transported in tin carriers. Overcrowding has to be avoided 100 fingerlings in a tin carrier are quite safe and sufficient for long distances. The fry and fingerlings stand transport fairly well.

12. *Studies on Rasbora Daniconius*

Simultaneous with the studies on the bionomics of *Rasbora daniconius* detailed investigations were carried out on the feeding intensity of Rasbora on Cyclops. The fish of size 30 mms. to 40 mms consume the maximum number of cyclops. The maximum feeding rate is at a temperature of 30 to 31 °C. The work is being continued with application to actual field.

13. Investigations on Tilapia moseambica.

Investigations on Tilapia were carried out on the following lines:

1. Methods of increased production.—Ponds manured with superphosphate, cowdung and sewage were used to find out the best manuring method for greater production.

2. The different proportions of sexes were used at time of stocking for finding out the best proportion for maximum yield.

The results found were the following :—

(*a*) The maximum total yield was in ponds manured with Raw Sewage.

(*b*) There was 100 per cent survival of stocked fish in ponds manured with Raw Sewage.

(*c*) In the ponds manured with organic manure there was very good breeding, in one pond manured with raw sewage as 6 new generations coming up in 7 months.

(*d*) In ponds manured, with superphosphate though there was maximum individual increase in weight of the stocked fish, the survival of stocked fish ranged 0 to 50 per cent. There was no breeding also at any time during the period of seven months.

This factor has been noticed in the case of ponds where large scale field work also was undertaken.

(*e*) In cases where seggregated sexes were raised the growth and yield of males was as high as 170 mm. in length and 10 times in weight of the original stock in seven months.

(*f*) The best combination of sexes in stocking is in equal proportions of males and females.

(g) The yield of Tilapia in seven months in experimental cisterns showed the following rates :—

	Converted to yield per acre of average depth of 1½ feet. found.
1 Manured with sewage.	572
2 Manured with cowdung.	352
3 Manured with superphosphates.	240
4 Unfertilised.	160
5 With sexes seggregated.	412

The work is being continued.

3. The utility of irrigation wells for growing of Tilapia also was investigated. The initial work in seven experimental wells indicated the following :

(i) It grows to a size of 160 mm. in eight months, when grown alone. Five generations also come into existence in the course of eight months.

(ii) In wells where predators like murrels had been introduced in combination with Tilapia of same size as predators the population was found to be kept down to the original stock and without a population pressure Tilapia were found to grow to a size of 270 mm. in eight months.

(iii) When Tilapia were stocked with murrels about thrice the size of the stocked Tilapia, the Tilapia were consumed and only 33⅓ per cent of the murrels survived.

(iv) The same observations were found with combinations of Etroplus and murrels. In wells where Etroplus and murrels of the same sizes were introduced Etroplus grew to a size of 170 mm. in eight months.

(v) In wells where only Etroplus had been stocked, Etroplus grew to a size 160 to 162 mm.

(vi) In wells where *Tilapia* and *Etroplus* of the same sizes had been stocked, Tilapia grew to a size of 130 mm. in eight months and bred four times and Etroplus grew to a size of only 120 mms. These investigations have revealed that Tilapia is a good fish for culture in irrigation wells. In the absence of population pressure by introduction of predators slightly larger than the stocked Tilapia, the growth of Tilapia and Etroplus is found to be very good. A combination of Tilapia and Etroplus of same sizes and a predator slightly bigger in size in equal proportion appears to be a very good combination for culture in wells.

Further work is continued.

14. Studies of Spawning of Mirror Carp.

Investigations were started in March 1955 and November 1955 on the reported non breeding of Mirror carp in Yercaud lake. The physio-chemical factors of the waters were almost similar to that of conditions in Ootacamund lake (November 1954) where the Mirror carps have bred in Ootacamund.

The question whether Mirror carp have bred in the lake was examined. The stocking data and the length frequency data of Mirror carp caught so far revealed.

1. Mirror carp have grown quite very well in the Yercaud lake growing to 18 cms. in first year. Thirtytwo cms. in second year, 44 cms. in third year, 52 cms. in fourth year, 60 cms. in fifth year and 67 cms. in sixth year. There has been a record of a 70 cms. mirror carp in 1950 May. This seems to have belonged to the 1944 Brood. The growth appears to be slightly faster than that in Ootacamund lake.

2. Though the periodical stocking with fingerlings have obviously vitiated the conclusions that can be drawn from the length frequency data of the Mirror carp caught in the commercial catches, the appearance of specimens of 23 cms. length on 22nd July 1954 does give certain indications of probable breeding of Mirror carp in the lake. After the stocking of 27th June, 1951, a further stocking has taken place only on 8th July, 1954, after a period of three years. The stocking of 6th July, 1954 has been with fingerlings 3·5 to 7·5 cms. These could not have grown to 23 cms. within a period of 16 days. The 1951 stock of fingerlings (5 cms. 7·5 cms.) should have grown definitely to a size very much higher than 23 cms. also for the growth studies revealed that a Mirror carp of over three years age must have grown to a size of 44 cms. in Yercaud lake. Between the period March 1954 and June 1954 specimen of 20 to 30 cms. have been caught on more than half a dozen times which denotes that these could never have belonged to 1951 brood but only to subsequent stock of 1951 or 1953 even and this recruitment of new brood could have happened only by breeding of the Mirror carps in the lake. In March, 1955 we have caught a specimen of 21·3 cms. which belongs to 1954 stock. This has evidently only substantiated the growth studies and shown that a condition of stunted growth has not risen in the lake so far to probably question the conclusions drawn above.

3. The second line of approach has been with the examination of gonadial maturation and appearance of eggs and larvae. The latter was verified periodical examination of the submerged vegetation on which the Mirror carp would be laying their eggs. In the November investi-

gation fairly large numbers of eggs of Mirror carp were found in the rich water hyacinth. The examination of gonadial maturity has shown that the gonads mature to the full in the both males and females. These investigations revealed that Mirror carp is breeding in the lake but the breedings in the lake is not very great probably due to the daily removal of fishes of 10 inches and below in the exploitation. It was recommended that no Mirror carp of less than 11 inches should be removed in the exploitation.

15. *Miscellaneous*

Investigations on Riverine Problems :—(*a*) Studies on the fishes of river Cauvery system was continued. Random samplings of the fishes from different collection grounds showed that in this year the percentage of *Labeos* has been less than last years: but the percentages, of *Cirrhina reba*, *Cirrhina cirrhosa* and *Cirrhina latia*, have increased. *Catla catla* continued to be of the same intensity as last year being about 3 per cent of the total catches.

(*b*) *Catla catla*, *Labeo kontius* and *Labeo fimbriatus* and *Cirrhina cirrhosa* commenced spawning towards the middle of July. *Barbus carnaticus*, *B. hexagonolepis*, *dorsalis*, *Chrysopoma* and *Cirrhina reba* commenced spawning towards the end of June.

(*c*) Examination of the particulars of fishery rentals and the fishery potential was continued, for the different stretches of the rivers. There appears to be a relationship between the fishery potential and the ayacut under each stretch of the rivers. In other words the fishery potential at each regulator could be roughly estimated from the ayacut under the regulator. Such estimations made for five regulators gave the fish population at those regulators as follows:—

	Crores		Crores
(i) Mandai	1/2	(iv) Tiruvalangadu	$1\frac{1}{2}$
(ii) Kadagambadi	1	(v) Manacheri	2
(iii) P. V. Head	1		

The estimates have to be checked up by actual statistics of landings before the method could be applied to the other regulators.

Age and Growth studies :—(*a*) The age and growth studies of *Labeo fimbriatus*, *Mastacembalus* armatus and *Tinca tinca* have been completed. The scales were utilised in the cases of *L. fimbriatus* and *Tinca tinca* and the first vertebral bone in the case of *M. armatus*. The age groups

were also checked up with Peterson's length frequency curves. The growth of the fishes at the different ages are as follows:—

Years.	Labeo fimbriatus.	Mastacembalus armatus.		Tinca tinca.	
		Male.	Female.	Male.	Female.
	cms	cms	cms	cms	cms
I	21.4	16.6	20.6	7.9	8.5
II	33	25.6	20.8	12.6	12.8
III	38.8	31.7	26.8	17.5	16.3
IV	44.6	37.7	34.2	21.4	20.6
V	30.2	43.3	41 0	24.7	22.9
VI	56.2	49.4	48.2	—	—
VII	62.0	56.6	55.0	—	—
VIII	64.9	62.9	63.6	—	—
IX	70.7	70.9	72.1	—	—
X	73.6	77.0	79.0	—	—
XI	—	83.0	85.8	—	—

(*b*) The studies were carried out for *Cirrhina cirrhosa* also The size groups have been determined from length frequency distribution. The scales are under examination for fixing up the ages of the size groups.

Mortality of Fishes in Mariamman Teppakulam, Madurai :—A large scale fish mortality which took place in the Mariamman Teppakulam at Madurai during the first fortnight of November 1955 was investigated.

The Teppakulam is a 15. acre square tank retaining water throughout the year. The present source of water supply is from rains and the town drainage during rains. During heavy rains as was the case during the month of November 1955 some sewage waters also drained into the tank. The water was dirty green in appearance with low quantities of Dissolved Oxygen at the surface and the bottom. The temperature of the surface and bottom waters are almost uniform showing a homothermal tendency.

The Free carbondioxide was absent at the surface but deleterious gases like methane, and hydrogen sulphide and free ammonia were found rushing to the surface and robbing the waters of its dissolved oxygen.

The polluted nature of the waters were reflected by the large quantities of Bicarbonates over 300 pp. million and chlorides of 400 pp million.

A four hours Tidy's oxygen absorption figure of 6.666 ppm. and Biochemical oxygen demand of 5.0 ppm. in 3 days corroborated the findings of pollution.

It was found that the Mariamman Teppakulam waters abounding in deleterious organic materials getting stagnated over years have rendered the water inimical to fish life and that the rains in the month of November 1955 further upset the balance bringing in loads of sewage and other pollutions, welling up the gaseous accumulations of hydrogen sulphide and methane, etc. and consequently causing the dissolved O_2 content to very low limits of toleration. Thus the mortality has been brought about by the individual and combined effects of all the deleterious materials mentioned above. The following suggestions were offered to the Asst. Director of Fisheries, Madura in this connection :—

(i) to reduce immediately the fish populations in the tank.

(ii) planting of water weeds like Vallisneria to help phytosynthetic activities and for better oxygenation of the waters.

(iii) To prevent unwanted deleterious material entering the tank.

Mortality of Fish in Coimbatore Well :—The step well about 40 feet square is situated in the compound of the State Bank of India at Coimbatore. The Assistant Inspector of Fisheries, Bhavani had stocked a consignment of Bhavani fry in the same during the previous years.

During the first fortnight of March, 1956 a dozen carps were found floating dead in the tank by the Inspector of Fisheries, Coimbatore. Subsequently the waters were collected and analysed to find out the reason for the mortality.

It was found that the well had access to drainage waters of the compound during rains and stored up such organic deleterious materials that were washed into it. The presence of large quantities of chlorides upto 350 ppm. and bicarbonate content of over 600 ppm. confirmed our suspicions of organic pollution in the well. The decomposition of the organic materials accumulating at the bottom coupled with the presence of abundance of phytoplankton reduced the dissolved oxygen content of the waters to lethal limits as low as 2% of saturation.

The mortality is thus attributed to the lack of oxygen in the waters during the early hours of the day.

Mortality of fingerlings in manured cement nurseries :—During the investigations on the effect of different organic manures it was found that fingerlings of fish put in cement nurseries manured with raw sewage, grass and cowdung were dying within 24 hours, whereas in nurseries manured with cotton seed, no mortality was noticed. On an examination of the nature of the water it was ascertained that the

ponds (Nurseries) manured with cowdung, sewage and grass had developed large quantities of Englenoids contents, forming a rich bloom especially in the sewage manured nursery. There was a high percentage of Dissolved Oxygen in these cement tanks during the day time and absolutely no Dissolved oxygen during the early hours. In addition to the depletion of Dissolved Oxygen large quantities of methane accumulations were found in the nurseries. The mortality was attributed to the complete lack of oxygen during the early hours and due to methane gas accumulation due to organic decomposition at the bottom.

Hydrobiology of Odathurai tank :—This is a minor irrigation tank of 190 acres situated in Bhavani Taluk and the fishery of which is vested with the Department for rural fishery Demonstration purposes.

A hydrobiological survey of the tank was conducted to ascertain the productivity of the tank. The tank had an alkaline pH of 8.7 and a good silicate content of 3.2 pp. 100,000. It supported a rich growth of diatoms, *Nitzschia, Navicula, Pinnularia,* Amphora, Cymeblla and Synedra and large numbers of (*Cyanophyceae*), *Cylindrosphoris* and *meriamopedia*.

The chemical characteristics of the waters were similar to that of Pollupalli tank at Palghat where mirror carps have bred. Hence the tank was stocked with 300 fingerlings of mirror carp during this year.

Extension Work

The Station furnished advice or material for research to the following persons and institutions during the year under report :—

1. Department of Fisheries Technology, Kalamasseri "Fisheries Museum and Specimen display."
2. Humanitarian League, Adoni. "Relationship of Superchlorination and fish culture in wells."
3. Assistant Fishery Demonstrator, Palghat. "Spawning of carps in Polpully tank."
4. Dr. S. L. Hora, Director of Zoological Survey of India, "Gambusia in Octacamund lake."
5. Secretary, Katteri Grama Sangam, Katteri Dam : "Information on Rural Pisciculture."
6. Department of Agriculture, Government of Nepal L "Culture of Mirror carp and Tench."
7. Janab Syed Gaffoor, Satyamangalam. : "Fish Culture in wells".
8. Sri H. Gibbon, Cullompur, Fernhill. "Maintenance of Food nursuries for Trout."

9. Dr. D. Bhatia, Deputy Fisheries Advisor, New Delhi. "Growth and Breeding of Mirror carp."

10. Sri P J. Sanjeeva Raj, M.A., F.A.Z., Madra Christian College, "Trout."

11. Messrs. A.V. Thomas and Company, Alleppey, "Fish culture in waters of the Tea Plantations."

12. Himalaya Experimental Farm, Dehra Dun. "Fish culture in hill waters."

13. K.N. Ramachandran, Tiruppur. "Aquarium maintenance."

14. K.T. Anantaraman, Coonoor. "Aquarium maintenance:',

15. Commissioner for Advancement of Backward Committies, Trivandrum. "Fish rearing in streams, rivers and ponds of the mountain area of Travancore and Cochin State.

16. T. Inone, Higashiokub Shiri jikoth, Tokyo. Information on the technical publications of Fresh water Research Station.

17. Assistant Director of Fisheries, Vellore. "Control of algae in Teerthakulam, Tindivanam".

18. Assistant Director of Fisheries, Tanjore. "Fishery of the Ullar River."

19. Assistant Directer of Fisheries, Madurai.
(a) "Breeding of Mirror carp in Kodaikanal Lake."
(b) "Eradication of weeds in Mannadimangalam tank."
(c) "Application of Fertilizer in Chettinad tank."
(d) "Fish mortality in Mariamman Teppakulam."
(e) "Fresh Water fish specimen for museum."

20. Assistant Director of Fisheries, Mettur Dam.
(a) "Breeding of mirror carp in Yercaud Lake."
(b) "Productivity of Mettur Dam."

21. Assistant Director of Fisheries, Mangalore. "Brackish water fish farm at Mulki and Pavanji."

22. Assistant Director of Fisheries, Tuticorin. "Fish Farm details for Manimuthar."

23. Assistant Director of Fisheries, Malabar. :
(a) "Fish cultural details for Walayar Reservoir."
(b) Fishing in Malampuzha Resorvoir."

24. Assistant Director of Fisheries (Marine Biology), "Tilapia investigations."

25. Institute of Science, Bangalore. "Divers of wallago attu."

26. Mr. Varma, Bangalore. "Carotenoids in Fish oils."

27. Dr. B. Sundara Raj.
(1) "Information of *Labeo paral.*"
(2) *Labeoj arul, Cirrhina spp.* and *Laboo kontius.*

28. Mr. G.S. Mallick, Director of Fish Preservation, Kashmir, "On mirror carp culture."

29. Deputy Adviser for Animal Husbandry, New Delhi. "Mirror carp culture."

EXHIBITIONS :

This station took part in the following Exhibitions:—

1. All India Khadi and Swadeshi Exhibition, Coimbatore.
2. F.A.O. Exhibition, Coimbatore.
3. Grama Sevak Training Centre Exhibition, Bhavanisagar.
4. Annual Day of the Agricultural Research Station, Exhibition, Bhavanisagar.
5. Flower Show Exhibition, Ootacamund.
6. All India Scouts and guides Rally Exhibition, Ootacamund.
7. Fruit Show Exhibition, Coonoor.
8. Community Project Exhibition, Erode.
9. Village Development Exhibition, Kotagiri.

VISITORS

1. Dr. B. Sundara Raj. Retired Director of Fisheries, Madras.
2. Mr. G.S. Mallick, Director of Fish Preservation, Kashmir.
3. Major General. Giani, Officer Commanding Staff College, Wellington.
4. Mr. T. Narayanan Nair, Retired Director of Fisheries, T. C. State.
5. Hon'ble Minister for Agriculture and Fisheries, Madras
6. Mr. K. P. V. Giri, President, District Congress Committee, Coimbatore.
7. Sri P. Shankar Rao, Collector, Nilgiris.
8. Mr. Varma, Indian Institute of Science, Bangalore.
9. 150. officers of the Staff College, Wellington.
10. Dr. S. L Hora, Director of Zoological Survey of India, Calcutta.

TRAINING

Training in Fresh Water Fisheries and fish culture was imparted to the following :—

1. The Forest Ranger Trainees of Forest College, Coimbatore.
2. Students of Fisheries Technology from the Polytechnic, Kalamassary, T. C. State.
3. Students of Fisheries Technology from the Central Polytechnic, Madras.

4. Grama Sevak Training Centre Trainees from the Basic Training School, Parli.

5. Grama Sevak Trainees from the Basic Training School, Gandhigram.

6. Grama Sevak Trainees from the Basic Training School, Bhavanisagar.

7. Village Leaders from the Tellicherry Block Development Area.

8. Village Leaders from the Krishnagiri Block Development Area.

9. Village Leaders from the Kallupatti Block Development Area.

10. All India Inland Fisheries Trainees, Calcutta.

11. Janab Fida Mohammed, Jamadar in Fisheries, Jammu and Kashmir State.

PAPERS EITHER PUBLISHED OR IN THE PRESS DURING THE YEAR 1955-56.

1. Menon M.D. and Murthi, B.K.—"On the so-called "Forage Fish" Tilapia mossambica. Part I. Its Food.

2. Menon, M. D. and Murthi B. K.—"Age and Growth of *Tinca Tinca*."

3. Murthi B. K. and Menon M. D.—"Age and Growth of *Mastacembalus armatus*.

4. Murthi B.K. Menon M.D. and Chacko P.I.—Age and Growth of *Labeo fimbriatus*."

5. Dorai Rajah, K. A.—"Limnology of Bhavanisagar Reservoir" A. Hydrology.

6. Pankajam, N.—"Limnology of Bhavanisagar Reservoir B. Phytoplankton.

7. Srinivasan, R. and Dorai Rajah, K. A.—An Investigation of the pollution of the Vellar Estuary by waste waters from the South Indian Starch Product Company Limited at Portonovo."

8. Ganapathi, S. V. and Srinivasan. R.—"Thermal Studies of the Chetpat Fish Farm Ponds.

9. Chacko, P.I. and Krishnamurthi, B.—"On the plankton of three Fresh water fish ponds in Madras City, India."

10. Chacko, P. I. and Srinivasan R.—"Observation on the Hydrobiology of the Major Rivers of Madras State, South India."

11. Chacko, P. I. Kuriyan G. K. and Thyagarajan S.—"A survey of the fisheries of the Cauvery River."

12. Srinivasan, R. and Dorai Rajah, K. A.—"Effect of Benzene Hexachloride on Fish life.

13. Chacko, P. I. and Krishnamurthi B.—"Observations on *Tilapia mossambica* Peters in Madras."

PROGRAMME OF WORK FOR THE YEAR 1956-57.

1. Segregation of carp fry and reduction in mortality in nursery and in transport.

2. Bionomics of Wallagonia attu and Catla Catla.

3. Effect of Microcystis on the growth and survival of *Tilapia*, *Labeo*, *Cirrhina* and *Cyprinus*.

4. Effect of manuring on the growth and survival of *Hydrilla verticellata*.

5. Studies on the Efficiency of fishing Gear and population of Barbus in Bhavanisagar.

6. Biochemical Studies of Fresh Water Fishes.

7. Effect of Fish Poisons on Fish (Poisons selected are) :—
   (*a*) Randia dumetorum.
   (*b*) Derris root.
   (*c*) Rotting Potatoes.
   (*d*) Soap Lye.
   (*e*) Euphorbia Tirucalli.

8. ***Studies on Tilapia***.—(*a*) Cropping.
   (*b*) Culture in Manured Ponds.
   (*c*) Combined culture with Mirror carp.
   (*d*) Effect of small currents on growth.

9. Studies on *Chela clupeoides* and the utility of *Chela clupeoides* in Cyclopscidal work.

10. Spawning of mirror carp.

11. Oxygen requirements of Fresh water fishes.

12. Aquatic manuring.

13. Analysis of Pond Bottoms and their relationship with productivity.

14. Bionomics of mirror carp *Barbus ticto*.

APPENDIX

Plankton

DIATOM :— Amphora. Cyclotella. Coscinodiscus. Cymbella. Fragillaria. Melosira. Navicula. Nitzschia. Pinnularia. Rhopalodia. Surirela. Synedra.

BLUE-GREEN ALGAE :— Anabaena. Cylindrosphaerium. Microcystis. Oscillatoria.

PROTOZOANS :— Arcella. Difflugia.

ROTIFERS :— Anuraea. Brachionus Salpina

COPEPODS :— Cyclops. Diaptomus. Eucyclops Microcyclops. Nauplii larvae.

GREEN ALGAE :—

Ankistrodesmus. Pediastrum. Scenedesmus. Spirogyra.

DAPHNIDS :—

Ceriodaphnia. Daphnia. Diaphanosoma.

DESMIDS :—

Cosmarium. Euglena. Phacus.

OSTRACODS :—

Cypridopsis.

APPENDIX

Glossary of Fresh Water Fish — Scientific Local and Common Names

Latin Name.	Tamil Name.	English Name.
Amblypharyngodon	Serukkai	Minnow
Barbus carnaticus	Pavoori	Carnatic carp
Barbus chrysopoma	Panjalai	Olive carp
Barbus dubius	Kozhimeen or Kozharanjan kendai	Cock fish
Barbus filamentosus	Michakendai or Sevali kendai	Spotted Barb
Barbus hexakonolepis	Karambai, Kodaikarambai	Chocolate mahseer
Barbus ticto	Palli kendai	Titeto Barb
Barbus sarana	Panjalai, Sani kendai	Golden Barb
Barbus vittatus	Kulla kendai	—
Catla catla	Toppameen, Donaimeen	Catla
Chela	Velichai	Silver fish
Cirrhina cirrhosa	Vellai kendai	White carp
Cirrhina latia	Kalaranjan	—
Cirrhina reba	Aranjan, Thattaranjan	Reba
Cyprinus carpio	Kannadi kendai	Mirror carp
Danio	Sellai paravu	Giant danio
Etroplus suratensis	Sethakendai	Pearl spot
Labeo fimbriatus	Selkendai	Fringe lipped carp
Labeo kontius	Karumughi kendai	Cauvery carp
Labeo rohita	Rohu	Rohu
Macrones oculatus	Katta keluthi	Cat fish
Macrones aor	Pona keluthi	—
Macrones vittatus	Sonankeluthi	—
Mastacembalus armatus	Kalaral	Spiny Eel
Nuria danrica	Meesaparavai	Flying barb
Ophicephalus marulius	Avuri	Murrel
Perilampus	Pachaimeen	Minnow.
Rasbora daniconius	Ogarai, Ovari	Top Minnow.
Rohtee cotio	Pattakunju	Rohtee.
Tilapia mossambica	Tilapia	Tilapia.
Tinca tinca	English kendai	Tench.

VI. ANNUAL REPORT OF FISHERIES TECHNOLOGICAL STATION, KOZHIKODE, FOR THE YEAR 1955-56.

BY R. VENKATRAMAN.

INDRODUCTION.

A historical account about the origin and progress of this Station was given in the previous report. The work done for ten years from 1945 to 1955 was summarized. In the following pages the research work done during 1955-1956 (April 1955 to March 1956) is detailed.

STAFF

1. *Superintendent.*— Sri R. Venkataraman, M.Sc., A.R.I.C., continuous superintendent throughout the year.

2. *Research Assistant (Biochemical).*— Sri S. T. Chari, B.Sc., was the Research Assistant till 3-3-1956, when he was promoted to act as Hydrologist.

3. *Research Assistant (Thermophysical).*—Sri A. G. Vasavan, B.Sc., continued to act as Research Assistant throughout the year.

4. *Research Assistant (Bacteriology).*—Sri A. Sreenivasan, B.Sc., continued throughout the year, as Research Assistant.

5. *Research Assistant (Chemistry).*—Sri K. Md. Sultan occupied the post from 23-5-1955 to 7-2-1956 when he was transferred.

6. *Laboratory Assistant.*—Sri P. S. Subramanian, B.Sc , continued in the post throughout the year.

7. *Home Economist.*—Kumari S. Timothy continued to act as Home Economist throughout the period.

RESEARCH REPORT

I. *Biochemical Section*

Fresh fish studies.—Nutritive value of fish as evaluated by the amino acid composition.

In the previous years report the nutritive importance of fish proteins and the amino acid make up was elaborated. The chromatographic technique of estimating the amino acids in fish proteins was described in detail. A study of the amino acid composition of proteins of important species is now presented. Table I shows the particulars. The first ten are among the more important of the "essential amino acids." It is clear that the percentage of these essential amino acids compares very favourably with those of other animal proteins. The following salient points may be noted: In regard to the content of Leucine-isoleucine-Phenylalanine and also Valine Methionine the soles and silver bellies are inferior to the other fish. The two sardines are surprisingly lacking Tryptophane, the key amino acid. The lysine content of sardine (chalamathi) is very poor. Compared to all other

fish the Prawns (*P. monodon*) appear to be the best source of essential amino acids. The shark though considered inferior to other fish, is quite as good as the others in the content of essential amino acids. The content of Sulphur containing amino acids was poor in Chalamathi—Cystine being totally absent. The very low tyrosine content in this fish is also noteworthy. Aspartic acid is completely absent in this fish though it is present in all others. On the other hand, the high glycine content in this fish contrasted with other fishes. Thus *Sardinella fimbriata* showed a great divergence in the amino acid composition when compared with other fishes. The high proline content of oil sardine is also a peculiar feature. On the whole fish appear to be a very good source of amino acids.

Biochemical studies on pearl oyster flesh.—During the great pearl fishery of 1955, which had revived after 27 years, a large number of oysters were fished for the pearls. Some contained the normal pea sized pearls, some contained only 'seed-pearls' and some were devoid of pearls. It was therefore thought desirable to study the biochemical composition of the various pearl oysters.

There was no significant difference in the contents of moisture total nitrogen, fat, ash, calcium, or phosphorus between the three categories of pearl oysters. The iron content of oysters without pearls was however high. The amino acid composition of the three categories did not reveal any striking difference at all. It is therefore concluded that the chemical composition of the flesh of oysters does not influence pearl formation.

Investigation on the nutritive value of semi-dried prawns.—Earlier work of this Station had shown that semidrying of prawns is a rational method of preserving prawns. However the effect of the process on the retention of the nutritive values was not studied and this gap is now filled up by the present investigation As a result of the process a small quantity (15.0%) of soluble proteins were lost. However this did not at all affect the amino acid content of the flesh proteins. The content of Leucines, Phenylalanine, Valine, Methionine, Tryptophan Tyrosine, Proline, Alanine, Glumatic Acid, Threonine, Glycine, Serine Aspartic acid, Arginine, Histidine, Lysine and Cystine was almost identical. Thus the process appears to leave the amino acids of proteins intact.

II. *Thermophysical Section*

Experiments on Semidried Prawns.—The prawns generally used in the West Coast for processing semidried prawns are *Penaeopsis dobsoni* (Mal. Vala chemmin), *Parapenaeopsis stylifera* (Mal. Karikadi) and *Penaeus indicus* (Mal. Vella chemmin). The percentage yield of semi dried prawn varies with the size and species of raw prawns used for the manufacture. In the commercial processing of prawns an accurate

knowledge of anticipated yield is essential to have an effective control over the quality. Detailed experiments were conducted to study the variation of percentage yield with species and size. Attempts were also made to arrive at the optimum moisture content of the finished product, based on the keeping quality and percentage yield.

In the experiment, consignments of different species of prawns were obtained and sorted out into different sizes. Each lot was processed separately. The weights of prawns in different stages of manufacture were determined using an accurate balance. The representative samples of raw prawns and the prawns immediately after blanching were taken out shelled and analysed for moisture and sodium chloride. Samples of peeled prawns and final dried product were also analysed. The percentage yield in each case was worked out. The estimated yield at moisture levels of 37.5 per cent, 40 per cent, 42.5 per cent, 45 per cent, 47.5 per cent and 50 per cent were calculated from the formula $X = \frac{Y-Z}{100-Z}$ where X is the weight lost per 100 weight units, while drying from an initial moisture content of Y per cent to a final moisture content of Z per cent.

From the experiments conducted it was seen that prawns *Penaeopsis dobsonii* give the maximum yield of about 20 per cent at a moisture level of 42.5 per cent. In the case of *Parapenaeopsis stylifera* the yield is minimum i.e., 17 per cent at 42.5 per cent moisture level.

A study of the keeping quality of the finished product at different moisture levels when stored at room temperature revealed that 42.5 per cent is the optimum moisture level in the finished product. Further reduction in the moisture content hardened the muscles texture and impaired the taste and digestibility though the keeping quality was improved. Higher moisture contents resulted in early spoilage of the finished product by the attack of fungi.

Experiments on preservation of semidried prawns at ice cold temperatures of 25—28°F after sealing in alkathene bags revealed that the keeping quality could be prolonged to 8—12 months as the result of such storage. The storage at further low temperatures in the vicinity of 0°F results in excretion of salt and hardening of the muscle texture. This study is still in progress.

Fish meal.—A fish meal plant for the production of fish meal on a pilot scale was installed at West Hill during this year. This is the first of its kind in India and is capable of handling half a ton of raw fish or offal in eight hours yielding 200 to 250 pounds of finished product. The production is now in full swing and fresh fish, salted fish and prawn-heads are being converted into high quality fish meal.

Experiments were conducted to study the storage of fish meal in alkathene-lined hessians. Previous experiments conducted in this Station have shown that sealed tins are the best for storing fish meal.

Since then, the introduction of polythene plastics for commercial packing has revolutionized the packaging techniques and at present cheap alkathene lined hessian bags are available suitable for packing different weights of fish meal. Our experiments revealed that such bags are ideal for packing fish meal being cheap, light and easy to handle Investigations on the keeping quality of fish meal stored in alkathene lined hessians are now in progress.

Salting experiments.—The storage studies of the samples of salted fish from market were continued this year. Eight samples of different fishes from Kozhikode market and five from Nadakkavu market were collected. Most of the samples of salted fish were found to contain a high percentage of moisture and because of this single factor they spoiled rapidly. Periodic drying of salted fish samples as a means of checking the rise in moisture during storage is also suggested. The present system of beach-drying small fishes like White Bait without the application of salt was found to be defective as the keeping quality of such products is very poor.

The keeping quality of a sample of Bombay duck dried without salting was also studied. The samples were obtained from a Bombay firm specializing in exporting such products. The samples were in absolutely good condition for six months and even after one year they were in an edible state. The keeping quality of this product can be ascribed to the low moisture content of 20 per cent.

Experiments were also conducted on the suitability of different salts for fish curing. In the previous experiments crushed salt containing 96 per cent Sodium chloride and little of impurities was found to be superior to the usual Tuticorin salt containing only less than 90 per cent Sodium chloride. During this year, the efficacy of Wadala salt containing 98 per cent Sodium chloride for fish curing purposes is being stuied. Samples of mackerels and sharks were cured using this salt and the keeping quality of the product is being studied by organileptic tests as well as analysis for H_2O. T.V.B. and NaCl.

Experiments on preservation of fish using antibiotics.—The experiments were done in collaboration with Bacteriology section. Perches were immersed in 5 ppm. solution of 'Achronoze BI' and the keeping quality was studied both at room temperature and in the refrigerator at 0–5°C. Controls were kept side by side. The antibiotic treatment was found to have a marked beneficial effect on the keeping quality of fish both when stored at room temperature and in the refrigerator. The experiments in this line are being continued.

Analysis of fishery by-products.—The Laboratory Assistant of this station is engaged in critical examination of the various fishery by-products that are processed under the supervision of this station as well as those manufactured by privare parties who are genuinely interested

in starting and developing fishery by-product industries. A total of 165 samples were analysed during 1955-56 as against 98 samples in 1954-55. All these samples were analysed in order to assess their manurial and nutritive value and to bring them up to the standard specification.

After the installation of the fish meal plant at West Hill representative samples of fish intended for processing in the fish meal plant and samples collected daily at the end of every operation are analysed to maintain quality control on the products. Besides, the moisture content of the samples collected at intervals of one hour are also determined in order to check the efficiency of the concentrator.

III. *Bacteriology Section*

Studies on salted fish and salts.—Work on the salted fish and salts with special reference to the red halophilic bacteria was continued during the year. Studies on the 'red' bacteria involve a long period by virtue of the delayed growth obtained on conventional laboratory media. Even the use of such rich nutrients like Proteose peptone, yeast extract, Neopeptone, Casitone, Tryptose, Tryptone, Beef extract, fish infusion, etc., did not promote a rapid and profuse growth. Various media were devised which were found to improve the growth of these red salt bacteria. A modified salt-skim-milk-agar medium permitted good growth of red bacteria in Two to Three days if 1.0 per cent $MgSO_4$ was included and if the pH was 7.6 finally. A better medium more easily prepared was 'Rice-milk-salt' medium which gave good growth and Chromogenesis of all types of red bacteria. Likewise a Casitone-filter paper medium was devised for testing physiological reactions. Bacteria were actually grown on a filter paper dipped in nutrient solution. This was useful for testing nitrate reduction, indole production, starch hydrolysis, etc.

Semidried prawns as well as heavily salted prawns did not develop the red attack though salted fish did. To investigate the cause a prawn extract medium was prepared, containing water extract of prawns, salt and starch. On this 'red' cultures were streaked. They grew very well and even exhibited their 'spoilage potential' by producing off-odours. It is probable that the inhibitory substance was present in the coagulated part of the prawns. May be that Mg. is bound as a complex preventing growth of the red halophiles. Further work will throw some light on this.

An attempt was made to control the red salt bacteria by the use of antibiotics. 4 ppm. and 10 ppm of aureomycin had no effect on controlling the growth of red bacteria on the salt-milk-agar medium

and in fact growth was as good as in the control. It was thought that this may be due to antagonistic effect of Mg. ions of the medium, in reducing the toxicity of the antibiotic. Sodium nitrite in concentrations of 0.2 percent controlled the rod forms of red bacteria though cocci were not suppressed. Sodium ricinoleate, a surface tension depressant prevented the growth of red cocci, while rod forms grew well. It is therefore thought that curing sheds cleaned with 0.2 percent $NaNo_2$ plus 0.2 persent sodium ricinoleate can control the red salt bacteria. For edible purposes however high concentrations of nitrites are not advisable.

An important contribution to the classification of red halophilic bacteria has been made. A large number of red bacteria were isolated from solar salts from various places. They were separated into distinct groups after detailed study. They mainly fell into three groups of rod forms—*Halobacterium indicum* N. sp. Venkataraman and Sreenivasan, and *H. minutum* N. sp. Venkataraman and Sreenivasan. It was more difficult to separate the cocci into distinct species. One particular culture, however was described as new species—*Sarcina marina*, N. sp. Venkataraman and Sreenivasan. This was an important culture since it was highly proteolytic in milk on gelatin, etc. It produced 'off-odours' and ammonia from prawn medium. It also produced indole. Classification is an essential requisite for a detailed study of these spoilage bacteria. Quite a large number of cultures are described in literature and many eminent workers consider some of them synonyms while others gave them the status of separate species. Eight well known red salt bacteria, viz., *Pseudomonassalinaria*, *P. cutirubra*, *Bact trapanicum*, *B. halobium*, *Sarcina littoralis*, *S. morrhuae*, *Micrococcus morrhuae* and *M. roseus halophilus*, were thoroughly studied and for the first time complete descriptions given. This will be of use to workers in this field. Work on the red salt bacteria is not only of interest to salt fish industry, but also in other industries like the leather and food where salt is used to preserve. In fact, fundamental work on this line is sure to yield results, which may save lakhs of rupees to the leather and food industries. At present it is known that high concentrations of Magnesium are required by these bacteria and hence denial of this by using salts with very low Mg — content may reduce the incidence of reddening of salted goods.

Investigations on frozen shrimps.—When headless, prawns-in-shell were stored at 0°F without deveining they began to show discolouration and started becoming 'stale'. The following analyses were carried out at once, under aseptic conditions :—

(*a*) Bacterial counts of prawns as received, i.e., frozen-in-shell,
(*b*) Prawns rapidly thawed, shell removed and bacterial counts of

'flesh' enumerated, (*c*) as in (*b*) but 'vein' or guts also removed
(*d*) Bacterial count of guts or veins.

The results are presented below :—

Sample		Counts per gram: At 37 C 48 hours Total counts	0-4 C 5 days Psychrophiles	0-4 C 12 days Psychrophiles
a. Prawns in shell before thawing	...	2,044,000	30	203,000
b. Thawed and shell removed	...	193,000	30	9,700
c. Shell removed and 'deveined' after thawing	...	112,000	Nil	Nil
d. Guts ("Vein")	...	140,000	30	22,500

The following are the comments on the observation made in the analysis.—Prawns with shell contain quite a large number of bacteria which may cause spoilage. The mere removal of shell resulted in the reduction of bacteria by 90·6 per cent. This was similar to the findings of Williams and Campbell (1952).

Guts (Veins) contain a large number of viable bacteria. Particularly noteworthy is the fact that guts had a high number of cold loving "Psychrophilic" bacteria, whereas, deveined flesh did not have any. The importance of removing the veins is thus evident.

Suggestions for freezing prawns.—Head and shells of prawns must be removed before freezing, so that the incidence of bacteria may be very low. Washing the flesh in water and a dip in chilled dilute brine for a few minutes is also recommended. Storage at 0°F (-18°C) with shells on, before freezing will not preserve the prawns since a large number of Psychrophilic bacteria will spoil prawns. Storage at 0°F may be resorted to after quick freezing the shelled deveined prawns.

Bacteriology of shrimps.—A representative collection of cultures was obtained from prawns and studied. The largest single groups were *Micrococci* and *Coryne bacterium*. Among the psychrophilic cultures were *coryne bacterium*, *Bacillus* and *Achromobacter*. Nine cultures were gelatin liquefiers but none of the 'Psychrophiles' liquefied it. Psychrophiles reduced nitrates to nitrites at 0°C. None of the cultures were indole positive and only a few produced acid in sugars. Only three cultures were definitely motile. The bacterial flora is thus different from that described by Williams and Campbell (1952).

Other activities.—A Home Economist has been appointed for purpose of evolving recipes for the various varieties of fish that are being caught in the West Coast and popularise them among the fish eating population, since fish is rich in protein, mineral salts etc., which are quite essential for a balanced diet. In the course of the last year,

nearly 19 recipes were worked out and a tasting panel instituted at the Fisheries Technological Station certified them to be good. It is known that biscuits and bread could also be made out of fish and specially prepared prawn pulp meal which is a very delicious preparation rich in proteins was also used for this purpose The representative sample was sent to the Director of Public Health for approval. The sweet taste and flavour of lemon, essence, etc., completely masked the odour of fish and the product was just similar in colour, flavour and texture to the usual milk biscuit. Unpleasant odour of fish was not at all predominant hence nearly 57 lbs. of biscuits could be marketed at the Municipal Exhibition.

In order to make known to the future generation the findings of the experiments conducted by the Home Economist, demonstration classes are conducted to the fisher children of Vellayil School and the methods of cooking fish are explained to them. The classes are usually started with lectures on subjects such as local fishing, cause of spoilage of fish, preservation methods, etc., accompanied by practical demonstration of cooking of dishes of fish hygienically. In addition to this, demonstration classes are conducted to the Home Science students of the Providence Girls High School, Kozhikode.

Publications.—Appended.

Programme of work for the ensuing year.—The recommendation of the Fisheries Research Council has been accepted and the programme of work is to be implemented. Currently problems initiated are: (1) 'Colombo curing' and 'Pit curing', (2) Antibiotic ices, (3) Salting of fish etc., (4) Loss of nutrients during the manufacture of fish meal, (5) Seaweed analysis, (6) Preparation of enzymes from fish etc.

Technical enquiries and assistance to Industries.—A large number of enquiries from the public, other Governments and institutions were received and answered. The Malabar Fisheries Corporation had some trouble in the freezing of prawns, which were becoming discoloured. Immediate investigations were undertaken and remedies suggested, after noting the defects. Likewise instances of gaseous spoilage of canned foods were brought to our notice, which were also invest gated and improvements suggested. This Station is also a consultant to the I.S I. in preparing the standards for salt for curing fish.

Publications

The papers published during the period June 1955 to May 1956 are listed below:—

1. Utilisation of various nitrogenous compounds by certain pseudomonas cultures from marine environments—Venkataraman and A. Sreenivasan - Proc. Ind. Acad. Sci. *42*, 31-37 (1955).

2. A new species of marine chitin digesting bacterium—A. Sreenivasan - Curr. Sci. *24*, (8), 270 (1955).

3. Drying of fish using infra-red lamps—R. Venkataraman, A. G. Vasavan and A. Sreenivasan - Indcom. Jour. *10*, (3), 291 (1955).

4. Spoilage of commercially canned fish—R. Venkataraman and A. Sreenivasan - Jour. Sci. Ind Res. *14*, A, 480 (1955)

5. The red halophilic bacterial content of some common salts—R. Venkataraman and A. Sreenivasan - Jour. Sci. Ind. Res. *14*, B, 606 (1955).

6. The Bacterial flora of fresh shark—R. Venkataraman and A. Sreenivasan - Curr. Sci. *24*, 380 (1955).

7. Studies on mussel pollution in Korapuzha Estuary (Malabar)—R. Venkataraman and A. Sreenivasan - Ind. J. Fisheries *2* (2), 314 (1955).

8. New species of marine bacteria tolerating high concentrations of copper—Curr. Sci. *25*, (1956), by A. Sreenivasan.

9. Further studies on the red halophilic bacteria from solar salts and salted fish—R. Venkataraman and A. Sreenivasan - Proc. Ind. Acad. Sci. *43*, (1956).

10. Some aspects of prawn preservation in Madras—A symposium; I.P.F.C. Proc. Tokyo (1955) (in press).

11. Preservation of fish by freezing in the household refrigerator —R. Venkataraman and A. G. Vasavan and A. Sreenivasan - Indcom. Jour. XI, (1), 84 (1956).

12. Fish preservation and processing—R. Venkataraman in "Progress of Fisheries Development in India" - (1956).

TABLE I

Amino acid composition of some proteins of fishes of West Coast (Expressed as per cent on 16 g N basis)

(1)	Chala nathi (Sardinella fimbriata) (2)	Nalla nathi (S. longiceps) (3)	Pomfret (Stromateus niger) (4)	Hammer head shark (Zygaena blochii) (5)	Silver belly (Leiognathus bindus) (6)	Sole (Cynoglossus semifasciatus) (7)	Mackerel (Rastrelliger kanagurta) (8)	Prawns (Penaeus monodon) (9)
Leucine ...	6·5	13·4	18·4	3·1	6·7	11·0	15·51	
Isoleucine ...	5·9			6·1	5·5			
Phenylalanine ...	7·3	6·1	6·2	5·4	5·4	3·8	4·2	6·2
Valine ...	8·8	5·9	6·4	5·6			6·0	
Methionine ...	2·9	3·8	4·7	3·1	7·3	6·9	4·3	11·9
Tryptophan ...	Trace	Trace	1·8	2·1	2·1	1·9	1·1	1·8
Threonine ...	4·7	4·7	6·4	4·7	5·8	5·6	5·5	*
Lysine ...	2·3	8·0	3·7	5·1	6·4	7·4	6·5	8·1
Histidine ...	1·8	1·7	0·7	3·1	3·9	2·6	1·9	2·3
Arginine ...	9·2	7·0	8·2	6·3	13·5	19·2	6·8	7·2
Tyrosine ...	0·9	5·2	†	3·5	3·2	1·9	†	2·4
Alanine ...	2·1	7·5	†	5·6	5·8	9·3	†	4·6
Proline ...	4·1	6·5	†	2·7	1·5	2·0	†	3·6
Glutamic Acid ...	4·2	13·4	†	9·8	11·1	13·0	†	24·6*
Aspartic Acid ...	Nil	10·7	†	4·9	9·2	7·3	†	16·8
Glycine ...	11·6	6·5	†	5·0	3·4	2·4	†	
Serine ...	2·3	4·8	†	5·8	4·3	3·6	†	
Cystine ...	Nil	1·0	†	2·6	1·5	1·6	†	1·2

Legend *: Glutamic acid plus Threonine.

†: Not estimated.

TABLE III

Keeping quality of semidried prawns

No.	Moisture	15 days	30 days	45 days	60 days	75 days	90 days
	per cent						
1	37·78	Good texture very hard	Good	Good	Good	Good	Good
2	40·08	Good texture hard	Good	Good	Good	Good	...
3	42·53	Good	Good	Good	Good	Colour pale	Pungeant odour
4	45·70	Good	Good	Good	Mould attack	Pungeant odour	Pulpy colour grey

VII. PROGRESS OF FRESHWATER FISHERIES BIOLOGICAL RESEARCH IN MADRAS STATE DURING THE PERIOD 1ST APRIL, 1952 TO 31ST MARCH, 1953*

BY P. I. CHACKO AND R. SRINIVASAN.

INTRODUCTION

The Madras Rural Piscicultural Scheme, first sanctioned in July 1942, was pursued for ten years at the Fresh-water Fisheries Biological Station, Madras, till 31st March, 1952, and the results of the investigations were detailed in ten annual reports submitted to the Indian Council of Agricultural Research. Appreciating the need for continuing these studies on a permanent basis the Madras Government sanctioned the permanent retention of the staff. The studies conducted during the year 1952-1953 are embodied in the present report.

STAFF

The Fresh-water Fisheries Biological Station continued to be housed in No. 95, Poonamallee High Road, Kilpauk, Madras, and was incharge of Sri P. I. Chacko, M.A., F.Z.S., Assitant Director of Fisheries (Fresh-water Biology). Sri R. Srinivasan, M.A., Hydrologist was incharge of the Hydrological Station.

RESULTS

I. Studies on large scale fish mortalities.

Sudden and large scale mortality of fish often occurs in fish ponds causing considerable financial loss to the pisciculturist and reduction in the fish-food resources of the country. Investigators have ascribed such mortality to physical, chemical and biological causes. But fish mortality in Madras State is often due to asphyxiation brought about by oxygen depletion in the pond-water, especially during nights or early hours of the day.

A case of large scale fish mortality in quarry Pool No. 3 of the Virudhunagar Fish Farm was investigated during the year under report. This fish farm consists of three quarry pools on the outskirts of Virudhunagar town. These pits are big and deep enough to be perennial. Pool No. 1 locally known as Pallivasal quarry pool has a water-spread of about 1·3 acres. The Government owned (known as poramboke) pools Nos. 2 and 3 are 0·3 and 0·4 acres in area respectively with depths ranging from 6 to 18 feet. The steep sides of the pools do not support vegetation. But macrophytes like *Chara zeylanica* were present in Pool No. 1 and *Typha elephantina* occurred in the other two. The fishes present in the pools were *Barbus chrysopoma*, *B. melanostigma*, and *Gambusia affinis*, but since 1950, *Chanos Chanos*, *Etroplus suratensis*, *Labeo fimbriatus and Cirrhina cirrhosa* have been stocked in the pools. Periodical nettings showed that the introduced

* The annual reports of the Fresh water Biological Station, Madras are published regularly since 1942-43 except for 1952-53. This omission is now rectified.

fish were thriving and growing satisfactorily But the total production of fish in 1950-51 in all the three pools was only 325 lbs. due to loss of fish by periodical natural mortality. The cases of mortality in July 1950 in Pool No. 1 and in August 1950 in Pool No. 3 have already been described in detail in the report for the year 1950-1951 and were attributed to an absence of turnover for several nights prior to the mortality, resulting in the formation of a gradually increasing oxygen-deficiency zone at the bottom especially during the night and of a very narrow upper zone with a moderate oxygen content which was not sufficient to accommodate all the 8,000 and odd *chanos chanos* and *Etroplus suratensis* stocked in the pool.

In the present case of mortality in quarry pool No. 3 all the fish stocked were in distress gasping for breath near the surface during the early hours of each day from 12th July, 1952 onwards, and by January 1955 210·00 pounds of dead fish were renewed. As the death of fish continued throughout the period, July to January, mortality could not be attributed to high temperatures alone. In the course of the investigation of this mortality between 4th and 8th February, 1953 a few *Cirrhina cirrhosa* also died, a post-mortem examination of which failed to give any satisfactory clue for their death. The thermal and oxygen conditions at different times of the day on the 5th and 6th February, 1953 in Pool No. 3 where mortality occurred and in Pool No. 2 where there was no mortality were ascertained as shown below:

Date and Time	Pool No. 3 (12 ft. deep)					
	Temperature in O. C.			Dissolved Oxygen p.p.m.		
	Surface	Bottom	Difference	Surface	Bottom	Difference
5—2—1953						
12 noon ...	28·0	26·0	2·0	13·0	2·3	10,7
6 p m. ...	26·3	25·0	1·3	8.4	0·5	7·9
6—2—1953						
0-00 hrs.						
6 a.m. ...	24·2	23·1	1·1	7·7	0·7	7·0
12 noon ...	24·0	23·0	1·0	1·2	0·0	1·2
	29·8	26·3	3·5	2·9	0·5	2·4

Date and time	Pool No. 2 (16 ft. deep)					
	Temparature in C.			Dissolved Oxygen p.p.m.		
	Surface	Bottom	Difference	Surface	Bottom	Difference
5—2—1953						
12 noon ...	30·2	26·0	3·8	2·2	1·5	0·7
6 p.m ...	26·3	24·2	2·1	4·7	0·0	4·7
6—2—1953						
0-00 hrs.						
6 a.m. ...	24·0	24·0	0·0	1·0	0·1	0·9
12 noon ...	22·2	23·3	1·1	1·2	0·1	1·1
	26·2	26·2	0·0	0·3	0·3	0·0

It would appear that there was a turnover by night in Pool No. 2 while there was none in Pool No. 3 where the mortality occurred. Further the blue-green algae, *Microoystisp* was very abundant (as much as 13,550 individuals per mille at 12 noon on 5th February 1953) in Pool No. 3 where as Pool No. 2 supported only a moderate amount of this algae (about 3,125 per mille at 12 noon on 5th February 1983). The presence of large No. of organisms in Pool No. 3 might have distributed the biological balance in the pond depleting on occassions especially during night or early morning hours almost all the contained oxygen, thereby causing the fish mortality. Further, in the presence of a pronounced thermal stratification and absence of turnover as in Pool No. 3, oxygen depression may increase the incidence of mortality. The plants at the surface extract dissolved substances from solution in the surface layers which cannot receive much replenishment from below on account of the thermal stratification. Following exhaustion of this food supply, the plants decay reducing the oxygen at the surface even faster than it is absorbed by the air. Even though the decay of the algae might not have been solely responsible for the death of fish in the present case as indicated by the high oxygen values during morning hours, it would have certainly contributed towards a faster depletion of oxygen by night. To prevent this, the decaying algae that float as a scum on the surface of the ponds should be removed periodically by dragging with a piece of cloth. Further the growth of algae in the ponds should be kept under strict control if the recurrence of such disasters to fish in farms is to be avoided.

II. Experiments on the control of aquatic vegetation

The disadvantages and inconvenience caused to fishery activities by wild growth of aquatic plants are well known. In Madras State, noxious weeds in inland waters are usually removed by manual labour. The use of chemical herbicides is not generally practised. However, the empolyment of manual labour becomes impractical in the case of vast expanses of water with great depth and with a lot of submerged vegetation and the use of weedicides becomes necessary. Certain experiments were carried out at the Fresh-water Biological Station, Madras with Methoxone (4 chloro, 2 methyl phenoxy acetic acid) and Dicotox containing the ethyl ester of 2, 4 dichlro phenoxy acetic acid and the results were detailed in the previous annual reports for the years 1947–48 and 1951–52 and in the journal of the Bombay Natural History Society, Vol. 51, Pgs. 164–169 During the year under report experiments were made with "Fernoxone" a Sodium salt of 2, 4-D and a I.C.I. product and are described below:—

Experiments were made in November 1952 to find out if it is possible to eradicate by using 'Fernoxone', the Water-hyacinth which had grown dense and covered the entire surface of the Palghat Fort

Moat in Malabar district. The moat had a perimeter of 3,600 feet with an average width of 50 feet. The total area was about 4 acres. The depth of water ranged from 1 to 3 feet and the water surface was about 18 feet below the surrounding ground level with facilities for getting into the moat at only one place near the gate. One-third of the moat surface was treated with 'Fernoxone' of 5th November 1952 as follows. One pound of the chemical was dissolved in 32 gallons of water and solution was sprayed roughly over 800 square yards of the vegetation by means of a Hyject Foot Pump sprayer. The same portion was re-treated with a second and similar dose on 7th November. The weeds withered and crumpled over after the first treatment. The Assistant Fishery Demonstrator at Palghat reported that all the treated weeds died by 25th November. The Assistant Director of Fisheries, Malabar, Kozhikode was therefore requested to purchase five, seven pound tins of Fernoxone at a total cost of about Rs. 190 and treat the remaining two-third of the moat vegetation as described above. Suggestions were also made to the Assistant Director, Kozhikode to contact the District Agricultural Officer and to induce the local ryots to take the silt in the moat for use as manure.

'Fernoxone' was also tried in the Ootacamund lake (Nilgiris district) which was infested with water hyacinth that formed a wide belt along the margin and covered about six to seven acres of waterspread and impeded fishing, angling and boating besides spoiling the beauty spot in the popular tourist centre. 1 found of the weedicide was dissolved in about 64 gallons of water and solution sprayed once about 1500 square yards of the vegetation by means of the Hyject foot pump sprayer. The local Inspector of Fisheries was asked to repeat the treatment over dense patches of vegetation three weeks after the first treatment. After the above treatments, the Inspector of Fisheries at Ootacamund reported that most of the treated weeds had died by January 1953.

Laboratory experiments was also made to find out the utility of 'Fernoxone' in killing submerged vegetation like *Hydrilla verticilata, Potomogeton indicus, Najas sp, Nymphaea stella and Vallisneria spiralis etc.* It was also found that all the above plants except *Vallisneria spiralis* can be successfully killed in about 18 days by a concentration as low as one p.p. million. Field experiment are in progress to confirm these findings.

III. Rheology of the Malampuzha River, Malabar district

A hydrobiological survey of the Malampuzha river was made in November 1952 with special reference to the development of fisheries in the Malampuzha reservoir. The Malampuzha is one of the tributaries of the Kalpathipuzha which after joining the Kannadi river forms the Bharathapuzha, the longest river in Malabar district. It finds its

source from the Palghat Gap in the Western Ghats, and its drainage area, though small (about 60 square miles) is exposed to the full force of the South-West Monsoon. The annual rainfall is about 80 inches. The catchment area is of gneiss which is fine grained and well laminated containing an abundance of quartz and hornblende and also felspar, mica, garnet, magnetitc and haematite. In several places there is an overlaying layer of black mould formed of decayed vegetable matter.

The Malampuzha reservoir which is the first major irrigation project for Malabar, is being formed by the construction of a dam across the river at a site about 8 miles from the Palghat town. This dam as a maximum height of 120 feet above mean sea level. The total length of the masonry portion of the dam is 4,000 feet and of earth bund 2,002 feet. Of this the spillway portion is 296 feet and is capable of disposing of a surplus discharge of 18,400 cusecs. The maximum and minimum water level are at 377.50 and 300 feet above M.S.L. The reservoir will have a capacity of 7800 million cubic feet and a water spread of 8.5 squre miles (5,440 acres). The supply canal which commences from the left flank is about 20 miles long and falls into the Gayatri river and irrigates almost the entire Palghat taluk. The additional yield of food grains as a result of this scheme is estimated to be about 10 000 to 15,000 tons of rice.

In the river stretch above the dam line there are 2 anicuts, the Calan anicut and the Naicker's anicut about 6 to 10 feet high for cultivating small strips of land on the banks. These anicuts are submerged during the rainy season. At the dam site the river is 440 feet in width. The depth of water varies from 1/2 to feet during the summer months and 8 to 10 feet during flood season when the flow of water is tremendous. The bed of the river is mainly rocky with scattered sandy and muddy patches. Mica occurs in the sand. The forest area that will be submerged by the reservoir contains tree like *Tectona Grandis Dalbergia latifolia, Pterocarpus marsupinm,* Lagerstraemia lanceolata, Mangifera, Auogeissus latifolia, Terminalia tomentosa, T. belerica, Hardiwickia binata Xylia xylocarpus, Stereospermum xylocarpum, Grewia tillaefolia and Bambusa arundinacea and wild animals and reptiles like elephants, cheeta, bear, spotted deer, barking deer, jackal, rabbit, monkey, giant squirrel, cobra, python and ratsnakes.

The biological conditions of the river above and below the dam site are varied and interesting. There are abundant growths of algae (*Spirogyra, Oscillatoria and Lyngbia*) over the submerged rocks, and brownish scums composed of dead filaments of these algae occur in the stagnant pools. The shore vegetation comprise of *Pandanus Odoratissimus, Bambusa arundinacea,* Lantana indica, Mussxenda fron-

dosa, Callistemon Centella, Mimosa pudica, Podostemon and various kinds of grasses, thorn bushes and creepers. The aquatic macrovegetation is formed mainly by Polygonum tomentosum, Cyperus distans, Marsilea quardrifoliata, and Eleocharis plantaginea. Phytoplankton is varied and contains blue-green algae (Oscillataria, Chroococus, Merismopedia, Lyngbia), Green algae (Chlamydomonas, Closterium, Cosmarium, Oedogonium, Mougeotia, Euastrum, Stigeoclonium, Scenedesmus, Pediastrum, Cosmarium, Spirogyra, and Fetmedon) and diatoms (Pinnularia, Synedra, Melosira, Gomphonema, Nitzschia, Hantzchia, Navicula, Fragilaria, Gyrosigma and Cyclotella). The diatoms are abundant, the number of individuals of Navicula, Synedra and Gomphonema being 16,000, 6,C00 and 5,000 per c.c. of plankton.

The Zooplankton is conpicuously poor and only few individuals of protozoa (Arcella, Difflugia accuminata, Centropyxix, Peridimium gatunense and Englena), nauplins larvae, dipterian larvae (simulium) rotifers (Brachionus angularis, Anuraea valga and Polyarthra platyptera) daphnids (Ceriodaphnia rigaudi and Moina Lubia) and copepods (Mesocyclops and Allodiaptomus). Larval stages of stone flies, mayflies, dragon flies and caddies flies are fairly common. Water bugs (Laccotrephes, ruber, Gerris nitida, Cylindrostethus products, Ranatra elongata, Lethocirus indicus and Micronecta quadristrigata) beetles (Cybister confusus and Gyrinus convexiusculus) prawns (Palaemon carcinus P. idae, P. Scabriculus and P. dolichodactylus) and crabs (Para telphusia jacquemontii and P. malabaricus) occur in the river. Mussels Uniomarginalis and Cobricule striatella) and gastropods (Melania tuberculatus and Paludomus annandelii) form the bottom fauna. The tortoise (Emyda granosa) infested with leeches probably Paraclipus vuluifera and the water snake (Natrix piscatar) are also available in the river.

There is no regular fishing in the river except by a few local ryots who use cast nets. Dynamiting and poisoning are also resorted to occasionally. The fish fauna consists of (1) Macrones malabaricus, (2) Lepidocephalus thermalis, (3) Garra, (4) Barbus chrysopoma, (5) Barbus dorsalis, (6) Barbus melanostigma, (7) Barbus mahecola, (8) Esomus danricus, (9) Rasbara daniconius, (10) Barilius gatensis, (11) Danio acquipinnatus, (12) Labuca dadiburjori, (13) Chela clupeoides. (14) Gobius striatus, (15) Ophicephalus marulius, (16) Ophicephalus striatus and, (17) Macropodus cupanus and, (18) Etroplus maculatus.

The river water is clear and colourles sexcepting during the flood season when the water is highly turbid. The water has dissolved oxygen supply especially below the dam where the river has a great flow. The rapid current in the river tends to keep the ph uniform over long distance. The water is slightly alkaline and has a hardness of 30 p.p.m., but is not rich in silicates and phosphates. Nitrates are completely

absent. The details of hydrological conditions of the river above and below the dam site as observed at 8 a.m. on 6th November 1952 are shown in Appendix I.

The existing fishery of the river is poor being comprised of 18 species most of which are uneconomical. *Ophicephelus marulius and O. striatus* which are the only important species are air-breathing and are well-known for their "nest building" habits and adaptation to all types of fresh-water conditions. On the whole, the fish fauna of the Malampuzha river is typical of a hill stream characterized by rapid flow of water, rockey falls and pools and rich riparian life. The Malampuzha reservoir gives scope for development of a commercial fishery of a considerable magnitude. As the catchment area is a forest tract with fine grained gneiss, large quantities of nutrient substances of vegetable and mineral origin are being washed into the reservoir. It is already noted that the plankton collected by us in November 1952 is richer than that collected in April 1951. With the completion of the project and the formation of lacustrine conditions, the biological productivity will increase several fold. Major carps occuring in the Cauvery, Krishna and Godavari rivers can grow in it. A programme for necessary transplantation of suitable species have already been initiated and fry and fingerlings of Labeo fimbriatus, L. Kontius, Barbus dubius, B. sarana, B. Carnaticus.

There is no doubt that these species will not only thrive in the reservoir but also breed in the innumerable streams flowing into it. This programme of enriching the fish fauna of the reservoir has to be pursued for about ten years for achieving permanent results.

According to estimates on the productivity of temperate waters, a reservoir of 5,000 acres should give a maximum yield of 11,000 pound of fish per year. As biological productivity of tropical waters is 2 to 3 times greater than that of temperate waters an annual yield of about 100,000 lbs. (about 45 tons) of fish per year can be expected from the Malampuzha reservoir when its population is stabilised probably within five to ten years. Thus the department will be able to judiciously harvest the fishery and market fish in the Palghat area which is situated away from the sea coast. It may be possible to supply fish even to Pollachi and Coimbatore towns. To facilitate stocking and exploitation of the reservoir, a fish farm is necessary at the dam site. For this purpose a suitable site has been selected by us and necessary plans and estimates are being drawn up. Rules for the conservation of the fishery of the reservoir and its tributaries and of the Malampuzha river up to its confluence with the Kalpathipuzha have also been drafted. These measures will also enrich the Bharathapuzha which is now devoid of major fisheries. They will also facilitate the collection of carp fry from the Malampuzha for stocking the rivers, ponds and other inland

waters in the West Coast. At present the development of inland fisheries in Malabar and South Kanara districts is handicapped as fish fry have to be imported from distant places in Tanjore district. The Malampuzha reservoir will give ample scope for limnological studies with special reference to the climatic conditions of the West Coast, and the results will be of considerable practical application for development of inland fisheries of Malabar and South Kanara districts.

IV. Limnology of upland waters.

The Madras State has three hill stations, namely, Ootacamund in the Nilgiris (7,200 feet above sea level) Kodaikanal in the Palni hills (7,000 feet. a.s.l) and Yercaud in the Shevaroy Hills 4,600 feet above sea level). In each of these stations there is a lake affording ample facilities for fishing for the pleasure and profit. The State Fisheries Department has taken steps to improve the fishery potentialities of these upland waters. The cold water fishes like the English Carp Carp (Carassins Carassius) the Mirror Carp (Cyprinus-carpio) and the Tench (Tinca Vulgaris) have been introduced into them, and these species form the bulk of the catches. With a view to suggest measures for the development and exploitation of the waters, a limnological investigation was carried out during the year.

The Ooty lake is about 65 acres in extent with a maximum depth of 8·5 meters close to the Westmere and near the outlet and a minimum depth of 1·5 meters near the fish-dale. There was a thick growth of *Eichornia* forming wide belt all around the lake during the year and as described already it was killed by January 1953 by the application of "Fernoxone". The Kodaikanal lake is also about 65 acres in area with a maximum depth of 9 meters opposite the Municipal office. It is fed by a few underground springs and mostly by the rains. It has a thick grass fringe near the bunds and has a macro-vegetation consisting of ferns (*Lastrea octhodis* and *Osmunde regalis)*, sedges (Scirpus quarosus), water lilies (Nymphaea stellata) Hydrilla verticellata and Potomogeton indicus. The Yercaud lake has a water spread of about 23·5 acres with a maximum depth of 4 meters at a place 140 yards from the windmill and 165 yards from the outlet. The emergent and submerged vegetation in the lake consisted mostly of Vallisneria, Hydrilla, Nitella, Utricularia, Scripus, Cyperus, Colocasia, Polygonum and Hydrophilla.

The hydrobiological conditions and their diurnal fluctuations were ascertained in the hot weather period of 1952. Ia Ooty and Kodai lakes the samples were collected at intervals of 2 meters whereas in the relatively shallow Yercaud lake collections were made at intervals of 1 meter. The surface water samples required for the physical chemical examination were collected as usual in two narrow mouthed flat stoppered bottles of 500 c.c. and 250 c.c. capacity respectively and the water in the smaller bottle was fixed for dissolved oxygen test according

to the Winkler method. The deep water samples were collected by means of Friedinger's deep water samples. The temperature recordings at different depths were made by means of the Friedinger's electrical deep water thermometer. Other chemical factors of the lake water were determined by the standard methods described by the American Public Health Association. The plankton collections from the different depths were made with the help of the closing plankton net of Friedinger. Quantitative analysis of plankton was made by examining and counting the number of organisms in 1 mille of water placed in a counting cell under the microscope using a high power objective (X 400).

The hydrological conditions at about 8 a m. at different depths in the 3 lakes during the two seasons are tabulated in Appendicies II and III. In Ooty lake the surface temperature varied from 22.9°C in the hot weather period to 18.0°C in the cold weather period where as in Kodai lake it varied from 21.6°c in the hot season to 18.2°c in the cold season. Thus the surface water of Ooty lake was hotter than that of Kodai lake by 1.3°c (2.34°F) in the hot weather period and colder than that of Kodai lake by 0.6°c (=1.08°F) in the cold season. This is to be expected since Kodaikanal has a more equable climate than that of Ooty and since Ooty was hotter than Kodai by 4.6°F in the hot season of 1952 and colder than Kodai by 3.4°F in the cold season of 1953. In Yercaud lake which is situated at an altitude of 4,600 feet only the annual surface temperature fluctuations are so marked, the difference between the hot and cold periods being only 1.6°c as compared with 4.9°c for Ooty lake and 3.0°c for Kodai lake. There was thermal stratification in all the three lakes both in the hot and cold seasons and the stratification was stronger in the hot weather period in all the instances. The stratification was the weakest in Yercaud lake which was relatively shallow and was the strongest in the Kodai lake which had the maximum suface water temperature in the hot weather period. The difference between surface and bottom water temperatures in the Kodai lake was 5.0°c and 1.8°c in the hot and cold weather periods respectively. The corresponding differences between surface and bottom temperatures in the case of Kodai lake were only 1.4°c and 1.1°c respectively. It is interesting that the Ooty and Kodai lakes situated at almost the same heights above m.s. 1. and holding almost the same volume and depth of water should differ so much in the degree of thermal stratification.

The diurnal variations of temperature at the various depths in the three lakes during both the seasons were noted and are shown in the Appendix. The surface as well as the deeper layers of water generally increased in temperature from 2 a.m. to 2 p.m. after which their temperature gradually decreased till the next day morning when they once again increased. The diurnal fluctuations in temperature in the case of

all the three waters were greater in the cold weather period than in the hot weather period. The daily fluctuations also tended to decrease with increasing depth though on occassions the variations were greater in the bottom layers than in the top layers.

The ph of the various layers of water in the three lakes was generally greater in the hot season than in the cold season. The annual fluctuations in ph were very much greater in the Kodai and Yercaud lakes than in the Ooty lake. These annual variations in ph generally decreased with increasing depth. In Ooty lake in the hot weather period the upper layers of water to a depth of about four meters had a lower ph than that of the bottom layers. This might have been due to the decaying water hyacinth that had grown dense in the lake. In all other cases ph decreased with increased depth, the difference between the top and bottom layers being as much as 1.8 in the hot weather period in the Kodai lake. The difference between the surface and bottom was lower in the cold weather period than in the hot weather period. As in the case of temperature the ph generally increased from 2 a.m. to 2 p.m. after which it decreased till the next day morning when it increased once again. The daily ph changes in both the seasons in the Ooty lake can be said to be less as compared with those in the Kodai and Yercaud lakes. There was also no marked difference in the daily fluctuations in ph between the two seasons.

The oxygen stratification was pronounced in Ooty and Kodai lakes whereas in the relatively shallow Yercaud lake the bottom layers were as well oxygenated as the top layers. In Kodai lake the oxygen content of the different layers as well as the oxygen stratification was greater in the hot weather period than in the cold weather period. The oxygen content was also above 2 ppm upto a depth of 4 meters almost throughout the year. In Ooty lake there was practically no oxygen below 3 meters almost throughout the year. The relatively low oxygen values in the hot season in the Ooty lake were due to the presence of the decaying water hyacinth which were completely killed and removed by January 1953 After the removal of the decaying vegetation the dissolved oxygen of the surface layers increased in the cold weather period. As in the case of temperature and ph, the oxygen also increased from morning to afternoon and then decreased till the next morning when it rose once again. The lower layers of water also recorded similar diurnal changes though not to the same extent. In Yercaud lake the diurnal fluctuations of oxygen content were almost uniform from top to bottom whereas in the deeper Kodai and Ooty lakes the changes were not marked in the bottom layers especially below 4 meters.

Carbondioxide generally increased with depth in both the seasons in all the three lakes. The relatively high values in the upper layers in Ooty lake were as already described due to decaying water hyacinth.

In Kodai and Yercaud lakes the carbondioxide content was greater in the cold weather period than in the hot weather period. There was no carbondioxide in the surface layers of Yercaud lake in the hot weather period when carbonates were present in a concentration of 1·5 ppm. as co_3. Carbonates were conspicuous by their absence throughout the year in Ooty and Kodai lakes. The bicarbonates increased with depth in all the three lakes. In Ooty and Kodai lakes the bicarbonates were greater in the hot season than in the cold season whereas in Yercaud lake it was greater in the cold season. The bicarbonates were very high in the Ooty lake and ranged from 115·9 to 152·5 ppm. $HC0_3$ as compared with the maxima of 42·7 and 54·9 ppm. respectively in Kodai and Yercaud lakes. The chloride content was greater in the cold weather period in the three lakes and ranged from 8·0 to 36 0 ppm. in the Ooty lake, 6 0 to 8·0 ppm. in Kodai lake and 21·0 to 22·0 ppm. in the Yercaud lake. Thus the annual variation in chlorinity were very much in Ooty lake when compared with the other two lakes. Throughout the period of study the chlorides were uniform from top to bottom in all the three lakes. The silicates increased from surface to bottom and were higher in the cold weather period than in the hot weather period in Ooty and Yercaud lakes. In Kodai lake they ranged from 2 ppm. in the cold season to 5·2 ppm. in the hot period. Phosphates were present in traces only in the cold season in all the three lakes and increased in quantity ranging from 1·9 to 3·75 ppm. $P0_4$ in the hot season.

The flagellates (Euglena acus, ceratium hirudinella), green alge (Oedogonium oblongellum, and staurastrum dejectum) Blue (Microcystis aeruginosa) were the common phyloplanktons in the Ooty lake. Of these Microcystis *aeruginosa* was abundant during the hot weather from the surface to the bottom. But in the cold weather ceratium hirudinella was in swarms and was present at all depths, though more in numbers at the surface during the night and at the bottom during the day. *Euglena* and staurastrum were confined to the upper half of the lake. Zooplanktons were represented by copepods, cladoceras and rotifers. Tonopodiaptomus and Eucyclops agiloides were common at the surface and sparsely present at the lower layers during both the seasons. Their nauplii occurred in large numbers during the hot weather period indicating the favourable breeding season of these copepods. Among cladocerans, Daphnia longispina, ceriodaphnia rigaudi and Diaphanosoma pancispinosum were fairly present during both the seasons. They were in larger numbers at the bottom at all hours during the hot weather period and at the surface during the cold weather period.

In the Kodaikanal lake, ceratium hirundinella was common during both the seasons. Microcystis aeruginosa was abundant from surface to bottom during the cold season (February 1953) but was

conspicuously absent in June 1952. Peridinium gatunense, Staurastrum dejectum, cosmarium granatum, and Tribonema were present during the warm period and Botryococcus, staurastrum, comarum, chrococcus and Desmidium in the cold season and of Zooplankters Tripodiaptomus was common during the cold season being more at the surface. Daphnia and ceriodopnia were only represented in few numbers.

In the Yercaud lake phytoplanktomic fons like Microcystis, Botyocus, Ceratirius Ankistrodesmus, and Selenastrum were all abundant from surface to bottom during the hot weather period. During the cold weather Tribonema continued to be in abundance, but of the other forms only ceratum and Tribonema were in fair numbers, and of zooplankters the copepod Tropodiaptomus and Mescyclops and their nauplii were common throughout the year. Daphnids and rotifers were also present in few numbers.

V. Hydrobiology of Adyar estuary

The Adyar river finds its source from the Guduvancheri hills in Kanchepuram taluk of Chingleput district, and flows through the Saidapet taluk and empties into the Bay of Bengal at Adyar within the southern limits of Madras City. On the whole it has a short course of 25 miles. The surplus waters of the chemrampakkam irrigation tank and other subsidiary natural drainages flow into the river. It is full only during the north-east monsoon period (October to December) when there is good flow of fresh water into the sea. As the strength of current weakens, tidal influence is felt up to a distance of about four miles from the month. By the end of January a sand bar is formed at the river mouth, and the estuary gets cut off from the sea. This bar gets prominent and reaches a maximum width of nearly a furlong till the next rainy season.

The surface water temperature ranged from 25. O°C in December 1952 to 32. O°C in July and September 1952 and closely followed the atmospheric temperature in its variations. It would appear from the data that the temperature below the bridge was greater than that near the bar on most occasions, but this may be due to the fact that the temperature at the former spot was always recorded half-an-hour after the temperature near the bar was noted.

The transparency of water varied from 30 cm. to 12 cm. during the period of study. The water was turbid in October 1952 when the flow in the river was great. At this time of the year the estuary was rich in silicates with as much as 40 to 60 p.p.m. SiO_2 and was relatively poor in plankton organisms. The estuary was rich in dissolved oxygen especially near the mouth throughout the period of study indicating its capacity to support good fisheries. The fluctuation of dissolved oxygen below the bridge was greater and more marked than that near

the bar probably because of pollution by drainages from the slums situated on the banks of the river above the bridge. The dissolved oxygen content was low below the bridge between June 1952 and August 1952 when there was practically no flow of water in the river and stagnant conditions were prevailing with the onset of the north-east monsoon in October 1952, the flow of water in the Adyar river increased and there was greater self-purification of the river as indicated by the higher dissolved oxygen values in the estuary from October 1952 onwards. Free carbondixoide was completely absent in the estuary except in January and February 1953 when it was present in small amounts ranging from 0·24 to 1·5 p p.m. The pH was also low and ranged from 7·4 to 7·6 in these two months whereas during the other months it was greater than 8·0 and varied between 8·1 and 8·8. This may be due to the fact that there was a heavy rainfall of 11·23 inches in the month of December 1553 and there was consequent dilution of the estuary water by the rain water. The dilution of the estuary water in January 1953 is also indicated by a reduction in salinity. The salinity of the estuary varied from 19·03 per cent in November 1953 to 31·5 per cent in April 1953.

Copepods were present throughout the year, with a peak from July to September. During this season, their nauplli are also abundant indicating thereby that this is favourable breeding period of these macrocrustaceans. Of phytoplanktonic organisms, the green alga *Ankistrodemus Convolutus* was common from August 1952 to February 1953. The diatom *Gyrosigma distortum* was present almost uniformly throughout the year. The marine diatoms *Fragilaria Oceanica, Navicula Gracilis and Sceletonema Costatum* were present in good nnmbers from January to May consequent to their entering the estuary when the bar is open. The other marine forms also occured during this period. The amphipod, *Paracalliope Fluviatilis* was present from July to November. One specimen of the Ctenophore, *Pleurobrachia globosa* was obtained in the plankton collected from the higher reaches of the estuary in September 1952.

A census conducted during the period of study showed that 802 men, 677 women and 577 children constituted the fisherfolk of 14 villages along the river course. They had 833 cast-nets (*Veechu Valai and Manivalai*), 133 drag nets (*Kondavalai, Nethivalai and Kalluvalai*), 28 encircling nets (*Penthavalai, Peravalai and Seruvalai*) 29 shore-seine nets (*Bodivalai or Agnivalai*), and 30 *Katchvalai* (crab traps). Two boats and 55 catamarans formed their crafts.

With cast-nets from shore, 1½ to 3 pounds of fish were landed per day per net, the bulk being prawns (*Penaess Carinatus, Penaeus Indicus* and *Metapenaeus Monoceros*), young stages of mullets (*Mugil Cephalus, M. Cunnensius* and *M. Olivaceus*), white sardine (*Kowala thoracata*),

nus Longicornis) and diatoms (*Sceletonema Costatum, Coscinodiscus Lineatus, Rhizosolenia Alta, Chaetoceros Peruvianus* and *Fragilaria Oceanica*) in its stomach in July 1952. *Sardinella Fimbriatus* showed larval bivalves, copepods (*Acartia Erythreae*) and *Leucifer Hanseni* in its stomach in January 1953. It was surprising to observe an entire specimen of *Engraulis Malabaricus* (3 inches in size) in the stomach of Illisha brachysoma (8 inches in length) obtained from the estuary in January 1953. Copepods (*Acartia Erythraea* and *Corycoeus Venustus*) and larval bivalves formed the chief food of *Stolephorus Malabaricus*. *Engraulis Malabaricus* and *Coilia Ramcarati* had *Acetes Indicus in* their stomach in July 1952 and January 1953. Mysids (*Rhopalophthalmus Egregius* and *Mesopodopsis Orientalis*) were the main items of food of *Ambassis Commersoni*. *Lutjanus Linelatus, L. Monostigma, Polynemus Indicus* and *Eleutheronema Tetradactylum* contained prawns in their stomach almost throughout the year.

A census was conducted and it revealed that there are 438 fishermen of seven villages actually engaged in fishing in the Vellar estuary by employing seven thurivalai, 46 thoondivalai, 1,686 cast nets, 165 kovavalai, 94 kozhuvalai, 121 kunnivalai and 10 sets (of 24 each) of kachavalai.

The total landings from the estuary during the 12 months from May 1952 to April 1953 is estimated to be about 182,625 pounds by the different tackles as shown below :—

	Kind of tackle	Landings in lb.		Kind of tackle	Landings in lb.
1	Cast net (from shore)	22,275	4	Ranchuvalai	28,260
2	Cast net (from craft)	114,710	5	Kovavalai	5,570
3	Koonivalai	11,660	6	Katchavalai	150

The bulk of the catches were formed by mullets (76,993½ pounds) and prawns and shrimps (48,342 pounds). Both these occured in the estuary throughout the year. The mullets had two peak periods in May-July and January-March. It is probable that this group breeds in the adjoining inshore sea throughout the year with two peak period mentioned above. The prawns and shrimps also showed two peak periods in April-June and in November. Young stages of the silverbellies (*Leiognathus Spp*) also occured in the estuary throughout the year, and were third in importance in landings (18,850 lb.). Evidently the nearby coastal waters are favourable for the spawning of this group of fish, which appears to breed almost throughout the year with a peak period from November to February. The other shoaling clupeoids like *Surdinella Gibbonsa* and *Engraulis Malabaricus* appear to have an important spawning period about the north-east monsoon. Young

ones of the jew-fishes (*Johnius Spp.*) contribute to a fair fishery almost throughout the year. *Eleutheronema Tetradactylum* is also present during the major part of the year with a peak from January to March. Cat-fishes occur in the estuary during the two monsoon periods only.

VII. *Hydrobiology of Departmental Fish Ponds*

The hydrobiological conditions of ten departmental waters on various dates are given in Appendix IV.

VIII. Publications.

The following publications were made during the year :—

1. "A Statistical account of the fish supply of Rajahmundry town" by P. I. Chacko and S. George, Cont. Fresh Water Biol. Res. Stat., Madras, I, 1–3, 1952.
2. "Fisheries of the Kadamba tank, Tirunelveli District" by P.I. Chacko, and S. George, ibid., II, 1–6, 1952.
3. "Fisheries of the Kanigiri Reservoir" by P. I. Chacko, B. Krishnamurthy and S. George, ibid , III, 1–9, 1952.
4. "Report on a survey of the dams and migratory fishes of, Madras" by P.I. Chacko, ibid, IV, 1–18, 1952.
5. "Fish culture in paddy fields" by P.I. Chacko and S.V. Ganapati, Ind-Com Journ., 7, 173–175, 1952.
6. "Inland Fish Statistics for 1951" by P.I. Chacko and S. George, Madras Govt. Press.
7. "The bladder wort, Utricularia flexuosa as a competitor for fish food" by P.I. Chacko, Sci. cult. 18. 230–240–1952.
8. "Development of Fisheries of Kodaikanal lake, Madurai District" by P I. Chacko, Ind.—Com. Jour. 8. 372-374, 1952.
9. "An investigation of the river Godhavari and the effect of the paper mills pollution at Rajahmundry" by S. V. Ganapati and P.I. Chacko Proc. 3rd meeting Indo Pacific Fisheries Council, Sections II and III, 70–74, 1952.
10. "The control of aquatic vegetation with 2, 4-D" by R. Srinivasan and P.I. Chacko, Journ., Bombay Nat. Hist. Soc., 51, 164–169, 1952.
11. "On the development and parental care in the Potomonid crab Paratelphusia (Barytelphusa) jacqumonti" by P. I. Chacko and S. Thyagarajan, ibid., 51, 289–291, 1952.
12. "Past, present and the future of the Hilsa fisheries in the Madras State," by P.I. Chacko, Proc. 4th meeting Indo-Pacific Council, Technical paper No. 44 18–20, 1952.
13. "On the utility of Sodium phosphate in the transport of fingerlings of Indian carps" by R. Srinivasan & P.I. Chacko, Proc. 40th Indian Sci. Cong. III, 212–213, 1953.

14. "Introduction of exotic cichlid fish Tilapia mossambica Peters in Madras" by D.D. Peter Devadas & P. I. Chacko Curr. Sci. 22, 29, 1953.

15. "Hydrobiology of the Malampuzha River with reference to development of fisheries in the Malampuzha Reservoir" by P.I. Chacko, R. Srinivasan and G. Evangeline. Ind.-Com Journ., 8, 118-124 1953.

16. "Tilapia culture in Madras" by D.D. Peter Devadas & P. I. Chacko, Madras Information, 8, 16, 1953.

APPENDIX I

Showing hydrological conditions of Malampuzha River at 8 a.m. on 6th November 1952.

Conditions	Above Dam	Below Dam
Colour of water	Clear	Clear
Temperature, °C	28·6	28·2
Transparency, cm.	24	23
PH	7·3	7·3
Dissolved Oxygen, mg/l	5·63	7·20
Dissolved Oxygen, cc/l	3·94	5·03
Dissolved Oxygen, Saturation	69·2	87·7
Free Corbondioxide, pp. 100,000	0·55	1·1
Carborates as Co_3 pp. 100,000	Nil	Nil
Bicarborates as HCo_2, pp. 100,000	45·75	45·75
Chlorides as Cl_2, pp. 100,000	72	72
Silicates as SiO_2, pp. 100,000	12·0	6·0
Phosphates as P O5, pp. 100,000	0·5	0·2
Total hardness as Ca Co_3, pp. 100,000	30·0	30·0
Phytoplankton	Oscillatoria, Chroococcus, Merismopedia, Lyngbia, Chlamydomonas, Closterium, Oedogonium, Mougeotia, Cosmarium, Scendesmus, Spirogyra, Hantzschia, Eunotia, Navicula, Synedra, Gomphonema, Fragilaria, Melosira, Pinnularia, Cymbella, Cyclotella, Gyrosigma.	Oscillatona, Pedi, astrum, Surirella-Synedra, Stigeoc-,-lonium, Enastrun, Tetraedon, Spirulina. Fragilaria.
Zooplankton	Arcella, Difflugia, Centropyxis, Peridinium, Brachionus. Anuraea, Polyarthra, Moina, Cerodaphnia, Mesocylops.	Peridinium, Euglena, Brachionus, Anuraea, Ceriodaphnia, Moina, Mesoeyclops, Allodiaptomus.

APPENDIX II

Showing hydrological conditions in three upland lakes at 8 a.m. during summer and winter periods

Seasan	Summer					Winter				
Depth in Metres	0	2	4	6	8	0	2	4	6	8
1. Ootacamund Lake, May 1952 and February 1953										
Temperature, °C	22·9	20·5	20·0	18·2	17·9	18·0	17.2	16.8	16·4	16·2
PH	7·0	7·0	7·0	7·1	7·3	7·2	7·0	6·9	6·9	6·9
Dissolved Oxygen, cc/l	3·0	7·71	Nil	Nil	Nil	5·2	2·3	0·1	0·1	0·1
Free Carbondioxide, pp. 100,000	35·2	25·3	18,7	8·8	13·2	1·43	2·42	4·4	4·51	4·95
Carbonates as Co_3, pp. 100,000	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Bicarbonates as HCo_3, pp. 100,000	149·5	146·4	152·5	149·5	149·5	115·9	125·0	131·2	131·2	146·4
Chlorine in Chlorides, pp. 100,000	8·0	8·0	8·0	8·0	8·0	36·0	36·0	36.0	36·0	36·0
Silicates as SiO_2, pp. 100,000	1·0	1·0	1·0	1·2	1·4	6·0	6·0	6·0	6·4	6·8
Phosphates as PO_4, pp. 100,000	2·50	3·75	3·75	3·75	3·75	Trace	Trace	Trace	Trace	Trace
II. Kodaikanal Lake, June 1952 and February 1953										
Temperature, °C	21·6	21·2	20·6	20·4	20·2	18·6	18·2	18·0	17·5	
Turbidity, cm	>30	>30	>30	>30	22	>30	>30	>30	>30	
PH	7·6	7·5	6·0	5·9	5·8	6·3	6·4	6·2	6·1	
Dissolved Oxygen, cc/l	6·7	6·5	3·9	0·1	Nil	4·7	3·7	2·4	0·4	
Free Corbondioxide, 100,000	2·5	1·4	2·4	5·3	6·6	2·2	2·2	2·75	3·5	
Carbonates as Co_3, pp. 100,000	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Bicarbonates as HCo_3, pp. 100,000	18·3	21·4	24·4	36·6	42·7	15·2	12·2	15·2	13·4	
Chlorine in Chlorides, pp. 1 0,000	6·0	6·0	6·0	6·0	6·0	8·0	8·0	8·0	8·0	
Silicates as SiO_2, pp. 100,000	4·4	3·6	4·4	4·4	5·2	3·0	2·0	2·0	3·0	

APPENDIX II—(*Contd.*)

Showing hydrological conditions in three upland lakes at 8 a.m. during summer and winter periods

Season		Summer				Winter			
Depth in Meters		0	1	2	3	0	1	2	3
III. Yercaud Lake, July 1952 and February 1953									
Temperature °C	...	21·2	21·0	20·8	20·3	19·6	19·2	19·0	19·0
Turbidity	...	23	20	20	17	18	17	16	15
PH	...	8·1	8·0	7·5	7·1	7·2	7·2	6·9	6·3
Dissolved Oxygen, cc/l	...	30·70	4·20	3·05	3·55	5·7	4·3	5·5	0·5
Free Carbondioxide, pp. 100,000	...	Nil	Nil	0·3	0·7	1·21	1·21	1·76	5·5
Carbonates as Co_3, pp. 100'000	...	1·5	1·5	Nil	Nil	Nil	Nil	Nil	Nil
Bicarbonates as HCo_3, pp. 100,000	...	13·7	13·7	15·25	16·5	51·9	48·8	51·9	54·9
Chlorine in Chlorides, pp. 100,000	...	21·0	21·0	21·0	21·0	22·0	22·0	22·0	22·0
Silicates as SiO_2, pp. 100,000	...	Trace	Trace	Trace	Trace	11·2	11·2	11·6	12·0
Phosphates as PO_4, pp. 100,000	...	1·9	1·9	2·0	2·0	Trace	Trace	Trace	Trace

APPENDIX III

Showing diurnal variations of temperature, PH and dissolved Oxyzen of three upland waters

Name of Lake		Ootacamund Lake									
	Season	Hot weather May 1952					Cold weather Feb. 1953				
Conditions	Depth	O	2M	4M	6M	8M	O	2M	4M	6M	8M
Temperature in Degree C	8 a.m.	...	...	...	...	...	...	...	...	...	...
	2 p.m.	...	...	...	...	...	19·4	19·3	18.0	17·8	17·5
	8 p.m.	22·2	19·5	19·5	19·1	18·5	18·4	17·9	16·5	16·2	16·2
	2 a.m.	22·9	20·5	20·0	18·2	17·9	17·8	17·6	16·6	16·2	16·8
	8 a.m.	...	...	...	...	...	18·0	17·2	16·8	16·4	16·2
	2 p.m.	23·4	21·6	20·0	18·4	18·2	20·4	19.8	17·8	17·4	17.0
	8 p.m.	22·8	21·6	19·8	18·1	18·2	...	...	...	...	...
PH	8 a.m.	...	...	...	...	...	...	...	...	...	...
	2 p.m.	...	...	...	...	...	7·1	7·1	6·8	6·8	6·1
	8 p.m.	7·2	7·0	6·7	6·8	6·8	7·2	7·2	7·0	6·8	6·8
	2 a.m.	7·0	7·0	7·0	7·1	7·3	7·2	7·0	6·9	6·8	6·8
	8 a.m.	...	...	...	...	...	7·2	7·0	6·9	6·9	6·9
	2 p.m.	7·3	7·1	7·1	7·0	7·3	7·2	7·0	6·9	6·6	6·8
	8 p.m.	7·3	7·0	7·2	7·0	7·1	...	...	...	...	...
Dissolved Oxygen, p.m.	8 a.m.	...	...	...	...	...	...	...	...	...	...
	2 p.m.	...	...	...	...	...	5·0	5·2	0·4	0·1	0·1
	8 p.m.	5·4	0·57	Nil	Nil	Nil	3·8	4·7	0·5	Nil	Nil
	2 a.m.	3·0	0·71	Nil	Nil	Nil	5·4	4·6	0·1	0·6	0·1
	8 a.m.	...	...	...	...	...	5·2	2·3	0·1	0·1	0·1
	2 p.m.	4·0	3·0	Nil	Nil	Nil	5·2	5·7	0·1	0·5	0·1
	8 p.m.	2·0	1·0	Nil	Nil	Nil	...	...	...	...	...

Showing diurnal variations of temperature, PH and dissolved oxygen of three upland waters—(contd.)

Name of Lake		Kodaikanal Lake									
	Season	Hot weather June 1952					Cold weather Feb. 1953				
Conditions	Depth	O	2M	4M	6M	8M	O	2M	4M	6M	8M
Temperature in Degree C	8 a.m.	...	...	...	...	...	...	...	...	...	...
	2 p.m.	21·6	20·8	20·8	19·4	19·0	20·4	19·2	19·2	18·2	...
	8 p.m.	21·2	20·6	20·0	19·0	18·8	19·6	18·4	17·2	17·2	...
	2 a.m.	20·8	20·6	20·6	19·8	19·6	18·6	18·2	17·1	16·6	...
	8 a.m.	21·1	20·9	20·0	19·8	19·4	18·6	18·2	18·0	17·5	...
	2 p.m.	21·6	21·2	20·6	20·4	20·2	21·0	20·4	19·0	18·4	...
	8 p.m.	...	...	...	...	...	...	...	...	...	...
PH	8 a.m.	...	...	...	...	...	...	...	...	...	...
	2 p.m.	7·0	6·8	4·4	5·6	5·6	6·5	6·3	6·1	6·1	...
	8 p.m.	7·0	6·6	6·0	6·0	6·0	6·3	6·3	6·2	6·1	...
	2 a.m.	7·1	6·6	5·8	5·8	5·7	6·4	6·3	6·1	6·0	...
	8 a.m.	7·1	6·8	5·8	5·8	5·7	6·3	6·4	6·2	6·1	...
	2 p.m.	7·6	7·5	6·0	5·9	5·8	6·3	6·3	6·1	6·1	...
	8 p.m.	...	...	...	...	...	...	...	...	...	...
Dissolved Oxygen, p.m.	8 a.m.	...	...	...	...	...	...	...	...	...	...
	2 p.m.	6·4	6·1	2·9	1·0	Nil	4·0	4·9	2·0	0·4	...
	8 p.m.	6·5	6·6	1·4	0·1	Nil	5·3	5·8	1·8	0·5	...
	2 a.m.	6·5	6·4	1·2	Nil	Nil	4·6	4·4	3·5	0·3	...
	8 a.m.	6·4	6·2	1·5	Nil	Nil	4·7	3·4	2·4	0·4	...
	2 p.m.	6·7	6·5	3·9	0·1	Nil	3·5	4·7	3·4	0·7	...
	8 p.m.	...	...	...	...	...	...	...	...	...	...

Showing diurnal variations of temperature, PH and dissolved oxygen of three upland waters—(contd.)

Name of Lake		Yercaud Lake							
	Season	Hot weather July 1952				Cold weather Feb. 1953			
Conditions	Depth	O	1M	2M	3M	O	1M	2M	3M
Temperature in Degree C	8 a.m.	21·2	21·0	20·8	20·3	...	...	...	...
	2 p.m.	21·6	21·9	21·8	21·0	21·0	...	18·4	17·2
	8 p.m.	20·8	20·6	20·3	20·2	21·4	19·2	19·0	18·8
	2 a.m.	20·6	20·4	20·2	20·2	20·2	19·5	19·2	19·0
	8 a.m.	21·5	21·3	21·2	20·8	19·6	19·2	19·0	19·0
	2 p.m.	...	...	...	...	23·4	20·0	19·8	19·6
	8 p.m.	...	...	...	...	...	...	...	...
PH	8 a.m.	8·1	8·0	7·5	7·1	...	...	...	...
	2 p.m.	8·0	8·0	7·5	7·1	7·5	...	6·8	6·3
	8 p.m.	8·1	8·0	7·3	6·7	7·6	7·2	6·9	6·4
	2 a.m.	8·1	8·1	7·3	6·6	7·3	7·3	6·9	6·4
	8 a.m.	8·0	8·0	7·6	6·9	7·2	7·2	6·9	6·3
	2 p.m.	...	...	...	...	7·4	7·3	6·9	6·8
	8 p.m.	...	...	...	...	...	...	...	...
Dissolved Oxygen. p.m.	8 a.m.	3·7	4·2	3·0	3·5	...	...	...	...
	2 p.m.	4·0	4·5	4·2	4·4	8·9	...	4·3	1·4
	8 p.m.	3·99	4·4	3·94	4·5	8·8	6·3	5·5	1·8
	2 a.m.	4·8	5·3	4·2	4·8	8·4	7·9	5·5	1·6
	8 a.m.	4·4	4·9	5·9	4·3	5·7	4·3	5·5	0·5
	2 p.m.	...	...	...	...	5·7	5·5	3·9	3·8
	8 p.m.	...	...	...	...	...	...	...	...

APPENDIX IV

Showing hydrobiological conditions in some of the departmental waters and fish ponds examined in 1952–53

Particulars	Adyar ponds			Fort St. George, Moat, Madras		
	Compound of Hon. Minister Sri M. A. Manickavelu Naicker		Compound of Hon. Minister Sri R. Nagana Gowd	South End	Middle Portion	North End
	Big Pond (1)	Small Pond (2)	3)	(4)	(5)	(6)
Shape and dimensions	Rectangular 200′×100′	Nearly Square 60′×60′	Oblong; 0·25 acre			
Depth of water	2 feet	6 feet	2 feet to 5 feet			
Date of examination	1–6–1952	1–6–1952	1–6–1952	18–7–1952	18–7–52	18–7–1952
Time of examination	9 a.m.	9-10 a.m.	9-40 a.m.		11-45 a.m.	
Temperature in degree c	31·8	30·7	3·60	30·8	31·0	30·6
Transparency in cms.	7.30	21	19	20·0	20·0	20·0
Dissolved oxygen ppm.	3·2	3·0	2·8	6·7	7·95	6·1
Free carbondioxide ppm.	3·3	3·3	3·3	Nil	Nil	Nil
Carbonates as co3 inches ppm. ...	Nil	Nil	Nil	60	54	33
Bicarbonates as co3 inches ppm. ...	128·10	112·85	112·85	198·25	164·7	170·8
Salinity as percent o.	10	2·6	4·4	14·81	14·66	14·05
pH	7·9	7·5	7·3	8·85	8·85	8·80
Silicates as Sio_2 ppm.	Trace	Trace	Trace	Trace	Trace	Trace
Phosphates as $P_2 0_5$ ppm.... ...	Trace	3·75	2·50	5·2	5·74	3·36
Chlorides as Cl_2 p.p.m.						
Phytoplankton	Fragilaria-Rare Gyrosigma-Rare	Navicula-A Cyclotella-A Gyrosigma-C Oscillatnia-A Spirulina-C Microcystis	Oscillatnia-F	*Cyanophyceae* :—Oscillatoria *Chloraphyceae* :—Anhistrodesmus, Cladoptora & Enteromospha *Bacillariophyceae* :—Navicula, Cyclotella, Tabellaria and Pleurosigma *Dynophyceae* :—Peridinium *Euglenophaceae* :—Englena		
Zooplankton	Rotifers (Anuraca, Brachionus, Diurella, Noteus and Salpina)—A Copeped(Prendodiaptonus)—F	Rotifer—F	Rotifers-A Anuraca, Brachionus Diuralla Noteus and Salpina.	*Rotifera* :—Brachious & Noteus *Cop pods* :—Mesocyclops, Acartia, Psendodiaptomus, and Nanpliris larvae *Insecta* :—Odonata larvae		
Bottom Fauna				***Marphysa gravelyi***		

APPENDIX IV—(*Contd.*)

Showing hydrological conditions in some of the departmental waters and fish ponds examined in 1952–53

Particulars	Agricultural Form at Arakuvelly	Peddapuram tanks		Palaghat tanks		
		Kasiraju tank	Tharakod tank	Thondikulam	Tharakod tank	Ramanatha-puram tank
Shape and dimension	(7)	(8)	(9)	(10)	(11)	(12)
Depth of water		6 feet	6 feet			
Date of examination	29—9—1952	16—12—1952	16—12—52	7—11—1952	7—11—1952	7—11—1942
Time of examination	10 a.m.	10-15 a.m.	11 a.m.	10-40 a.m.	10-55 a.m.	11-05 a.m,
Temperature in degree c	25·0	25·8	26·6	31·1	29·2	32·0
Transparency in cms.	20	0·8	5·5	6·5	19·0	13·0
Dissolved oxygen ppm.	7·8	6·0	8·0	2·95	0·40	3·95
Free carbondioxide ppm.	8·8	2·2	Trace	Nil	4·4	Nil
Carbonates as co3 inches ppm. ...	Nil	Nil	Nil	15·0	Nil	4·5
Bicarbonats as co3 inches ppm. ...	67·0	53·0	131·0	70·0	131	88·5
Salinity as percent c	...	...	...	...	...	...
pH	6·4	7·3	7·8	8·95	6·8	8·5
Silicates as Sio2	6·0	2·0	1·0	10·0	Trace	1·0
Phosphates as P2 05 ppm.... ...	0·4	Trace	Trace	0·5	1·0	0·1
Chlorides as Cl3 ppm.	4·0	39	80	220	197	168
Phytoplankton		Nil	Spiragyra-F Naugeotia-R Oedogonium-R Navicula-R			
Zooplankton		Palaenon Notonecta-C Daphinds-F Copepods-A Rotipers-R	Daphinds-A Copepods Cyprids-R			

VIII. FOOD AND FEEDING HABITS OF FISHES OF THE PEARL-BANK, THOLLAYIRAM PAR, IN THE GULF OF MANAAR.—BY P. I. CHACKO.

One of the principal causes of mortality of the Indian pearl oyster, PINCTADA VULGARIS, is the ravages of predaceous fishes. Herdman (1906) has observed that the file-fish (BALISTES) and the velameen (LETHRINUS) feed upon immature oysters, and that the ray (RHINOPTERA JAVANICA) on large oysters. In his reports on the Indian pearl fisheries Hornell (1905 and 1922) has pointed out the heavy risks to which young oysters are exposed to the depredations of rock-perch, trigger-fish and large rays. In attempting to explain the irregular cycle of the pearl fisheries of the Gulf of Manaar he has again emphasised the destruction caused to cysters by fishes like BALISTES, LETHRINUS, SERRANUS, TETRODON, RHINOPTERA and GINGLYMOSTOMA (Hornell, 1916). Pearson ETAL (1929) have indicated that though file-fishes attack the pearl oyster the principal enemies are the large rays which frequent the banks in shoals and which are harmful to spat and large oysters alike. They have frequently seen shoals of rays on the pearl banks and on many occasions large patches of broken shells on the bottom. They have also recorded fragments of pearl oysters from the stomach-contents of rays caught on the banks. They have assumed that the number of predatory fishes will increase with the number of oysters on the bank, and that nothing of any permanent value could be done to frustrate their destructive course.

Detailed investigation on the role played by these fishes in the natural economy of the oyster have not been carried out so far. As a preliminary to such a study, the stomach-contents of some fishes obtained from the Thollayiraw par during the pearl-bank inspections in 1954 and 1955 were examined; and salient features of the data obtained are recorded below.

I. *Abalistes stellaris* (*Bloch and Schneider*).

The trigger-fish is common on the pearl banks and they are easily caught with long lines. Eighty specimens obtained during the inspection ranged from 16·0 to 32·0 cm in length and from 220 to 460 gm in weight. The two sexes were represented in equal proportions and their gonads were in various stages of development. Their stomach contained the following.

FORAMINIFERA,—HETEROSTEGINA DEPRESSA.

COELENTERATES.—Medusae (unidentifiable) and bits of Alcyonarians like SOLENOCAULON, DENDRONEPHTHYA. SPONGODES and others.

CRUSTACEANS.—Crabs (DOCLEA, PINNOTERES and POROCELLANA), crab shells and appendages and stomatopods (GONODACTYLUS.)

MOLLUSCS.—Pelecypods like MODIOLA BARBATUS, CARDIUM PULCHRUM and PINCTADA VULGARIS; gastropods like NATICA and CYPREA; scaphopoda (DENTALIUM OCTOGONUM); and various shell-grit.

ECHINODERMS.—Tests and spines of echinoids like SALMACIS, TEMNOPLEURUS and ECHINOCARDIUM.

PISCES.—small fishes like PETROCIRTES BREVICEPS, ALTICUS BILINEATUS and PERCIS PULCHELLA; parts. vertebrae and scales of unidentifiable species.

ALGAE.—Filaments of Codium, bits of, of CAULERPA, HALIMEDA, SARGASSUM and TURBINARIA and pieces of nullipores like LITHOPHYLLUM and LITHOTHAMNION.

II. *Scolopsis bimaculatus, Ruppell*

Twenty-five immature specimens of the sea-bream, ranging in size from 19.0 to 23.0 cm. and weighing 225 gm on the average, were examined and found to contain the following in their stomach.

FORAMINIFERS	—	HETEROSTEGINA
COELENTERATES	—	unidentifiable medusoids
CRUSTACEANS	—	Isopods like ROEINELA and CILICACEA
MOLLUSCS	—	MODIOLA and other bivalve shell pieces; OLIVA and other small gastropod shells and grit.
FISHES	—	PERCIS PULCHELLA and scales and remains of other unidentifiable fishes.
ALGAE	—	Bits of CAULERPA and HYPNEA.

III. *Cephalopholls miniatus* (*Forskal.*)

Sixteen specimens of this rock-perch, 18·0 to 25·0 cm in size and 150-225 gm. in weight, were examined. Their stomach contained—

CRUSTACEANS	—	PENAEUS, PERICLIMENES, ALPHEUS, GONODACTYLUS, DOCLEA and other remains.
MOLLUSCA	—	Bivalve shell pieces
FISHES	—	Unidentifiable fish remains.

IV. *Epinephelus undulosus* (*Quoy and Gaimard*).

Fifteen immature specimens of this species of rock-perch, ranging in size from 15·0 to 22·0 cm showed the following in their stomach :—

CRUSTACEANS	—	PENAEUS, ALPHEUS, GONODACTYLUS and their remains.
MOLLUSCS	—	Bits of bivalve shells
FISHES	—	Fish flesh, vertebrae and scales.

All the four species of fish feed on the biota of the pearl bank. The stomach of the specimens of trigger-fish was mostly fiiied with parts and appendages of crabs, stomatopods and small fishes that inhabit the rocky beds. Broken pieces of bivalve and gastropod shells were found in many specimens. But broken shells of the pearl oyster was observed in three specimens only. The presence of two rows of teeth (outer row of incisors and inner row of flat plate-like crushers) on the upper jaw enables this fish to crush the shells Bits of corals, tests and spines of sea-urchins, nullipores and algae were frequently met with. In the case of the sea-bream, isopods, bivalve and gastropod shells and fish-remains were more frequent than the other items of its diet. The rock-perches consumed more of prawns and crabs than fishes and shell-grit.

Though all the four species of fish occurring on the Thollayiram par are observed to feed on molluscan shells, pearl-oyster shell was noted only in three specimens of ABALISTES STELLARIS. The ravages of these fishes on young pearl oysters may not be great. It is however probable that these fishes perform an useful function in feeding on encrusting organisms. It is interesting to note here that Malpas (1926) has observed that in the Wadge and Pedro Banks and the coastal waters of Ceylon fishes like SCOEOPSIS BIMACULATUS, LETHRINUS KARWA, EPHIPPUS ORBIS, DREPANE PUNCTATA, NASEUS UNICORNIS, BALISTES STELLATUS and TETRADON RETICULARIA feed on star-fishes and that CARCHARIAS SPP ; ELOPS SAURUS, SPHYRAENA OBTUSATA and LUTJANUS RIVULATUS feed on BALISTES SPP. Chidambaram and Rajendran (1951) have also noted that EPINEPHELUS TAUVINA, F. BLEEKERI, APRION TYPUS and LUTJANUS MALABARICUS obtained from the Wadge Bank had in their stomach BALISTES SPP. It is therefore evident that more investigations on the fishes of the pearl banks have to be conducted on a long-range basis to ascertain their food and feeding habits and their inter-relationships.

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IX. OBSERVATIONS ON THE REMARKABLE ADAPTABILITY OF THE MILK-FISH, CHANOS CHANOS (FORSKAL).—

By C. MALU PILLAY and P. I. CHACKO.

Introduction.

Owing to its rapid growth, non-cannibalistic habit, prolific nature, remarkable adaptability and other acceptable qualities CHANOS is cultured in marine, brackish and fresh water-areas in the Indo-Pacific region. But precise information on the appearance of CHANOS fry in the coastal waters is not available. In the Madras State the fry appear in great numbers in tidal creeks in the Gulf of Manaar region, particularly at Pamban, Krusadai Island and Tuticorin. The commencement and closure of the season fluctuates between February and March and June and July respectively. With a view to ascertain the conditions favourable for the breeding of this economic fish to breed and the adaptability of the fry, observations were made in the first half of 1955 with the following results.

Description of the nursery areas.

The Chinnapalem Creek, the main centre of collection of fry and fingerlings of CHANOS in Pamban, is mainly a rain-water drainage which is flooded with sea-water during high tide almost daily. The channel is fringed with thick growth of mangroves. Its mouth is mainly sandy; and as it is ascended its bottom becomes muddy. During low tide the channel is completely drained excepting the small pools and puddles at frequent intervals where the water is locked up.

The Chanos farm at Krusadai Island is situated at the north-western and of the island facing the Watchman's Bay. The island sloapes towards this bay; and therefore it gets inundated to an area of about ten acres during spring tides. The entire bed of this area is covered with a luxuriant growth of LAB-LAB. Because of the tidal current there is a good daily circulation of sea-water in the farm.

The Puckle Channel at Tuticorin is the main sewage-drainage of the town and is inundated with sea-water during spring tides and very high tides. It runs through beds of calcareous rocks; and its bottom is muddy except near its outfall where it is sandy. The water is invariably coloured; and the height of the water-column ranges from 0·15 to 0·75 metre. The light rays penetrate to the bottom in almost all the places. The channel is separated from the sea at ordinary times by a sand-bar and is connected to the sea during rainy days.

Occurrance of Chanos fry.

The appearance of Chanos fry in these nursery areas is almost simultaneous and is invariably preceded by a rainfall. It may be said that this preceding rainfall has a good effect on the oscillation of the season of appearance of the fry.

Hydrography of the nursery areas.

The hydrography of the three nursery areas have been studied from January to June selecting three stations in each. The results of the studies are given in Tables 1 to 4.

1. Chinnapalem Creek.

Three observation-stations were selected in the course of the channel - the first at the mouth, the second near the centre and the third at the deep higher reach known as ANAIKUNDU. The surface-temperature, specific-gravity, salinity, excess-base and calcium generally increased steadily as the creek was ascended. A steady rise in these factors were also observed as the season advanced till May followed by a slight fall in all these factors in June. The temperature exhibited wide range and it varid between 28·2 and 31·1 °C. The sudden rise noticed in May was due to the time lag in observations. The observations were made in May between 14·00 and 15·30 hours and in the other months between 10 00 and 11·30 hours, The pH was high in the first two stations till May but in June an abrupt full from 8·7 to 8·1 in the first station and a rise from 8·45 to 8·50 in the third station have been noticed. The salinity was always found to be higher than the salinity of the sea in communion; and exhibited high values up to 43·22 °/0·0. The high salinity conditions might probably be due to the greater evaporation at the surface consequent to the poor depth of the water-column and to the admixing of sea-water with saline water locked up in the pools and puddles. The water was generally characterised by high oxygen and stations 1 and 2 were supersaturated with oxygen till March. The high pH and the supersaturation of water with oxygen in the first two stations indicated high Photosynthesis favoured by high temperature and good penetration of solar rays. Poor assimilation of carbon-dioxide consequent probably to the reduction in the population of phyto-organisms might have resulted in the sudden fall in pH in the first station in June as observed by Marshall and Orr (1927) in the Clyde Sea area. The high excess-base in the third station might probably be due to the dissolution of carbonates and bicarbonates from the bottom deposites (Harvey, 1928).

The calcium-chlorine ration was generally high compared to the values of Thompson and Wright (1930), Kirk and Moberg (1933) and Harvey (1945) and was as follows:—

Month	Station 1	Station 2	Station 3
January ..	0·0284	0·0281	0·0273
February ..	0·0279	0·0245	0·0179
March —	0·0268	0·0243	0·0237
May ..	0·0232	0·0256	0 0250
June ...	0·0232	0·0250	0·0247

The poor calcium-chlorine ration at the third station in February might be due to the utilisation of calcium by organisms (Harvey, LOC. CIT.) but the ratio was rather the low. After March the mouth-region (station 1) exhibited low calcium-chlorine ratio showing probably the presence of the calcium-consuming organisms in that region. The silica was on the increase and the other nutrients like nitrates and phosphates were on the decrease as the creek was ascended. There was a regular fall in these nutrients from January to March. Silica continued to fall even in May followed by a rise in June whereas phosphates and nitrates shot up suddenly in May followed by a fall in June. As for nitrates, almost starvation-conditions have been noticed in February and June. The continued falling of silica and rising of oxygen indicated a steady rise in the diatom-population especially in the beginning of the season. The increase in silica in June following a regular fall till May right probably be due to the solution of diatom frustules (Harvey, 1945). The starved conditions of nitrates might probably be due to bacterial action and the general rise in phosphates and nitrates in May might be because of the direct regeneration (Harvey, loc. cit.).

2. Chanos fish-form at Krusadai Island

Three observation stations were selected in the main pond itself, one near the feeder channel (northern end), the other at the centre and the third at the farther end (western end). Though the chanos form at Krusadai is a small water-spread, variations in the physical as well as chemical factors were noticed from station to station. The temperature and salinity were found to be higher at the eastern portion and lower at the northern end. These factors were in the ascending order as the season advanced. The change in pH was not appreciable till the end of May but in June it suddenly shot up to 8·5 from 8·25 and 8·18 in the first two stations. The excess-base was abnormally high in May probably because of the dissolution of carbonates and bicarbonates from the bottom stratum (Harvey, 1928). Calcium was also high during the month. The calcium-chlorine ration were as follows :—

Month		Station 1	Station 2	Station 3
January	..	0·0303	0·0304	0·0304
February	..	0·0290	0.0290	0·0290
March	..	0·0270	0·0268	0·0269
May	...	0·0243	0·0261	0·0261
June	..	0·0242	0·0245	0·0253

The ratio was unusually high in January and as the season progressed it showed declining tendency. This ratio was almost the same in all the three stations in any particular month till March and in May and June stations 2 and 3 exhibited slightly higher values. This might probably be because of the utilisation of calcium by organisms in the vicinity of the first station at a greater speed (Harvey, 1945).

The dissolved oxygen was very low in May especially in the third station and was very high in June. The poor oxygen in May indicated greater consumption in May. The changes in nutrients were quite interesting. The water was very rich in the beginning of the season in all the nutrients and was lesser as the season advanced. In the case of silica the fall was abrupt after March and in phosphates and nitrates an abrupt fall was noticed only in June. The general abrupt fall in the nutrients and sudden increase in oxygen in June suggested the presence of a good population of phyto-organisms.

The adjoining smaller ponds were also of interest A comparison of the hydrography of the main pond with that of the smaller ponds are appended in Table III. They exhibited remarkably high salimity of 50·93 and 53·59‰ when the salinity of the water in the main farm was only 39·40‰. This high salinity conditions were due to (1) non-circulation of water in these ponds daily as in the main pond, and (2) the high evaporation. The oxygen was very poor and this might probably be due to greater respiration and to oxidation of debris and gases like hydrogen-sulphide evolved during the decay of vegetation. The calcium-chlorine ratio of these ponds were also high and were 0·025 in pond 2 and 0·023 in pond 3. The water was comparatively richer in silica but the other nutrients were very poor. Whether the poor conditions of the nutrients of these ponds was due to bacteria or due to the action of planktonic organisms or to non-circulation of water in these ponds and whether bacteria can survive in these high salinity conditions require further study.

3. Puckle Channel at Tuticorin.

The three stations of observations were the outfull and the two road-bridges. Only in January and February studies could be made. During this period the temperature variation was not much. The water was cool. But the speciffc gravity exhibited abrupt changes and varied from 0·1 to 19·8 and the water was almost fresh within about two furlongs from the sea-bar. In January the salinity was very low but in February because of the influx of sea-water due to tidal action it increased up to 25·75 from 8·69 in Janunry. The pH was high in the first two stations indicating absence or poverty of free carbondioxide in the water. Sudden fluctuation in oxygen leading to depletion was observed. Wider variations occurred in excess-base and calcium. The alkalinity, was low near the mouth whereas calcium was high at the region. The calcium-chlorine ratio was as follows :—

Month		Station 1	Station 2	Station 3
January	...	0 0260	0·0401	0·7173
February	...	0 0270	0·0290	0·0404

Even though the concentration of calcium was greater at the mouth, the calcium-chlorine ratio was higher as the creek was ascended.

The high excess-base and the calcium-chlorine ratio as the channel was ascended, night be due to the influx of fresh water rich in calcium, carbonates and bicarbonates and this was quite possible because of the calcareous rocks through which the water runs. The variations in nutrients were of much interest. Silica was rich and widely fluctuating and it increases as the channel was ascended. The water was also characterised by widely varying nutrients like phosphates and nitrates.

Discussion.

The abnormally high conditions of temperature and salinity are known to exist in fish-ponds in the Philippines (Adams et al, 1932), Indonesia (Schuster, 1949) and in the coastal lagoons of South India (Pillai, 1954). Schuster (loc. cit.) points out that in certain Indonesian marine fish ponds which are in direct communication with the sea the salinity varies between 28 and 46‰. In certain lagoons which cease to be in contact with the sea soon after the cessation of rain Pillai, (loc. cit.) has observed that the temperature varies between 29 and 39°C and Salinity between 32·6 and 210·8‰. The very high nutrients especially silica found in the Puckle channel might be due to the presence of debris. Similar high nutrients have been recorded in the Bombay harbour water by Bal et al (1946).

During the year under report the Chanos fry first appeared in all the three centres by about the second week of March following the showers towards the end of February and there afterward continued to occur till the middle of June. Some correlation between the occurrence of Chanos fry and rainfull has been noted by Thiemmedth (1955) also. The Chanos fingerlings were found from March till the end of June and even in the beginning of July. Probably the favourable conditions existing in the mouth-regions of these creeks soon after the drizzle in the end of February would have been a source of attraction to the Chanos breeders to the coastal waters to breed and thereafter on spring tides on the full-moon and new-moon periods till the middle of June. The breeding season of Chanos in the Philippines has been observed to be from March to June or July (Adams et al, 1932) and in Indonesia from March to December (Thiemmedth) ; but in the Gulf of Manaar coast of India it is found to be from March to June and on Palk Strait and Coromandel coasts in November-December also (Chacko and Mahadevan, 1955).

The fry are found throughout the creeks. They adapt themselves remarkably to the changing conditions. They can tolerate sudden variations in temperature, pH, salinity and oxygen. They can survive in high temperature upto 38·1°C and in salinity upto 53·59‰. Even in waters containing poor oxygen as in pond 2 of Krusadai chanos farm (0·50 cc/l) they are able to live. They tolerate also sudden fluctuations in nutrients. Low temperature (23·6 °C) and salinity

(5·35‰) as in the Puckle Channel are not abandoned by the fry and fingerlings. On the other hand they seem to prefer these conditions. Since they are purely plankton feeders high nutrients which are essential for a plentiful growth of phyto-organisms would be an asset. The fish fry could also tolerate the bad odour emitted from the Puckle Channel region and the hydrogen-sulphide and sulphur-dioxide odour emitted in the smaller ponds at Krusadai. Though the fry and fingerlings can withstand high temperature upto 38·1°C and salinity upto 58·59‰ in these waters their growth is stunted. Whether the poor rate of growth in ponds 2 and 3 of Krusadai form is due to the poor supply of nutrients or to the adverse effect of the high salinity, require further investigation. At this stage it may be concluded that abnormally high temperature and salinity stunt the growth of Chanos fry and that low temperature and salinity with high concentration of nutrients from favourable conditions for a rapid growth of the fish.

SUMMARY

The rich waters following the heavy rainfall in October, November and December afford a good pasture ground for CHANOS ; and the showers in February give a fillip to the fish to breed.

The breeders are attracted to the coastal waters by the favourable conditions existing at the mouth of the various creeks.

Normally in the Indian coast of the Gulf of Manaar the breeding season extends from March to June. Along the Palk Strait and Coromandel coast the fry occur in November-December also.

The remarkable adaptablity of the fry and fingerling of Chanos to the changing conditions of physical and chemical factors are discussed.

The tolerance of the fry and fingerings to the very high temperature and salinity and to the bad odours of hydrogen-sulphide and sulphur-dioxide are emphasised.

The rate of growth of the fry and fingerlings is stunted in the high temperature and salinity. Moderately low temparature and salinity with high nutrients form favourable conditions for rapid growth of Chanos.

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TABLE I—*Hydrography of Chinnapalem Greek at Pamban, 1955*

Particulars	January			February			March			May			June		
Station Nos.	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Temperature °C	28·2	28·35	28·50	32·9	31·35	33·0	33·50	32·85	33·50	37·60	38·10	36·50	30·30	33·25	34·60
Specific gravity	19·5	20·3	20·8	19·0	21·5	21·8	20·0	22·0	22·5	21·0	23·0	22·5	22·5	23·0	23·0
PH	8·7	8·7	8·6	8·7	8·7	8·5	8·7	8·7	8·5	8·7	8·5	8·45	8·1	8·35	8·5
Depth Meters	0·40	0·28	0·35	0·36	0·16	0·37	0·33	0·19	0·40	0·33	0·15	0·23	0·33	0·14	0·33
Salinity, ‰	28·75	30·54	32·00	30·08	36·58	38·73	31·25	38·03	39·58	37·66	41·33	43·22	37·55	40·10	42·66
Oxygen, Cc/l	4·50	4·75	4·80	5·88	7·14	4·62	5·20	6·50	4·42	5·00	4·70	4·10	4·85	4·20	4·10
Alkalinity, gm/l	0·0675	06·795	0·0780	0·0675	0 0795	0·0780	0·0690	0·0810	0·0810	0·0720	0·0990	0·1125	0·0849	0·0960	0·0990
Calcium, gm/l	0·4528	0·4750	0·4840	0·4640	0·4960	0·3872	0·4640	0·5120	0·5180	0·4831	0·5869	0·5992	0·4831	0·5544	0·5940
Silica mg/m³	250	280	305	140	150	182	125	145	150	94	130	120	120	165	156
Phosphate mg/m³	30·0	28·0	25·0	10·0	5·0	7 0	15·0	15·0	20·0	35·0	28·0	22·0	9·0	14·0	14·0
Nitrate-Nitrogen mg/m³	20·0	20·0	20·0	7·0	5·0	5·0	10·0	10·0	12·0	25·0	20·0	15·0	5·0	5·0	5·0

TABLE II.—*Hydrography of Chanos farm at Krusadai Island, 1955*

Particulas	January			February			March			May			June		
Station No.	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Temperature °C	26·0	26·3	26·5	28·5	28·8	29·2	28·8	29·0	29·1	29·5	29·8	30·6	35·3	36·1	35·9
Specific gravity	19·3	19·5	19·8	21·8	21·8	22·0	22·0	22·2	22·2	22·5	22·5	22·0	21·5	21·5	21·5
PH	8·30	8·25	8·20	8·30	8·35	8·35	8·20	8·30	8·30	8·25	8·18	8·18	8·50	8·50	8·25
Depth, metres	0·80	0·85	0·89	0·75	0·80	0·88	0·52	0·56	0·62	3·60	0·60	0·90	0·27	0·30	0·36
Salinity, %o	30·72	30·95	31·08	33·06	33·20	33·28	34·88	35·00	34·95	37·66	37·71	38·31	37·77	38·03	38·49
Oxygen, cc/l	3·70	3·82	3·95	4·30	4·15	4·20	4·40	4·38	4·30	3·00	3·40	2·20	5·54	5·04	5·85
Alkalinity, gm/l	0·0795	0·0805	0·0810	0·0780	0·0755	0·0780	0·0780	0·0795	0·0795	0·0816	0·0840	0·0870	0·0810	0·0780	0·0810
Calcium, gm/l	0·5160	0·5210	0·5224	0·5260	0·5290	0·5300	0·5220	0·5195	0·5205	0·5069	0·5418	0·5544	0·5069	0·5148	0·5386
Salica, mg/m³	350	390	375	275	250	280	255	235	220	154	118	132	72	107	120
Phosphate, mg/m³	50·0	50·0	55·0	38·0	42·0	45·0	35·0	35·0	40·0	34·0	34·0	28·0	13·0	13·0	14·0
Nitrate-Nitrogen mg/m³	35·0	35·0	35·0	30·0	30·0	30·0	30·0	30·0	30·0	30·0	30·0	25·0	10·0	10·0	10·0

TABLE III.—*Hydrography of three ponds of Chanos fish-farm at Krusadai Island in June 1955.*

Particulars.	Pond No. 1 Main pond.	Pond No. 2 Small pond.	Pond No. 3 Small pond.
Temperature, °C.	29·9	29·3	30·1
Specific gravity	23·5	28·5	29·0
pH	8·35	8·10	8·30
Depth, meters	0·40	0·49	0·47
Salinity, o/oo.	349·0	50·93	53·59
Oxygen, cc/l	3·78	0·50	1·13
Alkalinity, gm./l	0·0765	0·0855	0·0870
Calcium, gm./l	0·5294	0·7004	0·6841
Silica, mg./m³	115	132	140
Phosphates, mg./m³	7·0	8·0	7·0
Nitrates-N_2, mg./m³	5·0	5·0	5·0

TABLE IV.—*Hydrography of the Puckle Channel at Tuticorin in January and February 1955.*

Particulars.	January			February		
Station No.	(1)	(2)	(3)	(1)	(2)	(3)
Temperature, °C	23·56	23·60	23·70	23·60	23·70	23·60
Specific gravity	5·3	4·7	0·1	19·8	14·0	2·6
pH	8·9	8·7	7·8	8·9	8·85	8·35
Depth, metres	0·25	0·60	0·88	0·15	0·45	0·75
Salinity, °/oo	8·69	5·30	0·70	25·75	18·89	5·35
Oxygen, cc/l	4·48	3·78	2·80	0·0	0·15	0·0
Alkalinity, gm./l	0·144	0·204	0·153	0·153	0·192	0·303
Calcium, gm./l	0·125	0·117	0·064	0·384	0·304	0·128
Silica, mg./m.³	780	1235	1310	150	654	1580
Phosphate, mg./m³	8·0	16·0	4·0	87·0	52·0	35·0
Nitrate-Nitrogen, mg /m³	4·0	10·0	0·0	50·0	32·0	20·0

X. EFFECT OF THE SOLAR ECLIPSE ON 20-6-1955 ON THE MATEOROLOGY AND HYDROGRAPHY OF THE KUNDUGAL CHANNEL IN THE GULF OF MANNAR--

BY C. MALU PILLAI & P. I. CHACKO

INTRODUCTION

The rare occurrence of solar eclipse in general and the unprecedented nature of this eclipse during the past 1250 years prompted the present study. The nearness of the Kundugal channel to Ceylon where the eclipse was expected to be complete was another incentive. The Kundugal channel is a portion of the Pamban channel lying in between Krusadai Island and southern side of the Kundugal point of Rameswaram Island at 9°-15′ north latitude and 79°-15′ E. longitude in the Gulf of Mannar.

OBSERVATIONS

The different stage of the eclipse and their extent was observed with the help of coloured glass-slides. The morning was clear and bright and at about 7-10 hours the shadow of the moon touched the solar disc and at 7-20 hours about one-twentieth of the sun was obliterated. At 8-10 only about one-twentieth of the sun was visible. That was the zenith of the Eclipse at the Kundugal channel and at 9-15 the sun reappeared in its true size and vigour.

The variations on the meteorology and hydrography were studied regularly at one hourly intervals from 7 to 11 hours on the day of eclipse and the results are appended in Table I and similar observations made from 6 to 12 hours on 11th July 1955 (a non-eclipse day) are given in Table II for the purpose of comparison.

METHODS

The standard methods described by Normand (1934) were followed for the meteorological observations and those adapted by Chacko eta (1954) for the hydrographical observations. The nitrate was estimated by the method of Atkins (1932).

RESULTS

The result obtained are detailed below :—

1. PRESSURES.—The paessure was on regular increase till 10 hour followed by a slight fall at 11 hours. The inerease in pressure at 7 to 8 hours was fairly marked. But on 11th July 1955 there was a regular increase till 9 hours followed by a regular fall.

2. WIND.—The wind lost strength at the first stage and regained its vigour in the subsequent stages on the eclipse day, whereas on the other day the wind continued to gain in strength steadily with a negligible fall at 11 hours.

3. TEMPERATURE.—On the eclipse day temperature dropped by 0·2°F during the period 7 to 8 hours where after it increased steadily. But on 11th July 1955 the temperature continued to increase from 6 hours to 12 hours. The increase in temperature at the various stages were as follows :—

	20th June '55	11th July '55
7 — 8 hours ..	0.2°F	2·2°F
8 — 9 hours ..	1·6°F	1·6°F
9 — 10 hours ..	1·6°F	1·3°F
10 — 11 hours ..	2·5°F	1·4°F
11 — 12 hours ..	—	0·5°F

4. HUMIDITY.—Humidity decreased steadily from 89 per cent at 7 hours to 74 per cent at 11 hours on 20th June 1955 but on 11th July 1955 it arose by 8 per cent at 7 hours and afterwards dropped in smaller steps till 11 hours and then showed a sudden rise.

5. NATURE OF THE SKY.—The sky was clear and bright at 7 hours and was dull subsequently. From 8-30 to 10-30 it was over cast with thick Tnimbus. On 11th July '55 from 6 to 8 hours it was more or less dull either with the stratus or with scattored nibmus and thereafter it was clear with scattered. Cirro stratus and cirtus till 10 hours. At 10 hours again it became dull for a short time with Alto-cumulus. The surface temperature of water exhibited interesting variations on the solar eclipse day whereas the temperature of the bottom water was not affected much. From 27·73°C at 7 hours the surface temperature fell to 27·4°C at 8 hours and then increased steadily. The increase in the temperature of water at the surface and bottom were as follows :—

	Surface water	Bottom water
7 — 8 hours ..	—0·59°F	—0·27°F
8 — 9 hours ..	+1·64°F	+0·22°F
9 — 10 hours ..	+1·42°F	+0·00
10 — 11 hours ..	+0·81°F	+0·18°F

On 11th July '55 the surface temperature decreased at the first stage from 28·2 to 27·9°C and thereafter it continued to shoot up whereas in the temperature of the bottom water the changes were negligible and the first variation which was only a fall by 0·2°C was noticed at 8 hours and after 9 hours it rose up by 0·1°C for every hour. But at 12 hours there was a drifting of nearly 2°F. The details of the rise in temperature of water at the various stages are given below :—

	Surface water	Both water
16 — 7 hours ..	—0·54°F	0·0
7 — 8 hours ..	—0·36°F	—0·36°F
8 — 9 hours ..	+1·08°F	0·0
9 — 10 hours ..	—0·18°F	+0·18°F
10 — 11 hours ..	+0·18°F	+0·18°F
11 — 12 hours ..	+0·36°F	+1·98°F

7. SPECIFIC GRAVITY.—There was no appreciable variation in specific gravity on both the days.

8. P.H.—On No. 645 PH was 8·25 at 7 hours and 8 hours and from 9 hours onwards it showed a tendency to increase probably in consonance with the increase in the temperature of water and penetration of solar rays. Appreciable changes were not noticed on 11th July '55.

9. VISIBILITY.—The visibility was maximum at 8 hours (0·97 meters) and at 10 hours 10·79 meters) on the eclipse day, whereas on the other day visibility was high generally and the maximum was 1·64 meters at 7 hours and minimum 1·07 meters from 9 to 11 hours.

10. CONDITIONS OF WATER.—On 20th June 1955 only small ripples or small waves existed. It was low tide at 7-32 hours and high tide at 14-30 hours. The current was from east to west, i.e., from the Gulf of Mannar to the Palk Strait. On 11th July 1955 small swells and ripples were observed during the period. It was high tide at 5-50 hours and low tide at 11-23 hours. From 6 hours the current was from east to west, but was in the reverse direction from 12 hours.

11. SALINITY.—A rise from 35·62 to 35·90 pp. 1,000 at the surface and from 35·68 to 35·81 p.p. 1,000 at the bottom was recorded at 8 hours. From 9 hours onwards the salinity declined steadily. Salinity was maximum at 8 hours when the eclipse also was at its maximum. But on 11th July 1955 salinity was low at 6 hours and rose slowly till it reached the maximum at 10 hours.

12. OXYGEN.—The dissolved oxygen exhibited ascending tendency from 8 hours onwards till 11 hours when it suffered an abrupt fall. At 8 hours there was a fall but for which the rise would have been steady from 7 hours. But on the non-eclipse day the oxygen was maximum at 7 hours when the visibility was maximum and minimum from 9 to 10 hours when the visibility was also minimum.

13. EXCESS BASE.—The changes in carbonate are not very appreciable on both the days excepting the fact the alkalinity suffered a fall at 4 hrs. on the eclipse day.

14. CALCIUM.—The calcium content of the water of the solar eclipse day exhibited a continuous rise from 0·4749 g.m. litre at 7 hours to 0·4985 gmc/litre at 11 hrs. at the surface and from 0·49039 gm/litre at 7 hours to 0·5031 gm/litre at 11 hours at the bottom excepting for a small fall at 8 hours. On 11th July 1955 the calcium at the surface showed little change till 9 hours and at 10 hours there was however a rise followed by a fall at 11 hours. At the bottom there was a continuous rise till 9 hours and then there was a fall and followed by a

small rise at 11 hours. The calcium chlorine rates of the boats on the two days at different stages are given below:—

20th June 1955—ECLIPSE DAY.			11th July 1955	
	Surface.	Bottom.	Surface.	Bottom.
6 hours ..	—	—	0·0265	0 0269
7 hours ..	0·0240	0·0243	0·0265	0·0271
8 hours ..	0·0244	0·0244	0·0264	0 0273
9 hours ..	0·0250	0·0255	0 0265	0·0276
10 hours ..	0·0251	0·0252	0·0270	0 0260
11 hours ..	0·0252	0·0255	0·0264	0·0264
12 hours ..	—	—	0·0274	0·0276

15. SILICATES.—On the day of the eclipse the silicate was on a regular decrease from 85 mg./litre at 7 hourse to 68 mg./litre made at 11 hrs. at the surfac and 55 mg./litre m. at the bottom. The variations in silicate on 11 July 1955 were only negligible.

16. PHOSPHATES AND NITRATES.—The concentration of Phosphates and nitrates were absent on both the days.

DISCUSSION.

The marked increase in pressure noticed at 8 hours on the solar eclipse day was not observed on 11 July 1955. It might be inferred that this increase in pressure was the effect of the changes in the atmosphere caused by the eclipse. The wind had also dropped in velocity. There was a definite increase on the temperature of the atmosphere on 11 July 1955. The rise from 7 hours to 8 hours was 2·2 F whereas on the day of eclipse the rise during the period was only 0·2°F. This lithargy effect on the atmospheric temperature was attributable to the solar eclipse. The slightly heavy fall in humidity during the period 8 - 9 hours might be due to the fall in air temperature and comparatively poor wind force as observed by Sowell (1925) and Chacko at al (1954). There was dropping down in the surface temperature of water by 0.54°F at 8 hours on the eclipse day contrary to an increase by 0·36°F observed at 8 hours on 11 July 1955. This was attributable to the low temperature of the air and the poor solar rays consequent to the eclipse. The dull stay because of scattered cirubus might also be responsible to the poor temperature of water. The salinity attained the maximum about an hour after the low-tide on 20 June 1955 and this coincide with the zenith of the solar eclipse whereas on 11 July 1955 the maximum salinity was observed about an hour prior to the low tide. Sewell (1925) had observed that tide produces marked effect, but the direction in which the effect was produced varied enormously in different localities. The rise in salinity at

8 hours synchronised with the rise in pressure on the eclipse day. But after 8 hours though the pressure continued to rise the salinity decreased. On 11 July 1955 the variations in salinity cynchronise with the variations in the atmospheric pressure. The low oxygen at 8 hours might be due to poor photosynthesis consequent to the low temperature of the surface water and poor penetration of solar rays. The slightly higher pH, low oxygen and alkalinity at 11 hours were suggestive of greater utilization of oxygen by the brota. The higher calcium chlorine ratio on 11 July 1955 might be due to the influx of less saline and calcium rich waters from the Palk Strait, and the nitrate starvation might be attributed to the possible pressure of denitrifying bacteria.

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TABLE I :—*Showing hourly variations in the Meteorology and Hydrography of Kundugal Channel in the Gulf of Manner on 10th June 1955 (S. Surface. B. Bottom)*

Conditions	7 hours	8 hours	9 hours	10 hours	11 hours
	(1)	(2)	(3)	(4)	(5)
Atmospheric pressure, inches	29-914	29-938	29-44	29-960	29-950
Wind—direction and velocity, m.p.h.	SW—5-6	S|SW—4-7	S|SW—5-4	S|SW—6-4	S|SW—7-6
Maximum air temperature, °F	80-4	80-4	82-0	83-6	85-9
Minimum air temperature, °F	80-2	80-2	80.4	82-0	83-5
Humidity, percentage	89	86	81	80	74
Nature of sky	Clear and bright, with cirro-stratus	Dull with scatered nimbus	Dull and overcast with nimbus	Dull and overcast with nimbus	Dull and slightly overcast with nimbus
Temperature of water °C	S—27-70 B—27-73	S—27-4 B—27-58	S—28-31 B—27-7	S—29-1 B—27-7	S—29-55 B—27-80
Specific gravity	S—24-5 B—24-5	S—25-0 B—25-0	S—25-0 B—25-0	S—24-5 B—25-0	S—24-5 B—25-0
pH	S—8-25 B—8-30	S—8-25 B—8-30	S—8-28 B—8-30	S—8-30 B—8-25	S—8-33 B—8-33
Visibility, meters	0-81	0-97	0-90	0-79	0 92
Waves	Small ripples	Small ripples	Small ripples	Small ripples	Small ripples
Tidal conditions	low tide	low tide	flow tide	flow tide	high tide
Current, direction	E—W	E—W	E—W	E—W	E—W
Salinity, p.p. 1000	S—36-62 B—35-68	S—35-50 B—35-81	S—35-81 B—37-75	S—35-75 B—35-62	S—35-71 B—35-59
Oxygen, cc. litre	S—4-10 B—4-00	S—3-82 B—3-65	S—4-32 B—4-20	S—5-35 B—5-15	S—3-76 B—3-50
Alkalinity, gm. litre	S—0-07-9 B—0-0720	S—0-0714 B—0-0705	S—0-0720 B—0-0735	S—0-0720 B—0-0714	S—0 0690 B—0-0705
Calcium, gm. litre	S—0-4749 B—0-4903	S—0-4854 B—0-4837	S—0-4968 B—0-5049	S—0-4968 B—0-4968	S—0-4985 B—0-5031
Silica, mg. c. metre	S—85 B—85	S—75 B—75	S—70 B—60	S -65 B—60	S—68 B—55
Phosphate, mg. c. metre	S—6-1 B—7-0	S—7-0 B—7-0	S—8-0 B—8-0	S—8-0 B—7-0	S—7-0 B—8-0

TABLE II—*Showing hourly variations in the meteorology and hydrography of Kundugal Channel in the Gulf of Mannar on 11th July 1955 (S: Surface. B: Bottom)*

Conditions	6 hours	7 hours	8 hours	9 hours	10 hours	11 hours	12 hours
Atmospheric pressure, inches	29·940	29·956	29·964	29·980	29·974	29·972	29·962
Wind, direction & velocity m.p.h.	SW–5·3	SW–6·5	S/SW–7·9	W/SW–8·2	SW·8·2	SW·7·8	S—9·12
Maximum air temperature, °F	...	...	84·2	84·3	85·6	87·0	87·5
Minimum air temperature, °F	...	...	80·5	82·7	84·3	85·6	87·0
Humidity, percentage	...	78	75	7-	70	66	71
Nature of sky	...	Dull with scattered nimbus	Clear&bright with cirrostatus	Clear&bright with cirrors	Dull with aeto-cumulus	Clear&bright with cirro-stratus	Clear&bright with cirrus
Temperature of water °C	...	S—27·9	S—28·1	S—28·7	S—28·6	S—29·6	S—29·80
		B—28·3	B—28·1	B—28·1	B—28·2	B—28·3	B—29·40
Specific gravity	...	S—24·25	S—24·35	S—24·30	S—24·20	S—24·0	S—24·30
		B—24·3	B—24·40	B—24·40	B—24·40	B—24·40	B—24·50
pH	...	S—8·35	S—8·35	S—8·15	S—8·37	S—8·38	S—8·35
		B—8·32	B—8·35	B—8·38	B—8·38	B—8·38	B—8·35
Visibility, metres	...	1·64	1·25	1·07	1·09	1·07	1·24
Waves	...	Low swells	Ripples	Ripples	Swells	Ripples	Ripples
Tidal Conditions	...	ebbing tide	ebbing tide	ebbing tide	ebbing tide	Low tide	Low tide
Current	...	E—W	W—E	WE—	W—E	W—E	E—W
Salinity, pp. 1,000	...	S—35·05	S—35·25	S—35·37	S—35·37	S—35·19	S—35·26
		B—35·10	B—35·37	B—35·41	B—35·43	B—35·30	B—35·44
Oxygen, cc. litre	...	S—3·82	S—3·60	S—3·35	S—3·36	S—3·90	S—4·04
		B—3·95	B—3·40	B—3·20	B—3·20	B—3·30	B—3·40
Alkalinity, gm. litre	...	S—0·0695	S—0·0695	S—0·0711	S—0·0711	S—0·0721	S—0·5345
		B—0·0688	B—0·0695	B—0·0711	B—0·0721	B—0·0711	B—0·5415
Calcium, gm. litre	...	S—0·5150	S—0·5150	S—0·5181	S—0·5274	S—0·5138	S—0·5345
		B—0·5230	B—0·5340	B—0·5412	B—0·5073	B—0·5159	B—0·5415
Silica, mg. c. metre	...	S—64	S—61	S—52	S—48	S—43	S—50
		B—64	B—65	B—48	B—53	B—53	B—70
Phosphate, mg. c. metre	...	S—4·0	S—5·0	S—4·0	S—4·0	S—5·0	S—6·0
		B—6·0	B—5·0	B—4·0	B—4·0	B—6·0	B—9·0

XI. MARINE TURTLES AS POSSIBLE DISTRIBUTORS OF PEARL OYSTERS, BY P.I. CHACKO AND C. MALU PILLAI.

The pearl banks of the Indian coast in the Gulf of Mannar extend from Cape Comorin to the Rameswaram Island, a distance of over 150 miles. Hornell (1922) has divided these banks into three groups: (1) The northern Kilakarai group extending from Adams Bridge to Vaipar, (2) The Central of Tuticorin group from Vaipar to Mazapad and (3) The southern or Comorin group from Ramnad southwards. Of these, the central banks are more productive. Pearl fisheries were however possible only at irregular intervals for reasons explained by Hornell (1916). Recently Pearl fisheries were held at Tuticorin in March-May 1955 and February-March 1956 (Chacko, 1956).

In the northern area stray pearl oyster spats have been recovered in recent years by the staff of the Krusadai Biological Station from the coral reef aird Shingle Island, Krusadai Island and Pullivasal Island. But searches for oyster populations in the neighbourhood did not prove successful. It was considered that the recorded spats were those released from the pearl oyster farm of the Krusadai Station.

On 7th September 1955, a live specimen of the marine turtle CHELONE MYDAS was captured at Kundugal Point. Its carapace measured 21 cm. in length and 15 cm. in width, and was covered with 247 spats of the pearl oyster Pinctada vulgaris. A few specimens of BALANUS AND LEPAS also occurred on the turtle. The oyster spats ranged in size from 5 to 40 mm. as shown below:

	percent
5 — 10 mm. ...	12
10 — 20 mm. ...	12
15 — 20 mm. ...	17
20 — 25 mm. ...	24
25 — 30 mm. ...	10
30 — 35 mm. ...	5
35 — 40 mm. ...	

The weight of these spats varied from 25 to 3400 milligrams. Their age appeared to be 2 to 16 weeks. This indicated that spawning had occurred from May to August, which period followed the fine weather and variable wind of March-April as observed by Herdman (1905) in Ceylon pearl banks.

The present record of large number of pearl oyster spats on the carapace of a turtle is of significance and indicates the following :—

(1) The spats would have fallen on the turtle while it was resting over coral reefs and banks.

(2) The pearl banks in the neighbourhood appear to be populated which pearl oysters.

(3) The sojourns of turtle at the surface waters have not affected the growth and thriving of the spats.

(4) The turtle is likely to carry and drop the spats on other banks either when inbibing against matzes of weeds, corels, sponges etc., or when the oysters grow bigger and heavier. It is thus possible that marine turtles act as agents in distributing pearl oysters from one area to another. An inspection of the pearl banks of the northern groups seems desirable.

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XII. AN INSTANCE OF SUDDEN DEPLETION OF THE EDIBLE OYSTER BEDS OF THE ENNUR BACKWATERS

BY SRIMATHI GEMMA EVANGALINE AND P. I. CHACKO.

The Madras edible oyster Madrase is cultured by the Madras State Fisheries Department in the Ennur backwaters and the Pulicat lake. Studies on the biology and ecology of the oyster and on the conservation and development of its fishes is an importent item in the research programme of the Fisheries Station at Ennur. Observations so far made have been recounted in departmental publications by Hornell (1908, 1910, 1914 and 1921), Devenesan and Chacko (1955) and Chacko 1956). In this note, an instance of complete depletion of the oyster beds of Ennur backwaters bichters that took place in 1955 narrated birefly.

Routine observations on the oysters of all sizes occurring in the beds revealed that there were thrwing in good condition till 18th September 1955. From 20th Sept. 1955 the backwaters presented a glaring bottle green colour An examination of the beds on the same day showed that 25 per cent of the oyster population have perisheds From the next day onwards more oysters died and their flesh got detached from the shells and floated at the surface. By 24th there was 100 per cent mortality. Other fauna like green mussels, barnacles and fish also perished, but the backwater clam (*Meretrix casta*) alone was able to withstand the calamity.

The backwaters were cut off from the sea as early as 2nd June 1955 by the formation of a sand bar. Yet spawning of the edible oyster was noticed in the later half of July and in August 1955. There were occasional light showers in June (1·74 inches) and July (2 50 inches) and this would have compensated the effects of evaporation. Even marine forms like the ctenophore, Pleurobrachia globosa and the mysid, Leucifer hanseni were available in the plankton collection. made from the backwaters. But in August there was a rainfall of 7·88 inches. The flood waters of the Kortalayar river accumulated in the backwaters. Though there was an appreciable rise in the water level the sand bar remained closed. The salinity became very low, the water being completely fresh, but the turbidity was higher owing to the presence of suspended matter. The pH was 7·8. In the month of September, there was only negligible rainfall of 0·71 inch, on 6th and 8th atmospheric temperature rose up. Salinity was however low, say 3·8—7·6 per mille. The water level lowered considerably and there was a gradual increase in intensity of phytoplanktonic organism particularly the blue green algae *Phormidium and Microcystis.* There was also a growth of filamentous green algae *spirogyra* at the bed of the back-waters. The pH rose to 9·6. On 8th October onwards pH

showed a slight reduction and ranged from 8·3 to 8·7 but the water continued to be fresh. The sand bar was opened on 6th November and this resulted in the normal tidal influx and change in the course of events. The influex of freshwater which was responsible for lowering of salinity rise in temperature and pH and the heavy bloom of *Algae* were responsible for the mortality of the oysters.

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XIII. REPORT ON FISHING EXPERIMENTS IN THE OFFSHORE WATERS OF THE MADRAS STATE.

BY V. JOHN, P.I. CHACKO, R. VENKATRAMAN AND A. TAHER SHERIFF.

I. Introduction.

In our country, as well as in all other parts of the world, fishing with crafts propelled by wind and sailorly man-power was the original method of fishing till about 70 years ago. But in foreign countries like Japan, U.S.A., England, etc., the fishing Industry has seen tremendous progress so that most of the operations are conducted in those places now with the help of machines. But in our country the progress has been extremely slow till the attainment of independence. A few attempts to introduce mechanised fishing were made by some of the maritime states in this country also, but they were of short duration and not good enough to have any permanent effect.

The Bombay Government were the first to make an attempt at deep-sea fishing. In the year 1900, they got a trawler called "Premier" and conducted deep sea trawling experiments in Bombay waters. As they have not published a report on that, it is not possible to say anything about the results. Two years later Ceylon conducted some trawling experiments. A Parsee merchant of Colombo, Mr. Norrbhai by name, worked the Steam Trawler "Violet" in Ceylon waters. It is reported that Norrbhai's venture might have prospered had it not been for the strong opposition from the local catamaran and out-rigger canoe fishermen. Besides raising a very strong boycott of Mr. Norrbhavi's fish among the Colombo fish contractors, the fishermen went to the extent of attacking his vessal and damaging his fishing gear. Finding it impossible to overcome this fierce opposition, Mr. Noorbhai gave up the venture and the Ceylon Government purchased his vessel. In 1906, the Ceylon Company of Pearl Fisheries acquired the lease of the Ceylon Pearl Banks from Government and the trawler "Violet" was purchased by them. In 1907, this company, desirious of utilising the vessel in a commercial enterprise, decided to employ her in trawl fishing. They obtained the services of an experienced Grimsby Trawling Master, Captain Gribb, who made two cruises, one along the east coast of the island towards Madras and the other to the area off Cape Comorin. The results of these cruises, which were a purely private enterprise, were not made public until 1914-15, long after the failure of this company. They were then published by Mr. Hornell (formerly Scientific Adviser to the defunct company and later Director of Fisheries, Madras) in Madras Fisheries Bulletin No. 2. Mr. Hornell states that these cruises revealed the existence of two good fishing banks, one off the Tanjore district coast and the other, a richer and more extensive ground, off Cape Comorin. The skipper of the "Violet"

is reported to have returned to port enthusiastic over the trawling potentialities of the Cape Comorin bank. "It is a beautiful ground for trawl work" he said "similar to the famous Dogger Bank of Europe".

During the years 1908-11, the Government of Bengal conducted some trawling experiments with the Steam Trawler "Golden Crown" in the northern portion of the Bay of Bengal and came to the conclusion that the Bay would yield an ample supply of fish.

The Madras Fisheries Department can legitimately claim to have done more for developing Marine Fisheries than any other state in India. From its very inception it has been the aim of the Department to develop deep sea fishing. As early as 1905, Sir Frederick Nicholson, the founder of the Department had stated that the future of the fishing industry was intimately bound up with the introduction of large boats. By large boats he meant good sized boats of a few tons. decked if possible, power propelled and able to keep the sea for some days together. He was against taking a jumb from the dug-out canoe or catamaran to the Steam Trawler and was advocating gradual progress. In the year 1908, the Department under the direction of Sir Frederick Nicholson conducted a preliminary trawling survey along the Malabar coast with the pearl fishery inspection steamer "S. S. Margarita". The vessel was found too small and feeble for trawling work and Mr. Hornell, who in charge of the operations concluded that a trial with a more powerful and better equipped vessel should be made. In the same year two boats, a sailing vessel "Sutherland" of 12 tons and another a 15 h.p. motor vessel "Turbinella" of 25 tons were obtained and these vessels conducted fishing beyond the range of local fishing boats, the 'Sutherland' off Cannanore and Turbinella off Cannanore and Tuticorin till 1911. This vessel was found to be too small for large work. Side by side with these two vessels two Ratnagiri sailing boate (simple drifters of 6–10 Dn. capacity were chartered and employed for fishing in the West Coast waters from 8 to 12 fathoms. Though these vessels were found well adopted for deep-sea fishing with a large fleet of drift nets, yet they did not have sufficient room for getting and storing the fish to enable them to keep the fish for several days. In 1915-16 2 Ratnagiri boats were bought by the Departments and experiments were carried on with some amount of success till 1922 when they were abandoned as the crew gave trouble.

Between July 1920 and February 1923, the Ceylon Govt. conducted trawling experiments with the Steam Trawler "Lilla" in Ceylon waters and on the Pedro Bank and wadge Bank off the Madras Coast. These investigations were not prosecuted on a commercial scale with a view to catch as much fish as possible, but conducted only with a view to survey the trawling grounds. The good trawling

grounds discovered by this survey are—(1) *The Pedro Bank*, an extensive shallow water plateau situated off the extreme north-east corner of Ceylon, stretching across the mouth of Palk Strait and extending some distance up the Negapatam coast. It has an approximate area of 1,000 square miles. The results or the trawling showed that allowing a flat rate of 30 cents (5 annas) per pound of fish, the daily yield would be Rs. 675; (2) *The Wadge Bank* lying off Cape Comorin has an area of over 4,000 square miles. It differs markedly from Pedro Bank in being comparatively free from heavy growths of sponges or gorgonids. On this Bank "Lilla's" operations showed that allowing a flat rate of 30 cents (5 annas) per pound of fish, a day's catch would fetch Rs. 1,089. The estimated daily catch from the Pedro and wadge Banks during the survey were 1 ton and 31 cwt. respectively. These compare favourably with the catches in European waters. A private company in Colombo conducted trawling on the wadge Bank between 1924 and 1930 with the S. T. "Nautilus". The rssults are reported to be fairly satisfactory.

The Bombay Government conducted trawling experiments in 1921-22 in Bombay waters with the Trawler "William Carrie". The trawler worked from the 17th May 1921 to 27th February 1922 remaining at sea for 156 days. The catch amounted to 1,888,138 lbs. of fish which realised Rs. 18,899-14-0. These experiments were stopped on the ground that they were financially unsuccessful. The Bombay Government once again worked anoth trawler called "Madras" in 1923 in Bombay. Details of the results are not available.

In 1922, the Madras Government purchased a failrly powerful sea-going launch "Sea Scout", and Captain Gribb, a Master Fisherman having experience in Indian waters, was appointed to conduct fishing operations with the vessel. But the launch proved a great disappointment and so the experiments were stopped in 1924. In the same year the department was able acquire a second hand Steam Trawler for deep-sea fishing. This vessel arrived in India in 1926 and started deep sea fishing survey in October 1927. The department conducted systematic surveys of the deep-sea fishing grounds of the state for three years, 1927-28, 1928-29 and 1929-30. The reports are published in departmetal Bulletins. The survey revealed the existence of good trawling grounds off Point Calimere, Negapatam, Tranquebar, Portonovo, Cuddalore, Pondicherry and Sadras on the East Coast, in the Wadge Bank on the South and in the area lying between the Pigion Island and Kasaraged on the West Coast. The quantity of fish caught and sold during the survey was not much mainly because more attention was paid for surveying as much of the fishing grounds as possible than to catch and sell as much fish as could be obtained, and so the experiments resulted in financial loss to Government, and therefore, the Government decided not to continue the experiments.

During the 2nd World War, cod liver oil, which used to be generally used in India for the treatment of diseases caused by Vitamin A deficiency, became virtually unprocurable. Shark liver oil was found to be a very good substitute for cod liver oil, and the Director-General of Indian Medical Service, who visited Madras in July 1940, stressed the urgency of manufacturing shark liver oil on a commercial scale. The Department of Industries and Fisheries was entrusted with the work and the manufacture of shark liver oil was started at the Kerala soap Institute in 1940. In view of the vast possibilities of the new industry, the Government put up a separate factory with up-to-date equipmets for it at Kozhikode in May 1942. The demand for the oil from the military as well as civil population grew so rapidly that the factory began to find it difficult to meet it. It was therefore found necessary to develop deep sea fishing particularly for catching sharks. The abnormal conditions created by war placed serious limitations on the work at that time. Modern fishing boats and implements employed in foreign countries could not be had. The work was started with the old moto boat "Sea Scout" and some sailing canoes and catamarans, effecting improvements in the indigenous fishing tackle making them suitable for deeper waters. The work was conducted in as many as 24 centres on both the coasts, demonstrating to the fishermen the advantages of going further out to sea and using better fishing implements and mechanised boats. In addition to demonstrating to the fishermen, the advantages of going farther out to sea and using more efficient fishing crafts and implements, the operations conducted during the two years brought in a revenue of Rs. 1,11,649/- against a total expenditure of Rs. 2,68,428. After the close of the war, 8 M.F.V's were purchased from the Navy Disposals for deep sea fishing work. The M.F. V's were serving mostly as mother vessels and for towing the fishing canoes to the offshore fishing grounds. A few methods of fishing such as revolving-chain hooks lines for sharks, long lines, hand lines and trawl lines were successfully operated. Fishing experiments with mid-water trawls based on the local types of nets were also tried. As most of these vessels were old and decrepit, they were constantly under repair, and nothing very remarkable could be achieved out of them.

Simultaneously, the State launched a scheme for the construction of "Luggers" which are small sturdy vessels 21 feet in length with a square stern and powered by a 10 h.p. diesel engine. The department has built 13 such vessels at a cost of Rs. 6,000 each and has been conducting demonstrational fishing in important centres. The department loaned some of these boats to private fishermen, and also encouraged them to buy them by payment on easy instalments.

In 1954, the Madras State loaned the services of two F. A. O. Experts, one a Master Fishermen, Mr. Illugason of Iceland, and another a Naval Architect of repute, Mr. Paul Zeiner of Norway.

These two persons have been with us for more than a year. The F. A. O. also loaned to us two small powerful "Danish Boats", and Mr. Illugason, the Master Fisherman, has been conducting fishing on both the coasts with these vessels. During the 1954 season, Mr. Illugason conducted a number of fishing surveys off the West Coast from Badagara to Payyannur. He has also evolved the best suited net for some of our fisheries. He has designed a Nylon Shrimp Trawl net, and has, demonstrated its usefulness. At a time when the local boats were having no catches at all, he was able to bring fairly good catches of prawns by operating this net. The demonstrational fishing conducted by these two boats and a prototype boat made on the same model has had remarkable propaganda value. Fisherman from various parts of the coast have been asking for the supply of similar boats. Government are considering the construction and supply of 20 such boats to fishermen immediately, and another 80 boats in the Second Five Year Plan. In the meantime the three boats available are being lent to fishermen by turns on hire basis to make them popular.

Mr. Paul Zeiner, the Naval Architect sent by the F. A. O. has designed a surf-landing boat, i.e., a boat suitable for landing on a heavily surf-beatern hoast, where at present only catamarans can land. The first boat was not quite successful and therefore he wanted to try some others with slight modifications and the F. A. O. was pleased to sanction the amount required for making two more boats. If these boats succeed, it is bound to revolutionise the fishing industry on the East Coast. In the place of the catamarans, which at present cost as much as Rs. 750/- to Rs. 1,000/- each, the fishermen can use power boats (surf-landing boats) costing only double the amount.

This State has recently obtained under T.C.A. Aid four up-to-date power boats, and the F.A.O. Fishing Expert, Mr. Illugason, is demonstrating their use to the fishermen.

II. Early Attempts in Deep Sea Fishing in Madras State.

In February 1906 and May 1908 Sir F. A. Nicholson reported to Government on the desirability of introduction and extensive use of larger sized boats along the West Coast for the following reasons: –

(1) To take crews safely and comfortably into the further waters of the fishing grounds and to allow them to stay there for some days, following and catching the shoals, (2) to allow the use of better and more powerful nets and lines, (3) to save time, to lessen the number of hands, increase freedom of action and to permit the use of mechanical appliances to save labour and increase efficiency and (4) to enable means to be taken by the fishermen to ensure the proper preservation of fish from taint from catch to shore.

As a preliminary to the introduction of larger boats Hornell made a survey of the East and West coasts of the State and ascertained the suitability of the various ports and estuaries as harbourage for the fishing boats especially during stormy and cyclonic weather periods. The harbours, excepting that of Madras and Cochin are those formed by the estuaries of rivers and backwaters, the majority of which are not of use during the summer months owing to closure of the bars brought about by silting action of strong long-shore currents with a cessation of river flow. The important and probable fishing harbours are the following.

I. Coramandal Coast

Pulicat to Point Calimere.

1. Pulicat lake.—Open throughout the year.
2. Ennur estuary.—Closed during S. W. monsoon period.
3. Madras harbour.
4. Cooum estuary.—Closed during S. W. monsoon period.
5. Adyar estuary.—Closed during S. W. monsoon period.
6. Covelong.—Closed during S. W. monsoon period.
7. Sadras.—Closed during S. W. monsoon period.
8. Cuddalore.—Open throughout the year with average depth of 3 feet at mouth and 6 feet during high tide.
9. Vellar estuary, Porto Novo,—Open throughout the year with average depth of 3 feet at mouth and 6 feet during high tide.
10. Coleroon estuary.—Very shallow bar.
11. Tirumalavasal, Cauvery estuary.—Closed during summer ; 2–2½ feet of water during other times,
12. Tranquebar, river estuary.—2–4½ feet water throughout the year and navigable.
13. Karaikal, Porayar estuary.—2–4½ feet water throughout the year and navigable.
14. Nagore; Vettar estuary.—2–4½ feet water throughout the year and navigable.
15. Nagapattinam, Kaduvayar river.—1–2½ feet of water except in January and February.
16. Velanganni backwater.—6–12 inches during summer.
17. Thopputhurai river.—Always open with 2½ feet of low water.
18. Point Calimere.—Affords good protection during both the monsoons.

II. Dhoney Coast

Muthupet to Tuticorin

19. Muthuppet, Korayar estuary—navigable throughout the year.
20. Adirampatnam—Fully exposed, not suitable.
21. Tondi—Fully exposed, not suitable.
22. Pambam *cum* Mandapam–Good natural conditions, affording protection on north and south shores with reference to monsoons.
23. Kilakarai.—Well sheltered by coral islands about 5 miles from shore.
24. Tuticorin.—Suitable harbour.

III. Boat-catamaran coast

25. Pinnakayal, Tambraparani estuary.
26. Kayalpatnam, Tambaraparni estuary.

IV. Canoe Coast

Malabar and South Kanara.

27. Cochin.—Best backwater harbour.
28. Ponnani—Perennial, 6-10 feet,
29. Beypore near Calicut—Excellent river mouth with 4–9 feet over bar and 9–20 feet within.
30. Mahe river—6–7 feet of water ; but there are rocky patches.
31. Tellicherry—Shelter afforded by the river.
32. Mount Dilli and Baliapatnam river—Boats can go upstream throughout the year.
33. Kavai river estuary—Suitable for small boats only.
34. Kasaragod river estuary—Suitable for small boats only.
35. Kubla creak—Suitable for small boats only.
36. Mangalore—Good harbour with 9–16 feet of water.
37. Mulki river—0–7 feet of water, being exposed during low tide.
38. Malpe and St. Marys Isles—2–8 feet of water over bar and 6–12 feet of water in channel between river-mouth and isles.
39. Coondapur estuary—2–12 feet of water, affording good shelter.

In 1908 Hornell conducted a preliminary trawling cruise along the Malabar coast in the pearl fishery inspection steamer S. S. "Margarita" and concluded that (1) that shallow inshore zone bounded by the 6 fathom line is sufficiently rich in many localities, particularly opposite river-mouths, to support a profitable trawling industry conducted by sailing smacks, the principal bottom fish being large flat fish (Psettodes Irumei), large soles (Cynoglossus), large rays (Trygon bleekari,

AETOBATIS narinari and PTEROPLATES micrura), hammer-headed sharks, dog-fish (CHILOSCYLLIUM indicum), spotted doray (DREPANE punctata), a variety of small fishes, cuttle fishes and prawns (2) The zone between 6 and 30 fathom lines is quite unfitted for profitable trawling operations. The bottom is uniformly composed of a soft dark grey mud supporting a most meagre invertebrate fauna. The only fish that was present here in few members is PSETTODES irumei. (3) Outside the 30 fathom line trawling conditions improve greatly, the bottom becomes firmer and is largely composed of fine grey sand with an admixture of mud, shells and stones, Crabs, squat lobsters (SCYLLARUS) and fairly large gastropod molluscs abound.

Two fishing boats, one a sailing vessel of Scottish design, the "Sutherland" of 12 tons and another a 15 H.P. motor vessel 'Turbinella' of 25 tons of Arklow design were built in 1909–10. The former vessel conducted fishing experiments off Cannanore in February 1910 and obtained considerable hauls of seer and mackerel in 8 fathoms when the inshore boats of the local fishermen did not catch these fish. This boat however proved much too slow for the light winds of the West coast fishing season in 1910–11 and to be too big for small work and not big enough for large work. In the seme year 'Turbinella' conducted certain trawl fishing and though her nets were very small and insufficient she attracted attention by catching seer in fair quantities in her nets, a result never before seen at Tuticorin, in so much that the fishermen borrowed her nets on a quarter-share basis and attempted to use them. But owing to the feebleness of their boats the result was disappointing.

Simultaneously with the operation of the aforesaid two vessels, two Ratnagiri sailing boats (simple drifters from 6-8 tons from the Bombay coast) were chartered and employed for fishing with their own drift nets, measuring above half a mile when short, in waters from 8-12 fathoms off Cannanore, outside the usual limit of the Malabar canoes. They brought large quantities of seer, pomfret, sabre fish, small sharks. etc., the largest catch for one night being 1500 lbs. In 48 nights of fishing from October to December the two brought about 38,000 lbs. of fish, excluding the quantity taken by the crews for food and fish rejected as tainted and earned Rs. 1,600– from the fish cured. The crew of each boat comprised of 6 men. But the catches were often found tainted, since the fish, being caught in drift nets had been slowly suffocated and had often been dead some 12 hours on arrival at shore. As the crew refused to get the fish, a gutter was sent out on each boat. The latter gutted and washed the fish and applied salt and even a small quantity of boric preservative. This precedure helped to bring all the fish to the shore in good condition. This experiment proved that Ratnagiri boats are well adapted for deep-sea fishing season on the Wet coast of Madras State.

In 1916 two Ratnagiri boats with nets, etc., were purchased by the Department to explore to some extent the deeper waters up to the 100 fathom limit, (2) to obtain a supply of the larger sorts of fish for the cannery and curing yard, (3) to pay special attention to the where abouts of shoal fish like sardines, mackerels. etc., when not found inshore, (4) to experiment to the better treatment, temporary preservation, etc. of fish on board, and (5) to engage in other miscellaneous duties such as those of carriers. These boats were put into operation in 1916-17, one of them being manned by a Ratnagiri crew and the other by a partly local crew. They brought in considerable quantities of fish by staying out several days at a time. The experiment was however abondoned by the crew due to damages sustained by the boats during some bad weather.

In 1917-18, a very useful experiment was made in bringing two West coast canoes, nets and the men over to Madras to fish in Madras waters with the harbour as base. This attempt like most novel experiments, did not fully pay for itself. But a large amount (53,000 lbs.) of fish was caught, some under circumstances when catamarans could do nothing in the way of capture of valuable shoal fish for which the agile Malabar canoes and large nets are specially fitted. The experiment cost Rs. 4406-6-11 and the fish caught valued Rs. 3044-12-0. The experiment however created local interest and deserves a more thorough testing with local crews.

In 1918–19, two additional canoes were obtained from Malabar, with their complement of crews, nets and lines Within a period of 6½ months 83,187¾ lbs. of fiish were captured and sold for Rs. 4,912-0-9. The largest quantity caught on a single day was 2,080 lbs. worth Rs. 108-9-9. On several days when only a few catamarans were able to go for fishing owing to bad weather, the canoes went out and were able to land good hauls of fish. The boat-seine nets (pativala and sultanvala) and the gill-net (chalavala) proved successful in Madras waters.

The above experiments were continued in 1919–20 with four Malabar canoes and various kinds of nets and long lines. In 310 working days 114,850 lbs. of fish were caught and sold for Rs. 6,404, the average daily catch being 370 lbs. The boats were able to go out to sea on several occasions when the local catamarans could not be taken out on account of bad weather. The total expenditure during the year was Rs. 6,377 which included cost of provisions for the crew, house rent allowance, pay of a cook, etc. It was however clear that fishing on these lines is very profitable. In spite of this demonstration no Madras capitalist or fishermen has yet adopted these methods commercially.

In 1921-22, the experiments with the Malabar canoes and crews were carried out at Nagapatnam. But it proved that the large catama-

rans of this area were actually better adapted to local fishing conditions than the dug out canoe of Malabar. Not only were the catches of the canoes meagre, but they had not the weatherly quailties of the local catamaran. It is obvious that the catamaran can sail ever so much closer to the wind than the canoe and that unless capitalists come in with motor-boats no sailing craft can compete with the local craft in utility for several fishing purposes.

For the first time the department's proposals for the introduction of Western methods of fishing materialised in 1923–24 when the motor launch "Sea Scout" arrived in India in October 1923. Captain Cribb, the Master Fisherman who was engaged to conduct the experimental seine net fishing at Cochin. But the launch proved a great disappointment from the outset, as it was found quite unsuitable both in design and equipment for the purpose for which it was purchased, with the result that the experiments had to be terminated in March 1924.

III. Trawling Grounds of Madras coast.

The survey of deep-sea fishing grounds conducted by the S. T. "Lady Goschen", by employing a 50 feet otter-trawl from 1927 to 1930, are recounted in this section.

The vessel was a second-hand admiralty trawler, purchased and reconditioned at a cost of £ 5,699. She left England on 13th March 1926 in charge of Captain Cribb and arrived at Tuticorin on 21st April 1926.

In January 1927 the Trawler conducted a preliminery survey of the offshore fishing grounds at Calicut and a night's trawling on 24th which resulted in 1,657 pounds of fish.

After undergoing certain repairs the vessel resumed work in September 1927 in the extensive Cape Comorin plateau within the 100 fathom line.* On this bank, fine dredging bottom of fine grey sand and free from any obstructions was found outside the 17 fathoms. The first haul was made between 17 and 22 fathoms to the south-west of Manapad light house when for a two hours hault a record catch of 1652 lbs. of fish was obtained. Large rays figured prominently in this catch. All over this plateau, so long as the fishing was carried on outside of the 17 fathom line, plenty of fish were met with. It was noted that 20-23 fathoms were found at from 25-30 miles south-east of Manapad. To the south, west and east of Cape Comorin the bank is a good trawl ground and extends to a distance of 50 miles offshore. This ground situated as it is off a length of coast line extending 35 miles on either side of Cape Comorin covers an area of not less than

* This excellent ground for trawling was originally discovered by Mr. James Hornell and Captain Cribb in 1007 when engaged in experimental trawling in Ceylon.

4,500 square miles whereof atleast 4,000 square miles of sea-bottom within the 100 fathom line is suitable for trawl work. On the whole 56 hauls were made resulting in a total catch of 20,061 pound of fish, the average per haul being 300 lbs. The best haul was on 14th November 1927 off Manapad in 22 fathoms, when 1320 pounds of large fish were taken in 3 hours. The fish caught were mostly sea-breams, rock-cods, snappers, perches, rays and skates and sharks.

During the year 1928-29, the trawler continued its exploratory trawling, occupying 39 days on the Cape Comorin area in the months of December, March, April and May ; 21 days over the Cochin — Calicut area in November, December and April ; 5 days along the South Kanara coast and 2 days on the Bassas de Pedro bank lying off that coast.

The best haul from the Cape Comorin bank was in 32-33 fathoms on 8th December 1929 when 2,493 lb. of fish were taken in 2 hours. On the whole 26,403 lb. of fish were netted in 44 hauls at an average of 600 lbs. per haul.

On the South Kanara coast, with one exception when rocks were met with in 27 fathoms south-west of Mangalore, the bottom consisted of mud from 9 to 32 fathoms. Here the best catch of 3,050 lbs. was obtained in a haul of 3 hours on 26th December 1928. A total of 8,323 lbs. was obtained in 7 hauls, the average per haul being 1,190 lbs. The important kind of fish caught were sharks, skates, rays, catfishes, goat-fishes and big jawed jumper.

The sea-bottom from 15 fathoms off the coast between Cannanore and Kasaragod was mostly favourable for good trawling with few obstructions, the bottom being mud and sand. Three hauls brought 509, 1480 and 2501 lbs. respectively.

The banks opposite Calicut in 8-54 fathoms were found to be composed variously of mud, sand and occasional patches of rock. But this varies with reference to the current and shifting of mud banks, the strong southerly coastal current set up by the south-west monsoon sweeping the sea bottom of soft mud and sand and leaving the underlying rocks exposed and thus accounting for the presence of rocks in the cold weather. A total catch of 17,783 lb. was obtained in 32 hauls, the average being 556 lb. per haul. The best haul was 1,933 lb. The Chief kinds of fish were horse-mackerels, sharks, rays, catfish, big-jawed jumper and jew-fishes.

The Bassas de Pedro is a large bank, 70 miles long and 10-15 miles broad with a depth of 20-34 fathoms, lying about 120 miles west of Mangalore. A preliminary survey of the fishery potentiality of this bank was first made by the trawler in November 1927. It was ascertained that the southern portion of the bank was found to consist of

sandy bottom and afforded facilities for trawling while the northern portion presented immense coral rocks destructive to trawling gear. The hauls made in the southern section of the bank consisted mostly of large rays, rock-cods, perches, snappers, porgies, all prime fish of considerable economic value. Four hauls of 1,224, 330, 171 and 169 lb. were obtained during these trials.

The total catch during the year 1928-29 was 61,863 lb. for 96 hauls from both the east and west coasts with an average of 645 lbs. per haul.

In 1929-30 the coast from Pigeon Islands to Calicut on the West coast and from Point Calimere to Madras on the East Coast were surveyed. Most of the 35 hauls made in the Mangalore-Malpe section were within the 70 fathoms, as the sea-bottom beyond this up to 100 fathom line was found to be rocky and unsuitable for trawling. The trawling ground within 70 fathoms on this section consisted mostly of mud. Sharks, rays, catfishes, and horse-mackerels were the main catches. A total quantity of 6 tons 16 cwt. were obtained with an average of 435 lb. per haul.

Forty hauls were made in the section from Point Calimere to Porto Novo. Between 10 and 20 fathom line rocks were frequently encountered. Good class edible fish of large size including rock-cods, sea-perches and breams, horse-mackerels, snappers, etc., were much more common than in the case of the West coast. On the whole 6 tons 18 cwt. with an average of 385 lb. per haul, were obtained. The best haul was 2,830 lb. in 3 hours in the section between Point Calimere and Negapatnam.

In 1930-31 the survey of the East coast was commenced from Negapatnam to Madras and good trawling grounds were located off Tranquebar, Porto Novo, Cuddalore, Pondicherry and Sadras within the 10 and 50 fathom lines. The bottom at 100 fathoms and its vicinity was found to be rocky and destructive to nets. Soft muddy bottom was also very common between the 10 and 20 fathoms. The offshore belt between Point Calimere and Pondicherry so abounds in large sea-perches that this area may be said to constitute a perch fishing ground. The best haul was 1,490 lb. in 2 hours. Likewise the offshore belt between Pondicherry and Madras was characterised by the preponderance of large horse-mackerels. The best haul in this section was 1305 lb.

On the West coast the portion of the coast from Pigeon Island to Kasargod was surveyed for six weeks in November — December. The nature of the bottom in this area was generally muddy throughout. Rocks were met with on two occasions on or near the 100 fathom line. Sea-perches, catfishes, pomfrets, flat fish and horse-mackerels were common in this section. A cuttle fishery of some magnitude was found

to exist off Coondapur where one haul brought nearly 400 lb. of large cuttle fish, *Sepia singalensis.*

A total landing of 18 tons, 17 cwt. and 56 lb. of fish was made in 120 hauls during the year with an average of 350 lbs. per haul.

As a result of the above datailed exploratory deep-sea fishing experiments the following five new fisheries, all of which were previously unknown, were located :—

(1) An extensive shark ground opposite Point Calimere, (2) squat-nosted lobster fishery from Point Calimere to Cuddalore and beyond, (3) perch fishing ground from Point Calimere to Pondicherry, (4) Horse-mackerel fisheries from Pondicherry to Madras and (5) large cuttle-fish fishery off Coondapur in South Kanara.

An ever more remarkable fact brought out by the survey was the striking contrast between the offshore fisheries of the east and west coasts. The offshore fisheries of the East coast was found to be far superior in quality and value to those on the West coast. The prevailing belief that the fisheries of the West Coast are more valuable than those on the East coast is apparently true only of the strictly inshore grounds fished by the fishermen. The existence of such a wealth of good class fish on the East coast had never been suspected before. As these prolific grounds immediately adjoin the area fished by local craft, the discovery opens up great possibilities for development on the East coast.

IV. Shark Fishing Industry of the Madras State

A. *West Coast*

The shark fishing industry is better developed on the West Coast of this State than on the East Coast. The districts of Malabar and South Kanara, which constitute the West Coast, account for only about one-sixth of the total coast-line of the State. But the fish landings on this coast are about three times as much as those on the East Coast. This is mainly because of the more favourable natural conditions available on the West Coast. This is mainly because of the more favourable natural conditions available on the West Coast. The muddy bottomed and comparatively surfless region of the West Coast attract seasonal migratory shoaling fishes. These are followed by sharks which feed upon them The appearance of the shoaling fishes and the proper exploitation of the inshore fisheries by the employment of boats (dug-out canoes), various types of nets and long lines have largely contributed to the heavy catches off the West Coast.

Shark fishing has been in existence for a very long time on the West Coast. As early as 1905, long line and drift nets were being used for catching sharks off South Kanara by the Ratnagiri fishermen, who used to frequent the South Kanara Coast with their large boats during

the fine weather period. The catches of sharks, however, were only poor, mainly because it was not a very remunerative industry in those days, the livers being thrown away except when oil was required for coating boats, and the flesh being eaten only by the poorer classes of people.

The fishing implements used in the past on the West Coast for catching sharks consisted of harpoons, long lines and drift nets.

Harpoon (*Uli or Chattuli*).—The harpoon consists of a smooth cylindrical shaft made out of coconut or palmyra wood 8 to 10 feet long and about 2 inches in diameter, with an iron head barbed on one side. The iron head is 8 to 14 inches long, with a barb flange at the far end diverging at an angle of about 30 degrees and 2 to 3 inches long. The shank is usually rectangular in section at the butt end, where it expands into a shallow cone about 3 inches deep for the reception of the distal end of the wooden shaft. The farther end of the harpoon line is tied to the head just beyond the socket. The other end of the line is attached to the wooden shaft near the proximal end. The line is 30 to 40 fathoms long.

The harpoon is used either as the sole fishing implement or in conjunction with long lining. Harpooning requires considerable skill and this method of fishing is slowly dying down.

Long lining.—This method of fishing was introduced from the Bombay Province. Two types of long lines are in use, CHERIA BEPPU which is a small hook-line and VALIA BEPPU or a large and strong hook-line.

Cheria Beppu.—The length of the line ranges from 250 to 600 fathoms. Hooks about 2 inches long are attached to every 5 or 6 feet of the main line by 9 inch snoods. The line is buoyed at each end by a large and conspicuous buoy of light wood or empty tin with numerous smaller floats at intervals along the whole length of the line. The length of the buoy-line is regulated to suit the depth at which fishing is to be done. A stone sinker, hung from each end of the complete line anchors it in position at the requisite depth. The bait used consists of pierces of mackerel, sardine, eel, etc. The fish caught are chiefly cat-fish, seer, Leather Jacket (Palameen), sciaenidae or Jew-fish (kora) and shark. This is the most popular fishing implement used in shark fishing, because all varieties of carnivorous fishes will be caught in this.

Valia Beppu.—This is used exclusively for catching large sharks. The line used is shorter, being only 100 to 200 fathoms in length, with the hooks attached at 10 fathom intervals from the ends of jointed iron-wire snoods about 18 inches long. Stout country-made hooks measuring 5 to 9 inches in length are used, and are baited with large pieces of fish other than shark, or of dolphin or beef. The line is

buoyed as in the case of Cheria Beppu by a large wooden buoy or empty kerosene tins at each end, and smaller ones at intervals. Two stone sinkers anchor the tow ends.

Drift net.—This net is made out of hemp in short pieces each about $7\frac{1}{2}$ fathoms by $2\frac{1}{2}$ fathoms, with 8 to 10 inch meshes. Ten to fifteen pieces of such nets are attached together and used as a drift net for catching sharks. The nets are made to remain vertical in the sea by fixing floats to the top and weights at the bottom

These implements have been undergoing considerable improvements since the Department of Industries and Commerce started deep sea fishing operations in 1943.

The deep-sea fishing operations were undertaken with the immediate object of supplying shark liver oil for which there was a large demand from the Military department. But in addition to this object there was also the motive of augmenting the food supply of the State. The Madras Fisheries Department was extracting shark liver oil on a small scale since 1934 ; but production on a commercial scale was started only in 1940. In view of the vast possibilities of this new industry, the Government put up a factory at Calicut with up-to-date equipment in May 1942. But the demand for the oil from the Military department grew so rapidly that it was found difficult to get sufficient quantities of shark liver to meet the demand. The Department of Industries and Commerce had, therefore, to organize and develop shark fishing as mentioned already.

But the abnormal conditions created by the war placed serious limitations on the work. Modern fishing appliances employed in advanced countries could not be had. So the Department was compelled by circumstances to effect improvements in the indigenous fishing implements. This has in a way been a blessing in disguise ; because even the fishermen, the most conservative set of people, began to effect the gradual improvements in the fishing implements.

The fishing implements which were found successful in shark fishing were long lines and drift nets. But experiments in improving the old implements were now conducted and demonstrations carried out in the use of these improved implements. As a result of these experiments and demonstrations a larger number of hooks and greater lengths of drift nets began to be employed. In long line fishing, chain hooks and revolving chain hooks were introduced. The revolving chain hook introduced by the Department has a chain about 10 feet long with a snood chain of about 3 feet attached to the middle of the main chain. Either side of the snood, the chain is 5 feet long with 5 links, of about a foot, made of 9 or 10 gauge galvanized wire. The size of the hooks is 5 to 8 inches and it is made of 5 inch round steel rod. The chain has 3 revolving swivels, one in the snood chain about 18

inches above the hook and another on either side of the chain to allow it to turn round freely when the entangled fish struggles and moves all round. The chains are attached to cotton lines about ⅛ inch thick at a distance of 10 fathoms apart. About 50 hooks are used in one set of lines.

The experiments and demonstrations in shark fishing conducted by the department during 1943–45 have shown that the shark fishing industry is a paying one. The table below (see next page) gives details of the catches, the weights of the fish caught, the sale proceeds, expenditure incurred, etc.,

The expenditure includes boat hire, wages paid to the fishermen at rates varying from Rs. 35 to 45 per month, pay of the supervising staff consisting of a maistri on Rs. 30 to 40 in each centre, cost of bait and repairs to fishing implements. The receipts consist of only the value realized by selling the flesh at a fairly cheap rate ranging from 6 pies to to 2 annas per pound. The value of the shark liver oil obtained is not included in the receipts nor is the price of shark fins which now fetch as much as Re. 1 per pound, but were fetching practically nothing some time ago.

Centre	Fishing Gear used	Fish caught in pound: Shark	Other fish	Total	Sale proceeds	Expenditure	Oil obtained
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
South Kanara district—							
1. Gangolli	Chain hooks and No. 1 hooks ...	7,064	715	7,779	517 9 0	2,073 4 4	809
2. Hangarakatte	do. ...	27,278	4,433	31,711	1,348 15 0	2,652 12 4	1,647
3. Malpe	No. 1 and 2 hooks ...	3,980	390	4,370	530 5 9	573 4 3	172
4. Ullal	No. 1 hooks ...	67,354	5,023	72,377	4,611 4 0	6,036 9 3	3,003
5. Hosdrug	do. ...	3,486	1,733	5,219	568 4 6	625 12 3	115
6. Nileshwar	Chain hooks and No. 1 hooks ...	20,483	2,217	22,700	1,292 2 5	1,470 2 11	907
	Total ...	129,645	14,511	144,156	8,868 8 8	13,431 13 4	6,653
Malabar district—							
1. Madai	Chain hooks and No. 1 hooks ...	5,341	431	5,772	832 10 6	1,220 1 6	395
2. Tellicherry	do. ...	25,081	4,896	29,977	4,475 1 0	4,769 7 4	1,901
3. Badagara	Chain hooks ...	2,176	91	2,267	366 6 0	832 3 0	147
4. Tikkodi	Drift nets ...	238	180	418	35 5 0	121 11 0	3
5. Calicut	Chain hooks and Nos. 1 and 5 hooks ...	23,032	11,880	34,912	4,315 5 6	4,584 9 3	935
6. Tanur	Chain hooks ...	30,090	4,142	34,232	5,538 14 4	3,880 4 1	1,852
7. Kadappuram	Chain hooks and Nos. 1 and 5 hooks ...	11,027	5,602	16,629	2,710 11 0	3,367 15 0	699
8. Kootayi	Chain hooks ...	18,246	406	18,652	2,163 6 0	2,438 6 0	1,329
9. Palapatty	do. ...	1,870	188	2,058	197 4 6	398 12 0	116
10. Ponnani	do. ...	6,029	50	6,079	871 13 6	1,151 11 6	356
11. Cochin	Nos. 1 and 5 hooks ...	4,427	485	4,912	577 14 0	1,296 5 0	257
	Total ...	127,557	28,351	155,908	22,084 11 4	24,061 5 8	7,990
	Grand Total ...	257,202	42,862	300,064	30,953 4 0	37,493 3 0	14,643

In South Kanara, the best shark fishing grounds lie off Ullal between 25 and 35 fathoms. The 100 fathom line is about 45 miles off this place and sharks are found right up to this depth. The difficulty on many of the days has been to reach the fishing grounds in the dug-out canoes and if the fishermen have been able to go out to distances upto 20 miles and above, it is more because of the settled conditions that prevail on this coast during certain months of the year, viz., October to January, than the suitability of their boats. Other good shark grounds in South Kanara lie off Gangolli, Hangarakatte, Malpe and Manjeshwar.

In Malabar good fishing grounds for sharks lie off Madai, Tellicherry, Tanur, Kadappuram and Ponnani. The shark grounds are nearer to the shore in Malabar than in South Kanara. The 15-fathom line is within 10 miles from the shore in many places. The beds are therefore easily accessible in favourable weather.

It is noteworthy that most of the good fishing grounds located lie opposite river mouths; an obvious explanation for this is that in the rainy season of the South-West monsoon these rivers discharge into the sea immense volumes of water heavily laden with fine silt and organic matter, which produce plenty of food for plankton-feeding fishes which in turn attract sharks.

The details of the results of the two years' fishing experiments, as given above, show that shark fishing is a paying industry, especially considering the fact that the first year's work was more or less in the nature of preliminary investigations. There were also several unfavourable conditions which made the cost of fishing high. Moreover the sale price of sharks was not high in proportion to the working cost. But when normal conditions prevail the working cost will be reduced. All the above facts tend towards the conclusion that the shark-fishing industry can be developed on economic lines to very great advantage.

B. East Coast

The waters off the East Coast abound in shark life which is, however, considered by fishermen to be one of the greatest evils. Out of about 37 kinds of sharks found in Indian waters, eight are economically important on the East Coast.

1. The long-tailed shark is pelagic and piscivorous. It has sharp triangular teeth and is one of the most ferocious sharks, frequently attacking bathers and grows upto 9 feet or more.

2. The black-finned shark grows to a very large size and is very common along this coast. Large numbers of this shark are caught near Sethubavachatram. It feeds voraciously on silver-bellies, prawns, etc.

3. The long-snouted shark does not grow to a large size.

4. The grey shark feeds mostly on cuttle-fish and grows up to 7 feet.

5. The Tiger Shark is also one of the most dangerous of sharks It is a scavenger of the sea.

6. The saw-fish with its snout produced and flattened presents a saw-like appearance due to the existence of large teeth on its lateral edges. Great injuries are sometimes inflicted by this shark which strikes sideways and is known to cut bathers into two halves with the "saw". It attains a length of 20 feet or more.

7. The Hammer-head Shark is peculiar in having the front part of the head produced outwards on each side with the eyes at the ends of the extension. This shark is reputed to be very dangerous in some localities. The young of this shark are caught in large numbers along this coast.

8. The Dog-fish is a small kind of shark. In spite of the abundance of sharks off the East Coast, no effort had been made to fish them till recently when the Fisheries Section of this Department has demonstrated how rich these waters are and now with the methods adopted on the West Coast these denizens of the sea could be taken without any great difficulty. The industry is still in its infancy on this coast.

Hook and line, and nets are used in capturing sharks. The few sharks that are caught are those taken accidentally in nets laid out for other fishes. They are caught in Iragavala, Killivala, Peddavala and Kettavala to the north of Madras and in Vellavalai, Valavalai and Pachuvalai to the south of Madras. Besides these, Thirukhavalai is used for catching sharks as well as skates and rays. Most of these nets are entangling nets anchored across the path known to be followed by food fishes.

Thirukhavalai, the net generally used on this coast for catching sharks, rays, etc., is about 200 to 220 feet in length and 15 to 18 feet in depth. The net is made of stout sunhemp cord, with 12-inch meshes. Along the upper-edge a strong coir head rope carries ten sub-cylindrical wooden floats. A ground rope is used without sinkers. Beyond each end of the net the head and ground ropes are prolonged 15 feet and then brought together and formed into a loop. To this is attached an anchoring cable 24 feet long, made fast at the other end to a wooden one-fluke anchor having several heavy stones tied to the end of the shank. In some places mooring is by a heavy stone tied at the end of the ground rope at each extremity of the net.

When set the net stands as a slightly inclined wall of netting. To facilitate the entanglement of big fish that strike the net, the upper

margin runs freely upon the head rope, weak stoppers being inserted at each fathom-length by means of a single tie of coconut strip. When a big fish strikes the net some of these stops give way facilitating the tangling of the fish in the folds of the net.

The net is moored overnight in shallow water across the path known to be followed by food fishes. Sharks following small fishes become entangled in the meshes and are retained. In hauling the net one end is gathered up and the boat pulled alongside until the shark comes to view. It is then brought to the surface and with a sharp blow on the head is rendered harmless. A gaff is then placed in the mouth and then pulled aboard.

Sharks are also caught occasionally by whiffing or trolling, i.e., fishing with line towing bait near surface, when the catamarans and boats sail on the outward and inward journeys. With the introduction of long lining by revolving chain hooks and No. I hooks, as described in Part I of this article, catches of sharks at the few centres on the East Coast have been remarkable.

As soon as the sharks are landed they are opened and the liver removed for the extraction of oil. The flesh is either sold fresh or salted when the demand is little. In the latter case, it is filleted, salted and kept stacked in brine tubs. Next day, the fillets are washed in the brine formed in the tubs and then thoroughly sundried to be packed and despatched to inland places.

Several useful by-products are obtained from the sharks. The hide of the shark makes excellent leather and is probably the toughest in the market. The liver and the pituitary glands are used for medicinal purposes. The glandular secretions have been found to contain a powerful ingredient. The teeth and vertebrae are used in the manufacture of jewellery. The find are dried and the famous shark fin soup is made out of it. The fins and cartilage are also used in the manufacture of glue. Excellent leather is also obtained from shark bellies which are cured.

At the present day, apart from the liver, only the fins are chiefly utilized. Fins taken from sharks are cured by dipping the cut ends in chunam and then thoroughly sun-dried. This product is now in great demand As much as Rs. 1-8-0 per pound is obtained for good white fins. With the growth of the industry, all the products will be utilized and the slowly shark will become the prime gold-winner for this coast.

Conclusions.—Very good fishing grounds exist in several places on both the coasts all within about 30 miles from shore. The good shark fishing grounds located during the course of the experiments are off Malpe, Ullal, Madai, Tellicherry, Calicut, Tanur, Kadapuram and Ponnani on the West Coast and off Pinnakayal, Pamban, Adiram-

patnam, Cuddalore, Kadapakkam, Sadras, Madras, Sathankuppam, Uppada, Cocanada and Lawson's Bay on the East Coast. Though it is possible to reach all these fishing grounds in sailing vessels, to save time in going to the grounds and back, to spend more time in actual fishing operations, and to be able to conduct fishing for more days in the year, it is necessary to employ power vessels of the type described in paragraph 17 above. Auxilliary vessels will be the best. The fishing implements most suitable for catching sharks are the revolving chain hooks, long lines with No. I hooks of Norway make—Key brand, and wall nets (Pachu valai). These should be lengthened to increase their catching power. The best baits for catching sharks are—beef, eels, flesh or dugong (Porpoise) and cat fish.

Tiger shark (Galeocerdo sp.) yield the largest quantity of liver as much as 22 per cent of the total weight of fish. Carcharias sp., Hammer-headed sharks and saw fish yield oil of high vitamin potency.

V. An Experimental Hand-Line Fishing on the Wadge Bank

An experimental fishing with hand lines was conducted for the first time on the Wadge Bank from February to April 1949. Two vessels, namely, M. S. Lady Nicholson (length 107 feet, beam 24 feet, tonnage 85 nett, propulsion by twin-screw 150 b.h.p. Clenifer engines, speed 3 knots with fore and jib sails, crew 10 in number) and M. F. V. Gouhar Khaleeli (length 75 feet, beam 20 feet, tonnage 75, propulsion by single screw 160 b.h.p. Liter Diesel engine, speed 8 knots with a jib sail during favourable weather, crew 6 in number), and three Tuticorin type canoes (28 feet long, with maximum speed of 15 knots with lugger sails, and with capacity for half ton of fish) were engaged in the operation. The base of work was at Leepuram about 2 miles north of Cape Comorin. M. S. Lady Nicholson served as a mother ship, accommodating the crew, fishermen, provisions, water-supply, fuel and fishing gear. M. F. V. Gouhar Khaleeli towed the canoe to Wadge Bank on alternate days, leaving the anchorage at about midnight and reaching the bank by about 8 a.m., covering a distance of about 50 miles. When a good ground was struck (usually in depth varying from 5 to 65 fathoms) the canoes were let loose for independent fishing. Of the nine in each canoe, five attended to rowing in order to prevent drifting away from the mother vessel. The crew of the latter also attended to fishing. By about 4 p.m. the vessel left the bank for the anchorage.

Gear employed:—The gear employed was 50 cotton lines (each 100–150 fathoms in length) of strong twist (0·4 cm in diameter) with 5 Norwegian No. 4 hooks attached to one end at intervals of 2 feet, and weighted with a sinker about 8·10 pound in weight. Once a week these lines were washed in fresh water and then tanned in a decoction of bark of Acacia arabica. The entire set of gear cost Rs. 450. Procur-

ing good bait in sufficient quantity did not present much difficulty. Cotton gill nets (kolavalai) operated in 7–10 fathoms obtained about 60 pound of the Rainbow Sardine (Dussomieria hasseltii) and silver bellies (Leiognathus spp) Brightly lit lamps hung on the sides of the vessels for about 15 minutes during dark nights attracted the rainbow Sardine (Dussumieria hasseltii) and silver bellies also procured from the local bag-seine of fishermen. The baits were kept either fresh or slightly salted in wet gunny bags. Even on occasions when there was no good stock of bait, fishing was not hampered as a few perches hooked first were cut into small pieces and then used a bait.

Analysis of catches :—On an average about a ton of fish was caught during the short period of about 8 hours. While hauling the lines from depths varying from 45–65 fathoms the fish were found dead with their air bladders ejected out. Due to this, very often the fish got unhooked and drifted away necessitating the canoes to set out and pick them up. On return to the anchorage, the catches were transferred on board to M. S. Lady Nicholson and then sorted and weighed. They were then landed in canoes at the nearby villages of Kootpalli and Idinthakarai and sold at a price of 2–2½ annas per pound. On an average about a ton of fish were caught during the eight hours of fishing. The catches comprised mostly of sea bass (Epinephelus tauvina, E. miniatus, E. bleekeri and E. undulosus) and snappers (Lut janus malabaricus and Aprion typus). Few sharks and seabreams (Lethirinus) were also obtained. On the whole 35.440 pound of fish were captured on 15 days of actual fishing on the bank during a total of 45 days of the expedition as detailed below. Based on the number of hours fishing and the number of hand lines employed, the catch per line is about 47 pound per hour.

Kind of fish		Weight in pound
Sharks	..	1,609
Epinephelus spp	..	19,335
Aprion typus	..	9,448
Lut janus malabaricus	..	2,899
Lethrinus lut janus	..	727
Miscellaneous	..	1,422
Total	..	35,440

Details of the hydrobiological conditions of the Wadge Bank during the period of fishing have been recorded earlier by Chidambaram and Rajendran (1951.)

Economic aspects :—The foregoing results reveal not only the richness of the Wadge Bank but also the feasibility of exploiting it with

indigenous crafts and tackle. In fact, the local fishermen of Idinthakarai and Cape Comorin were encouraged by the operations of the departmental boats during the first five days to such an extent that they accompanied the departmental crafts in 8 canoes and 20 catamarans on 10 days and captured about 10 tons of fish. The total cost of the experiment was Rs. 5,770–11–9, and the total revenue realised was Rs. 5,452 as detailed below :—

Expenditure

	Rs.	A.	P.
Wages and allowance of fishermen	4,887	3	0
Hire and repairs of canoes	327	15	6
Cost and repairs of gear	450	0	0
Cost of bait	105	5	0
Total ..	5,770	11	9

Revenue

Sale proceeds of fish	5,401	0	0
Sale of 222 pound of shark liver	50	0	0
Total ..	5,451	0	0

These details will reveal that such enterprises, if continued on a long range basis will be very profitable, when it is considered that the gear purchased for the present experiment will last for about three years. Expenditure on hire charges of canoes, and wages and allowances of fishermen can also be reduced if the venture is made on a co-operative basis by the fishermen themselves. It has however to be admitted that the pay and allowances of the crew of the motor vessels and their running cost of Rs. 1,100 and 1,483 respectively have not been taken into account as they form part of regular expenditure incurred by the Department on its deep sea fishing activities. Even if this is considered, there is every possibility of organising hand lining on a commercial basis on the Wadge Bank. A great advantage for this venture is that radical changes are not required in the existing craft and tackle if the local fishermen, who are usually conservative are, with proper guidance and encouragement induced to go to deeper sea and harvest its richer fisheries with their own indigenous gears, provided facilities are given for quick transport of their catches for the fishing ground to the shore and to suitable markets.

The above experiment had considerable propaganda value. As enterprising fishing concern, Messrs. Roche and Co., of Nagercoil, has been conducting fishing on the same lines in the Wadge Bank

engaging a motor-fishing vessel on hire. The company requested the Department to give a M F. V. on reasonable hire. But as the departmental vessels are not good condition, their request has not been complied with but they incur loss by employing vessels which require frequent repairs.

VI. Shrimp Trawling Experiment

Prawns form an important fishery on the West Coast of Madras State and the experimental fishing operations by Mr. Illugason, F.A.O., Fishery Engineer has proved that Flat Trawl net is a better gear than the indigenous seine net used by fishermen to catch prawns.

Under the F.A.O. assistance to Madras State, a Danish Boat, 22 feet in length and fitted with a 10 H.P., Dan Engine was provided and this boat worked at Tellicherry During the period from 25th January to April 1955, a flat trawl net was operated form this boat. The catch was mostly prawns and for days during the above period, 25,726 pound of prawns valued at Rs. 1963-13-0 were caught. The Flat Trawl net was a cotton trawl net received under F.A.O. aid with 30 feet head rope. The body, wings and jigs were of webbing 10/15 threads and 2 feet stretched mesh, while the cod end was of 10/42 threads and ½ inch stretched mesh. The head rope was of sisal 1½ inches in circumference with 11 cork floats, each 6 inches into 4 inches. The ground rope was of same thickness as the head rope with 17 lead weights, each weighing 250 gms. The net was "hung in" 20 per cent and was preserved in tar. Steel wire rope 8 m.m. in diameter was used as the Trawling wire and the simple otter Boards, each weighing about 60 pound were used. The line-hauler fitted in the boat, hauled up the trawling wire easily. The grounds between latitudes 11°30 feet, 11°48 feet 5 inches and longitudes 75°35 feet; 75°23 feet 2 inches (Cannanore to Kadalur) in depths from 3 to 6 fms. with muddy bottom were fished. The same area in depths from 10 to 12 fms. was also tried on certain occasions during the above period, but with catch of either prawns or other fish.

During the same period from January to April statistics were collected of the landings of prawns on a local seine net fishing along the Tellicherry coast varying in depth from 3-6 fms. For 70 fishing days, the maximum catch landed on this net was about 5,600 pound of prawns and 8,400 pound of miscellaneous small fish valued at Rs. 896/-. The local boat seine (Kollivalai) was with a head rope about 80 fathoms long and ground rope 45 fathoms. The bag measured 40 fathoms in length. The meshes varied from ¼ inch near the mouth to 1/32 inches near the cod end. Two sinkers were used on the ground rope of the wing. A coir webbing 10 fathoms in length 7 fathoms in breadth and 2 inches mesh was joined to the ground

rope. This net was operated from two Dug-out canoes. The net was hauled up after 15 minutes. The fishermen belived that the period from February to April was an off season for prawns and the mostly set out for mackerals and sardines. But the good catches of prawns obtained by the Danish boat surprised the fishermen; and therefore they operated their "Kolli valai" for a few days close to the Denish boat but with poorer catch. For instance, from 17th to 22nd February 1954, Danish boat made five hauls each lasting an hour and caught 2119 pound of prawns whereas one "Kolli valai" operated in the same ground could catch about 500 pounds of prawns and miscellaneous small fish. This explains that prawns during this period were not in thick shoals and the "Kolli valai" operations from the canoes covered a very small area compared to trawling from the Danish boat which covered about 1½ miles per hour.

The following observations were made during the experimental trawling operations from the Danish boats :—

(1) Trawling close to the shore between 3 to 5 fathoms yielded good catch of prawns during the period from January to April 1955. But no prawns were caught in depths above 7 fathoms during the same period. There was also no catch of prawns during May and June 1954, the begginning of south-west monsoon.

(2) The maximum speed obtained from the Danish boat while trawling was 1½ knots only and the catch of prawns with this speed was found better than when the speed was increased.

(3) Usually the length of trawling wire used on each side is thrice the depth of water where the net is to be operated. But in this experiment that longer length of wire (usually four times) yielded better results.

(4) The catch was always found better when trawling against the current. This obviously means that while trawling along the current, the head rope is lowered thereby closing the trawl.

VII. Utilization of Deep Sea Catches

Before we study the methods of preserving and utilizing the deep-sea catches, it is imperative to know something about the causes and prevention of spoilage of fishery products. Fish is a highly perishable commodity by virtue of its high moisture and protein content, and bec.use of the bacterial load it always carries. Spoilage in fish is of three types — bacterial, enzymatic and chemical, the former two being more common than the last. Fish in its habitat always harbours microorganisms, especially in the slime and gills which are good nutrient media Depending on feeding, the gut also harbours quite a lot of these organisms. But fish flesh itself, curiously enough, is sterile. On the death of fish, or when it is taken out of water, the bacteria

from the surface as well as those from the guts attack and penetrate the flesh. The spoilage odours are due to the production of ammonia, trimethylamine and other basic volatile compounds from fish proteins. The digestive enzymes of fish, which after the death of fish continue to act, split up the fish musle proteins to simpler nitrogenous constituent (autolysis). The third type of spoilage, viz, chemical is the oxidative rancidity produced, especially in oily (fatty) fish, due to oxidation of the unsaturated fatty acids of the fish oils which therefore become brown to dark in colour. Other less common oxidative changes are for, e g, the blackening of prawns by Tyrosinase systems (Polyphenol oxidases etc.). With this background, we can proceed further and study and methods of controlling the spoilage agencies.

Bacteria thrive only in the presence of optimum amounts of nitrogenous compounds, at optimum temperatures, and at relatively high humidity. Normally most of the saprophytic bacteria to which group the food spoilage bacteria belong require an optimum temperature of about 25 to 35°C while the parasitic forms develop at 37°C. Any higher or lower temperatures adversely affect their survival. Hence temperature may be used to control microbial spoilage of foods for e.g. application of heat or cold. Likewise elimination of the moisture content by drying or dehydration, adversely affect the growth of bacteria. Of course there are exceptions to the rules, as for instance the Psychrophiles (cold loving) and the thermophiles (heat loving) which thrive even under adverse conditions. But we are not going to consider this here.

Application of cold in preservation of fish on board and on shore

Icing:—Bacteria multiply very rapidly at room temperature and the magnitude can very well be understood by the following illustration—2 in ½ an hour, 16 million in 12 hours and 4 billion in 16 hours. Lowering the temperature arrests bacterial multiplication. Icing immediately after hauling is the best way to slow down the rate of spoilage. Fish may be placed in chill room at 32°F, covered with ice with the same results. By proper icing it was found possible to keep fish from 7 to 9 days without spoilage. The temperature must however be 32°F to 30°F. If it goes below 30°F, the fish will tend to freeze slowly, and this will affect the quality of fish on thawing. At 32°F the fish will remain in prime condition for one week and in slightly tainted condition for another week but beyond this period, it will turn positively bad and will be unfit for consumption. Washing the fish in chilled sea water will bring down the temperature of the fish much more rapidly and if this is followed by icing, the ice chips will last longer as the amount of heat to be extracted from body of fish, will be very much less. So it is suggested that a preliminary dip in chilled sea water be given prior to heavy icing. A note of caution is to be struck in the use of ice. It

is not the "be all and end all" of preservation but is only a very temporary preservative, and as such its application is to be resorted to only, where storage for very short periods is contemplated.

The importance or icing can be noticed from the fact that reduction of temperature from 37°F to 31·5°F doubled the keeping times in fact even a reduction from 33°F to 31·5°F was significant. Whereas at 31·5°F fish remain good for 11-12 days at 77°F the keeping period is hardly 30 hours. Every 10°F rise in temperature causes bacteria to multiply and fish to deteriorate two and a half times rapidly.

Freezing and cold storage:—Considerable development has taken place in the shore organisation on handling and preserving fish such as quick freezing, deep freeze storage etc. Much headway has not been made in handling on board a trawler due to obvious reasons such as restriction of space, compactness of machinery, etc. But tangible development in this line also is being made and it may not be long before an efficient method in handling 'on board' is evolved. Recently the Torry Research Station of the D.S.I.R., U.K., have installed a vertical plate contact freezer in their research vessel "*Keelby*", designed for freezing fish at sea Freezing fish on board a trawler immediately after hauling will assure prime quality at the time of landing. Also long periods of voyage lasting upto a month may be possible. The ideal temperature for quick freezing on board a trawler will be 30°F and this can be stored safely in the frozen fish storage at 20°F.

Filleting of fish on board the trawler will be ideal, as this will give added space for storage. But to install filleting machinery may require lot of space and also efficient handling of the offal may not be possible. So the best method will be to freeze fish in the whole condition immediately after it is hauled.

Brine freezing systems are also generally used on board but the brine frozen fish are used only in canning industry. Use of ammonia as a refrigerant on board the vessel is not safe since any leakage is dangerous. Hence it is preferable to use the "Froon" type of refrigerants which are non-poisonous, non-corrosive and non-inflammable, besides being more efficient. Experiments by the U. S. Fish and Wildlife Service have shown that freezing fish at sea, with subsequent thawing, filleting and refreezing on shore caused no marked adverse effect at all. On the U. S. vessel 'Delaware' brine freezing equipment has been fitted up. The safe load is about 30 lb. of fish per cubic feet. The fish are moved with rotating drum in a brine tank at 0·10°F, when they are frozen in less than three hours. In order to get lower temperatures in liquid medium for freezing fish, Holston (CFR 14 (129) 36-40 1952) used a sugar-Ca C12 brine (34 per cent glucose and 20 per cent CA C12) and increased the range at about 78°F to 20°F. No adverse organoleptic changes were observed. First class frozen fish

require three conditions, viz., (1) Fresh fish, (2) Rapid freezing and (3) Low temperature of storage.

Handling and stowage aboard:—Great care should be taken on maintaining good hpgienic conditions, as this is a *sine qua non* for the quality of fish. Improper handling such as allowing fish to lie on the deck directly under the influence of sun's rays, not gutting the fish properly, and allowing the waste to lie all around, and packing the fish in dirty ice will all accelerate spoilage. The slime carries the heaviest load of mocro-organisms, viz., about 90 per cent. Hence removal of slime by washing must be done as expeditiously as possible after catching. The gut contains autolytic enzymes as well as putrefactive bacteria which rapidly attack fish flesh. Therefore gutting must be done at once before application of ice or freezing. Cutting (1954) mentions two principies to be followed in handling fish at sea, viz., (1) cleanliness and (2) coolness. Rate of spoilage on board is controlled by the degree of contamination and also by the conditions of stowage and the temperature of fish during stowage. Chilling with plenty of ice will not yield good fish, if it is heavily contaminated with bacteria, as a result of improper gutting and washing at sea. On trawlers best results are obtained by gutting and wasning the fish immediately after catching and getting it down below packed in ice as soon as possible. Plenty of ice should be used especially at the sides of the ship, where heat leakage is the maximum. Worst conditions are the delay in icing in summer and stowage against ships side with inadequate deployment of ice, which made the fish five days older than fish treated under ideal conditions. Fish should not be exposed on deck for too long a time in warm weather. Internal organs like liver and kidney must be completely removed. While gutting, the muscle must not be slashed as this will result in contamination by penetration of bacteria into the flesh. Fish on the deck must be washed with fresh sea water (not harbour water) and the entrails thrown over board at once. Lapses in cleanliness may cost a number of days in terms of freshness of fish. In trawled fish the intestines and faeces are squeezed out due to pressure and these must be removed by hosing the fish.

Use of wood in fish holds is to be discouraged to prevent multiplication of germs. Only constructions in light metal alloys, preferably anodized must be used. The entire hold-deck and hatches must be sterilized by hot sea water at 50°C, after emptying the load.

Bulking in considerable depth (4 feet or more) is a bad thing and fish thereby look two to four days older due to bruising and squashing. But fish stacked two layers deep are good. There may be loss of weight (and nutrients also due to the pressure, when the juice is squeezed out of the fish at the bottom. Laying fish on a bed of ice without spreading in on top also increases the rate of spoilage.

Fish must be shelved, covered with ice for better quality. Single shelving of 18" depth or boxing is superior to bulk stowage. Fish stowed above this must be placed on a support above the next lower layer. Gas storage (30 to 40 per cent C02) with icing is better and keeps fish beyond 8 days. In some cases this method succeeded in preventing some of the oldest fish on trawler from spoilage upto 21 says after catching. By extra care and cleanliness the duration of freshness will be extended from 6-7 days to 10-12 days. The fish should not be exposed to hot sun on the deck and if the fish are large they can be bled.

Transport:—Rail wagons insulated with "fibre glass" or 'Onazote' and lined with aluminimum sheet with rubber gasketing for doors is the ideal vehicle for transport. Facilities for bunkering ice or for hanging blocks of solid C02 (dry ice) should be present. More of ice also should be used in warm weather. The car itself should be provided, with salt and ice mixture to minimize the melting of ice added to fish. Mechanical refrigeration, however, has not become common in railways. The Fisheries Research Board of Canada have experimented with mechanically refrigerated wagons. Here the freezing portion is in a 'packaged system' or a detachable part going in flush with the wagon, and can be removed from the latter whenever needed. An average temperature of -2°F (-18.9°C) was attained. Such a system is highly desirable in India, where fish have to be moved over long distances.

For road transport, open lorry with taurpaulin would result in very poor retention of ice. Uninsulated covered van would warm up very rapidly. Ice could be dispensed with, if a highly insulated container which could be pre-chilled so that fish could be pre-cooled to 31°F before packing. Advantages of such boxes are (1) fish could be properly packed instead of being loose as in ice-packed box, due to melting of ice and (2) considerable saving in the net carriage costs.

A container for transport of frozen fish, made of light alloy, efficiently insulated and which can travel by road or rail without handling costs during the journey from quayside to the fish market. This must be capable of being placed on truck or wagon. The entire container can be kept scrupulously clean. Such a container with an unladen weight of only 17 cwt. can carry a load of 6 tons and have a space of 560 C feet. We have now some well insulated (not 'refrigerated') vans for bulking and transport of fish in ice. Shelving arrangements are so perfect with wire trays that the fish will not be crushed due to pressure. The size of such tray and trailers could be adjusted according to needs. The Fisheries Technological Station, Kozhikode, has evolved containers for transporting

iced and frozen fish suited for transporting small quantities upto 100 lb. and also large quantities upto 5 cwt. (560 lbs.)

2. *Curing of fish*:—As already pointed out spoilage of fish caused by three agencies, and here consideration will be given to the prevention of spoilage by various method of curing. In brief the effect of salting fish is to remove water by osmosis. The preservative action of salt is due to the following properties: (1) reduction of moisture, which is so essential for the growth and activities of spoilage organisms and (2) Suppression or destruction of spoilage organisms, which cannot thrive in high salt concentration. By the action of salt bacterial proteins are coagulated and so they are rendered inactive. "Ionic effect" is also responsible for the suppression of bacteria. The autolytic enzymes of fish are either destroyed by denaturation or are rendered inactive at high salt concentrations. Hence quick penetration of salt retards the autolysis of fish. But as far as the chemical changes like oxidation or hydrolysis of fish oils are concerned, they are not affected by salt and if any, they may accelerate rancidity. Hence usually fatty fish are not preferred for salting.

As for the application of salt-curing to deep sea catches, it is not widely prevalent as is chilling or freezing. It is only rarely that fish are curd on board. Even fish that are not required for fresh consumption but for salting are iced on board and salted in shore establishments. But in India, where salted fish is in great demand fish salting can be practiced on board and if this is not feasible, then in shore, after chilling the fish on board immediately after catching. Fish for salting should be of best quality. They must be thoroughly washed, free of slime and blood and if the fish are big, must be gutted and decapitated. These precautions will ensure a first class product.

The head is first cut off, then the fish is split open and the backbone removed. A preliminary washing in sea water will remove dirt and blood Then salt is applied. In India 'dry salting' is quite common. The split fish are 'scored' if they are large fish like seers, sharks, etc. They are arranged skin downwards and flesh upwards and salt is spread on the flesh side. Layers of fish are thus arranged and the top most layer is laid skin upwards. Salting may be done in wooden vats (if on vessels) or in cement tanks. Salt extracts water from fish flesh and forms brine which collects at the bottom and can be drained off. The optimum ratios of salt to be applied to fish of Malabar coast have been worked out at the Fisheries Technological Station, Kozhikode. Certain small fish like *Engraulis*, *Stolephorus*, silver bellies, soles, etc., are not eviscerated but salted 'in the round,' i.e, in entirety. They are then presumed to develop a peculiar flavour relished by connoissurs. After the fish are 'stuck-through' by salt

they may be removed, piled again and weighted with load so that more of water may be extruded. Then they are hosed with clean sea water and dried on barbecues or hung in hook in the sun to dry. During adverse weather, which is prevalent during a great part of the fishing season in the west coast of India, artificial driers may be made use of.

The Fisheries Technological Station, Kozhikode, have a method of drying fish with infra-red lamps which is also coming into vogue in Japan. Drying with infrared lamps in suitably designed chambers, will be a very efficient and economical method for the monsoon months in West Coast. When the fish are well dried, they are removed and packed.

Now the trade uses mostly the palmyra leafmats for packing. We are not package-concious yet to appreciate appealing types of packages. For example they could be packed in waxed cartons, moisture and vapour proof papers, or in metal foils. On the basis of our experience in the packing of semidried prawns 'alkathene' appears to be promising. These alkathene packed cured fish could be stroed in tea chests.

Shortcomings of salting fish:—Unless salt of very high purity having a Na Cl percentage of not less than 96 is used spoilage cannot be prevented. Presence of excess of calcium and magnesium salts retard the rate of penetration of Na Cl and this slowing down encourages spoilage of fish. Excess of Mg Cl_2 causes spoilage by its capacity to absorb moisture and thus rendering the dried fish moist. Presence of excess Mg SO_4 imparts a bitter taste to fish while presence of calcium salts give a 'chalky' appearance. High amount of sulphates are also deleterious to the quality of fish.

As a result of salting, the fish proteins are 'denatured' and their digestibility decreases. Though salted fish are not so rapidly spoiled by micro-organisms as fresh fish, bacteria cause discolouration and spoilage of salted fish. They may however be checked by sterilizing the salt and by storage at low temperatures of 5 to 10°C. The spoilage of salted fish is explained by the presence of highly salt tolerant bacteria in sea water and sea fish.

As regards to type of salt to be used, salt of highest purity only is to be preferred. Instead of the coarse big crystal salt, it has been found advantageous to use, crushed salt for a better product. But powdered salt will penetrate so rapidly that it will cause 'salt-burn.' At present the Na Cl content of fish curing salts is 94 to 97 per cent. For a soft cured product very pure Na Cl is desirable. But a small amount of Ca and Mg salts is considered to be necessary to give a firm texture to the flesh and also give the 'cured flavour'.

Brine salting is not practised in India and it has no special advantage over 'dry salting' in which peneration of Na Cl is quicker.

However 'Colombo curing' which is a type of brine salting is practised widely in South and North Karnataka coasts, and the product is entirely marketed in 'Colombo,' where the people seem to have developed a special taste for this product. In this method fish and salt are alternately arranged with a layer of 'gorakapuli (pulp of dried fruits of *Pithe-Colobium Saman*), in cement bins. It is heavily weighted and left for a month or two adding more and more of salt. When the salt has 'struck-through' the fish is removed and arranged in barrels, with head inward and tail outward and after arranging the layers in a circular fashion one above the other, it is heavily stamped by foot, so that as much of moisture as possible is squeezed out. After tightly packing the barrel with fish (roughly about 6,000 mackerels may go in a barrel) the barrel is plugged, and kept in this condition in a cool place for a week or two before finally sealing. During this period, the fish will sink further and the brine that oozes out is not drained, but poured again on the fish through the bung hole provided at the top.

The preservation action is brought about by salt as well as 'gorakapuli.' By proper chromatography it has been found that two organic acids are present in gorakapuli, one being tartaric and the other appears to be citric acid.

Fish pickles, sauces, etc.:—When small clupeids, whitebait etc., are caught they can be salted 'in the round' in vats and allowed to remain in the 'self' brine formed. Due to repression of bacterial action but continuance of enzyme action (because af the presence of viscera) there is a step-wise hydrolysis of fish proteins, resulting in the formation of a fish hydrolysate containing proteoses, peptones, peptides and amino-acids. This is a typically oriental product and has got high nutritive value.

Smoking:—The principle of smoke curing of fish depends on the action of the phenolic conssituents of wood-smoke, which have bacteriostatic properties. There is also partial dehyderation by the hot smoke. Since smoked fish has not commended itself to the Indian taste a detailed description of the process is unnecessary. However it may be mentioned that the Fisheries Technological Station, Kozhikode has produced some smoked fish having very good appeal.

Canning:—This is one of the most efficient methods of preserving fish and great strides have been made in the techniques in this aspect especially in America and Norway. When large quantities of suitable fish are obtained, they could be brought ashore by icing or better by brine-freezing for canning. The main principles of this method are the destruction of micro-organisms by the heat processes and by the removal of air. Highly sterile products could be obtained by canning fish. A detailed description will be out of place here.

Fish meal and fish oils:—Fish meal and oil industry is a very essential one, which is yet to make headway in India. Especially when the deep-sea fishing activities are multiplied, there is a definite need for a bye product industry like the meal and oil industry to utilize the large catches.

Meal for animal feeding can be produced by a simple process. For example the waste products of fish canning, salting or filletting operations, viz., heads, entrails. etc., are first ground and then dried in a steam-jacketed drier either with vacuum suction or without it. After drying it may be pressed and ground into powder.

When whole fish are used, a different method has to be followed. The Fisheries Technological Station, Kozhikode, produces wholesome fish meal from fresh shoaling fishes, like silver bellies, catfishes, mackerels, the gogglers, soles, jewfish etc., and this is utilised by the veterinary institutions for animal feeding. In some western countries fish meals hygienically prepared from freshfish, including shark are used even as human food.

When fatty fishes like sardines are used the fish must be freed of oil. The fish is cooked and pressed to separate out the oil. The residue known as 'guano' is not a perfect fish meal in that it still contains a large quantity of fat which may discolour the meal by oxidative browning and production of rancid odours. Hence further treatment is given to extract the last traces of oil. This can also be utilised as fertilizer for the plantation crops.

Fish manure:—When gutting operations are carried out on board the fishing vessels, the entrails are thrown over board, as it is not practicable to preserve them on-board; and further they will be unnecessary sources of contamination only. But on the shore, it is possible and profitable to convert these guts and gills into very valuable manure. The Fisheries Technological Station, Kozhikode, has demonstration centres for making such manures, in the East and West Coasts.

The 'self-brine' formed in the fish curing operations is also a very valuable fertilizer since quite a good amount of soluble protein nitrogen is present in it. Hence it is dried and used as manure especially for coconut plantations.

Liver Oil Industry:—At present the need to obtain enough shark-liver oil for therapeutic use, alone justifies the deep-sea fishing operations. Though formerly cod and halibut liver oils were considered to be the rich sources of vitamins A and D, as a result of pioneering work in this State, Shark livers were shown to be equally good if not better sources of vitamins A and D. The oil from the liver is extracted by methods similar to those from body. Livers are

disintegrated and cooked to break up the cells and release the fat. The oil is then pressed out and centrifuged for clarification. The oil is finally blended. The Government Oil Factory, Kozhikode is having upto date equipment to get a satisfactory recovery of the vitamin oil. The liver debris will be a rich source of nitrogen and of B group vitamins including B12 and can be profitably used as poultry and cattle feed.

Sharkfins are preserved with salt and lime and exported to the far-east where it is a delicacy. The shark-fin rays contain a protein food and a soup prepared from this is appreciated by the Chinese The shark skin may be utilised as a special leather - it is known as shagreen. The possibility of obtaining various hormone, enzyme and pharmaceutical preparations, from the glands and organs of shark are immense.

XIV. SHRIMP TRAWLING ALONG THE MALABAR COAST - 1955—56. BY V. JOHN AND A.T. SHERIFF.

INTRODUCTION.

Shrimps (Prawns) form an important fishery on the Malabar coast ranking among the first ten or twelve fisheries in quantity and value The total catches made by the fishermen with their indigenous nets amounts to about 1½ lakhs of rupees on the average. They are caught from the littoral waters of the coast from May to December, the peak period being September-October. The experimental shrimp trawling operations conducted on this coast from Tanur to Mangalore, under the guidance of Mr. G. S. Illugason, F.A.O., Fishery Engineer have proved the existence of rich shrimp grounds along the Malabar coast from December to April also. Thus it seems possible to get shrimps from the Malabar Coast almost throughout the year if proper fishing craft and gear are used.

DESCRIPTION OF FISHING VESSELS USED

1. *Danish boat* :—This boat, provided by F.A.O., is 22 feet in length and 7 feet in beam. It is fitted with a 10 B.H.P. single cylinder, 2-stroke semi-diesal engine and reversible propellor. It is also fitted with a " Line Mauler " and a " Rail Roller " for hauling up the trawl wire. The boat is sturdy built of Danish-grown timber with a high flaring bow and cruiser type stern. It is light enough to be hauled up on the beach when harbours are not within easy reach. Its hull and propeller are well protected for beaching. This boat requires just four men to work and the engine is simple to handle consuming low quantities of fuel.

2. *M. V. Samudra* :—This is a reel gill net wooden vessel allotted to Madras State under the T.C.A. Programme. It is of length overall 10.40 M, Breadth, 3·35 M., Depth, 1.50 M , Draft, 2'2 inches fore, and 4'2 inches aft, and of gross tonnage, 11.66. Total capacity is 30.029 C.M. It is powered by 3 LD-G Yanmar Diesal engine of 42 B.H P. of 4 cycle vertical solid injection. There is one generator of 30 Amperes for lighting. Maximum speed is 8.222 knots, R.P.M. 800. It is provided with an Echo sounder (Raytheon Junior Fathometer) and an insulated fish hold (1.2 Mx. 1.5 M) of 5 tons capacity. There is Crew-accommodation for five, fuel storage of 250 gallons and fresh water tank for 100 gallons. The wheel house is well forward, with the engine bedded under it. The stern is broad and square providing enough working space. Deck machinery consists of a wooden roller 4 feet long and 1 foot in diameter fixed on the stern gunvale. This has been removed and a small trawl winch provided by F A.O. was fixed just behind the fish hold hatch. Each drum of the winch is capable of holding 100 fathoms of 8 mm trawl wire. The main engine drives the

winch through bevel gears. Two iron rollers were also fixed on the stern gunvale, each in a line with the centre of the winch drum.

Description of trawls

No-overhang of flat trawl nets of cotton provided under the T.CM. Programme were operated from both the Danish boat and M.V. Samudra. The net used for the Danish boat was 30 feet by head rope, while Samudra operated the 40 feet trawl. The nets were made up each of 13 pieces of netting. The square, belly, wings jips and threads were of webbing 10/15 threads and 2 inches stretched mesh, while the cod end was of 10/42 th. and 1 inches stretched mesh. The head rope was of Sisal 1½ inches circumference with 10 cork floats for 30 feet trawl and 14 cork floats for 40 feet trawl. Each float was 6 inches long and 2½ inches in diameter. The foot rope was also sisal 1½ inches in circumference with 17 load weights for 30 feet trawl and 23 for 40 feet trawl. Each lead weight weighed 250 gms. The webbings were hung 72% to head ropes.

Otter Boards

The Otter boards used from "Samudra" were provided by F.A.O. Each board was made of 4 pieces of 5/8 inches thick hard wood 3¾ feet long and 2 feet broad strengthened on each side with 4 vertical ¼ inches thick iron straps rivetted together through the wood. The lowder edge of the board was of iron ¼ inches thick and 2 inches broad rivetted on to the iron straps. Each board weighed 40 lbs. The iron brackets 5/8 inches in diameter were fixed to the board as shown in the figure. The trawl wire was shackled to the centre hole in the iron bracket of the board.

The Otter boards used from Danish boat were also provided by F.A.O. Each board was made of 2 pieces of 2/4 inches thick hard wood 42 inches into 21½ inches with 2 vertical ¼ inch into 1½ inches iron plates rivetted together. The iron brackets were 5/8 inches in diameter and iron shoe ½ inch wide and 1 inch thick. The details are explained in the figure. Each board weighed 28 lbs.

Topography of the Coast

The Beypore coast is low and sandy fringed with coconut trees. Kadalundi, Beypore, Kallai and Elathur rivers flow into the sea on this coast. A rocky patch lies on the south-eastern entrance of the Beypore river, which is the only river navigable throughout the year, the average depth over the bar being 6 feet. Rocky shoals also lie scattered off Calicut up to 4 miles from shore. Tellicherry coastal are. is of alternate cliffs, with sandy beach, fringed with coconut trees North of Tellicherry up to Cannanore the coast is finged by rocks above and below water. Koodali, Anjarakandi and Valarpatanam rivers flow into the sea on this coast. River Netravati flows into the

sea on the Mangalore coast. Besides numerous small rivers flow in torrents during the south-west monsoon and become shallow streams during summer. The substratum of these areas is of thick mud.

Operation of Trawls

The trawl was dragged over the bottom by two long warps of trawl wire (galvanised wire of 8 mms.) extending from the vessel to the two Otter Boards attached to each corner of the mouth of the net by two pieces of 8 mm. galvanised wires each 4 fathoms long. The vessel in towing the trawl caused the Otter Boards to move along the bottom of the sea on their iron shoes, stretching open the mouth of the net between them. The head rope of the net with floats tending to keep the net up, the foot rope with weights running close to the bottom and the drag of the water passing through the meshes of the net, held the net wide open. The trawl wires were marked at every ten fathoms and care was taken to run them out from the winch evenly to avoid fouling the gear. On reaching the ground, with propeller stopped, the cod end first and then the whole net was thrown over the stern. Next, the vessel moving ahead slowly, the otter boards were released by two of the crew, one on each side, simultaneously running the trawl wires evenly. The length of the trawl wire paid out, was usually eight times the depth of water where trawl was operated. The vessel was then maneuvered very slowly to the chosen course and run at 520-550 R.P.M. (approximately 2 1/8 knots) in the case of "Samudra" and at 1½ knots the maximum towing power available in the Danish boat. While hauling the trawl, the speed of the vessel was not lowered. When the otter boards reached the stern, the winch and propeller were stopped, the other boards hauled up on deck by two men. This was done very quickly and then the vessel was run at full speed for about 5 minutes to drive away to the cod end, the fish trying to escape out. Moving slowly with the wind aft or quarter on the working side, the propeller was stopped, the net hauled in and cod end emptied. The period of operations was usually from 5 a.m. to 3 p.m. when calm sea prevailed. By afternoons the winds blew from south-west and the sea became rough enough to make trawling difficult especially from the Danish boat.

Results

The exploratory trawling operations were initiated by Mr. Illugason since January 1955. At Tellicherry, the first centre selected, 30 feet flat trawl was operated from the Danish boat in depths ranging from 6 to 10 fathoms. The catch was poor consisting of small sea breams, silver bellies and miscellaneous small fish. The operations were then shifted by middle of January very close to the shore in depths from 1 to 3 fathoms when good hauls of shrimps were made. The operations were continued till the end of April 1955 in the same depths

along the Tellicherry coast when nearly 11½ tons of shrimps and miscellaneous small fish were caught, fishing for 60 days only in a total of 203 hours which works out to 431.3 pounds per day and 127-5 pounds per hour. The fishermen believed that the shrimp season lasts only from June to September, though small quantities of shrimp were caught in their bag seines (Kollivala) during January to April. Kollivala is a local boat seine with a head rope about 80 fathoms long and ground rope 45 fathoms. The bag measures 40 fathoms in length. The meshes vary from ¼ near the month to 1/32 inch near the cod end. Two stone sinkers are used on the ground rope of the wing. A coir webbing 10 fathoms in length, 7 fathoms in breadth and 2 inch mesh, is joined to the ground rope. This net is operated from two Dug out canoes. The net is carried in both the canoes with the bag between them. After reaching the ground the canoes move-away from each other across the current paying the net. They then close the net along the current, stay for about 15 minutes and then haul up the net. The maximum catch on a Kollivala on the same ground off Tellicherry hauled by one unit of two canoes during the period from the middle of January to April 1955, but for 70 days only, was nearly 6½ tons of miscellaneous small fish and shrimps. The results of the Danish boats, therefore which attracted the attention of fishermen, formed the foundation for an intensive survey of the coast line for shrimps from Beypore to Mangalore with the Danish boat and M. V. Samudra from January to April 1956. Trawling for 72 days, actual fishing hours being 371 during the above period along the Beypore, Tellicherry and Mangalore coasts in depths from 1 to 5 fathoms, M. V. Samudra landed nearly 18 tons of shrimps and miscellaneous small fish making on an average of 6 hauls a day, each lasting either 40 minutes or an hour. Thus nearly 570 lbs. was the catch per day and 110 lbs. per hour on an average.

The Danish boat operating the 30 feet trawl for 47 days during January to April 1956 along the Beypore and Mangalore coasts in depths from 1 to 3 fathoms landed nearly 9 tons of shrimps and miscellaneous small fish making on an average 5 hauls, each lasting either an hour or 40 minutes. 430 pounds was therefore the catch per day and 93 pounds an hour's catch.

The appended statement shows the details of results :—

Marketting

The shrimps caught (Metapenaeus and Parapenaeopsis species) were good size about 4 inch in length on an average. With the departmental enterprise of manufacturing semi-dried prawns at the Fisheries Technological Station, Calicut, about 10 per cent of the total catch was disposed of there. About 80 per cent of the catch was taken by Messrs. Malabar Fisheries Corporation (Private) Calicut for quick-freezing and export to U.S.A. Nearly 10 per cent was marketed to local merchants for fresh consumption. The price per pound was Rs. 0-2-0.

Small Jew fish *(Sciaena Spp)*, silver bellies (*Leiognathus spp*), crabs, young pomfrets (*Strometeus spp*) Soles (*Cynoglossus spp*) constituted chiefly the miscellaneous forms of the daily catch throughout the coast line surveyed. These were disposed off to local merchants at prices varying from one anna to one and a half annas per pound.

Discussion

The results of trawling, proved the existence of potential shrimp grounds along the inshore belt in 1 to 5 fathoms depth from Tanur to Mangalore during December to April and the possible existence of similar grounds which have not yet been trawled north of Mangalore and South of Tanur during the same period from January to April each year, when the fishermen consider it an off season for shrimps. The fact that the trawl alone makes good hauls of shrimps (nearly 75 per cent of the total weight) as against poor catches of shrimps (nearly 35 percent of the total catch) in the fishermen's bag seines (Kolli Valas) during January to April leads to the conclusion that the shrimps shoal in midwater on the same inshore grounds during June to September when the fishermen easily land them in their Kolli Valas, that this Kolli Vala, which does not sweep the sea better becomes not very effective during January to April when shrimps remain very close to the thick muddy bottom and that a trawl with a heavy ground rope and otter boards to plough the substratum, distrub the shrimps and drive them to the net is very necessary.

The results of "Samudra" from the appended statement clearly show that during January and February 1956 the catch per day along the Beypore coast was 313·1 pounds, during February and March 1956 along the Tellicherry coast was 553·0 pounds per day and during March and April 1956 along the Mangalore coast was 984·5 pounds per day. Likewise the Spanish boat catch increased from 366·6 pounds per day during January and February 1956 along the Beypore coast to 503·1 pounds per day during March and April 1956 on the Mangalore coast. This will not, however, prove that shrimp grounds on the Mangalore coast are richer than the Beypore coast. Simultaneously fishing the different sections of the coast during the same period will only confirm the existence of comparative richer grounds. The results of the Danish boat from the end of January to the end of April 1955 along the Tellicherry coast averaging to 431·31 pounds per day, which is more than that obtained from January to February 1956 along the Beypore coast and less than that from March to April 1956 along the Mangalore coast leads, however, to believe that the potentiality of the shrimp grounds along the whole Malabar Coast increases from January to April each year.

Statement showing the Details of Shrimp Trawling along Malabar Coast, 1955—56

	Area trawled.	Name of the Boat	Period fished	Gear used	Number days fished	Number of hours fished	Weight of shrimps	Weight of fish other	Total catch in pound	Weight of Catch per day	Weight of catch per hour	Per cent of Shrimps catch
1	Tellicherry Coast, Lat. 11° 30', Long 75° 35' to Lat. 11° 48'5' Long 15° 23'2'.	Danish Boat.	25th January to 30th April '55.	30 feet flat trawl of 2 inch stretched mesh.	60	203	20,705	5177	25,882	431.3	1127.5	79.9
2	do.	Two canoes.	Jan. to April '55.	Kolli Vala.	70	300	3,880	7320	11,200	160.0	37.3	34.6
3	Off Beypore and Chaliyam.	Danish Boat.	1st Jan. to 21st February 1956.	30 feet flat trawl of 2 inch stretched mesh.	24	150	6,248	2552	8,800	366.6	58.6	71.0
4	Off Mangalore ...	Danish Boat.	21st March to 17th April '56.	do.	23	70	9,141	2431	11,572	503.1	165.3	78.9
5	Beypore Coast Lat. 11° 0' Long. 75° 49' to Lat. 11° 18' Long. 75° 41.5'.	Samudra.	2nd Jan. to 4th Feb. '56 and 13th Feb. to 17th Feb. '56.	40 feet flat trawl of 2 inch stretched mesh.	32	163	6,824	3197	10,021	313.1	61.4	68.9
6	Tellicherry Coast, Lat. 11° 39', Long 75° 30' to Lat. 11° 52', Long 75° 17'.	Samudra.	7th February to 11th Feb. '56 and 20th Feb. to 7th March 1956.	do.	20	106	8,185	2876	11'061	553.0	104.3	73.9
7	Mangalore Coast Lat. 12° 46' Long 74° 48' to Lat. 12° 55', Long 74° 46'.	Samudra.	20th March to 19th April '56.	do.	20	102	16,145	3545	19,690	984.5	193.0	82.3

XV. AN EXPERIMENTAL INTRODUCTION OF NYLON DRIFT NET IN THE COASTAL WATERS OF TUTICORIN, GULF OF MANNAR, BY P. I. CHACKO.

The use and value of nylon netting as opposed to line linen and cotton netting in the fishing industry have been reported favourably from various countries. It is resistant to bacteria, mildew and rot inducing organisms and under normal conditions there is no deterioration from storage. This is an advantage over cotton since its deterioration from fish slime bacteria and mildew is very rapid. There is no possibility of fire by spontaneous combustion as with linen or cotton. Few of the common chemicals react with nylon, Petrol, Diesel oil and alcohol do not harm it. Nylon is smoother and is more wear-resistant. It stretches appreciably under a strain and its elastic recovery is high and therefore could catch more and larger fish.

With a view to demonstrate the utility of nylon to the local fishermen, experimental fishing was conducted at Tuticorin. One of the commonly used drift net in Tuticorin is valavala. It has six pieces each 75 feet long and 20 feet broad with a mesh 1.5 inches from knot to knot. It is made of No. 10 count cotton yarn and has floats along the head line. A set of this net costs Rs. 500. It is operated throughout the year in waters of depth 8-10 fathoms from a boat with a crew of 5 men. One valavali was got made with nylon (75 cones of No. 7) and operated by a Fisheries departmental unit from November 1954 to April 1956 with the results shown in the appended table.

The above experiment proved the efficiency of nylon over the local cotton net. Though the catches varied with reference to oceanographical and weather conditions, the average daily catch with the nylon net was twice that of the ordinary cotton net. The cost of the former is double of the latter but it is possible to realise the capital value within a few weeks. Besides, the local tackle requires frequent mending and does not last as much as the nylon net. The latter therefore became popular among the local fisherfolk who have now begun to demand special supplies of nylon twine. To meet this growing demand a scheme under the Second Five Year Plan is being implemented.

Table showing fish captured by operating one nylon net off Tuticorin, November 1954—April 1956.

Month	No. of days of operation	Range of catch per day in lbs.	Total weight of fish in lbs.	Value realised in Rs.	Chief catches
(1)	(2)	(3)	(4)	(5)	(6)
1954				Rs. A. P.	
November ...	4	160 — 1,080	1720	100 7 0	Leather-jackets young sharks, rays, sabre fish, perches and horse-mackerels.
December ...	17	15 — 136	504½	504 9 0	Leather-jackets spotted dory, sharks, rays, bekti horse-mackerels, cat-fishes, sabre fish and thread fins.
1955					
January ...	9	48 — 353	980½	233 13 0	Leather-jackets sharks, rays, sabre fish and catfishes.
February ...	11	22 — 190	816	636 11 0	Seer, sharks, leather-jackets and horse-mackerel.
March ...	26	51 — 1,089	6712	6,722 12 0	Seer, sharks, leather-jackets, sabre fish, catfishes, bekti and, tunnies.
April ...	22	44 — 355	4459	1,681 14 0	Seer, tunnies, sharks horse-mackerels, sabre fish.
May ...	24	22 — 648	5213	1,972 7 0	Leather jacket, Sabre fish, shark, seer, rays, cat fishes.
June ...	23	41 — 464	3421	1,400 13 0	Leather jacket, sabre fish, seer, rays, cat fish.
July ...	25	15 — 421	3520½	1,206 3 0	Sabre fish, seer, sharks, leather jacket, rays.
August ...	22	35 — 327	2459	1,018 3 0	Sharks, seer, horse mackerels, sabre. fish, leather jacket.

Month	No. of days of operation	Range of catch per day in lbs.	Total weight of fish in lbs.	Value realised in Rs.	Chief catches
(1)	(2)	(3)	(4)	(5)	(6)
				Rs. A. P.	
September ...	25	10 — 450	3885	1,261 12 0	Sharks, rays, spotted dory, leather jacket, seer.
October ...	24	12 — 822	3491	1,892 15 0	Shark, rays, seer, sabre fish, saw fish.
November ...	26	26 — 315	3077	691 14 0	Sharks, rays, pomfret, seer, plough fish, sabre fish.
December ...	18	11 — 321	2276	555 15 0	Sharks, rays, sabre fish, thread fins, pomfret.
1956					
January ...	19	29 — 605	3142	750 3 0	Sharks sabre fish rays, seer, leather jackets saw fish.
February ...	16	40 — 270	2186	719 7 0	Sharks, Sabre fish, rays, seer, cat fishes.
March ...	20	110 — 311	3355	1,179 8 0	Sharks, seer, rays, sabre fish, leather jackets, cat fishes.
April ...	17	58 — 1984	4262	1,222 3 0	Leather jackets, sharks, rays, cat-fishes, seer, sabre fsh tunnies.

XVI. DAILY OBSERVATIONS ON THE TEMPERATURE AND SPECIFIC GRAVITY OF THE SURFACE WATERS OF THE INSHORE WATERS OF THE ARABIAN SEA OPPOSITE THE MARINE BIOLOGICAL STATION, WEST HILL, MALABAR COAST, FROM 1949 TO 1955.

BY P.I. CHACKO AND M.J. MATHEW.

Temperature and specific gravity are two of the important physical factors which are responsible for the changes in the environmental conditions of the sea and thereby on the life cycles and populations of marine plants and animals. At the marine Biological Station, West Hill, these factors are recorded almost daily in connection with the investigations on the fisheries of the Malabar coast. The samples of waters are collected from the surface at about 8.00 hours at a fixed point in the sea at the three fathoms line opposite the station by means of a bucket lowered from a rowing boat; and insulated thermometers and Sea Wasser Araometers were used to determine the temperature and specific gravity.

The surface temperature readings are shown in Tables I - VII. It will be seen that there is a regular increase in temperature from January to May, accompanied by a fall reaching the minimum in July-August. The maximum temperature is 29.0 - 31.1°C in March - April, and the minimum is 21.2 - 25.0°C. The specific gravity data are shown in Tables VIII - XIV. This factor is also high (1.0240 - 1.0281) in April-May and low (1.0110 - 1.0125) in June - August, thus showing a close inter-relationship between temperature and specific gravity.

TABLE I—*Surface Temperature °C 1949*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	27·8	28·3	30·1	...	27·9	...	26·0	26·8	...	25·2	27·2
2.	...	28·2	28·1	30·3	29·4	29·2	26·8	27·4	27·4	...	...	26·8
3.	28·7	28·4	27·8	...	29·7	27·9	...	28·2	26·4	...	...	28·1
4.	28·7	28·1	28·3	28·2	30·2	27·5	26·3	25·4	...	27·2	30·3	...
5.	28·8	28·5	29·4	28·6	...	...	26·7	26·1	...	26·9	25·4	27·7
6.	28·5	...	30·1	29·3	29·6	27·2	26·4	25·2	...	27·2	...	26·8
7.	28·1	27·6	30·3	29·2	30·2	27·7	26·3	...	...	28·2	27·9	28·1
8.	27·5	27·9	29·6	29·9	...	28·2	27·5	...	26·6	28·6	27·4	28·2
9.	...	28·0	30·0	28·9	29·6	...	...	26·0	26·6	...	25·2	28·1
10.	27·6	28·3	30·4	...	30·1	28·4	...	26·3	26·2	25·6	26·1	28·3
11.	...	28·1	...	30·1	30·5	27·8	26·7	27·0	...	25·0	25·4	27·9
12.	...	27·8	28·3	30·2	30·4	...	26·2	26·7	...	25·7	25·1	27·7
13.	...	...	29·8	...	27·3	25·6	26·2	26·1	26·5	25·3	...	27·4
14.	...	...	30·2	...	29·2	28·8	25·7	...	26·0	25·6	25·3	27·6
15.	...	27·6	29·9	...	29·7	...	25·6	26·3	25·8	25·6	29·0	27·4
16.	...	29·3	30·5	30·1	29·5	28·3	24·6	26·6	26·6	...	27·6	27·6
17.	28·0	29·1	27·9	29·0	29·7	28·0	...	26·1	25·8	25·2	25·2	27·4
18.	27·9	28·7	28·1	30·7	29·7	...	26·1	27·2	...	25·2	25·9	...
19.	28·1	29·0	...	30·8	28·6	...	27·3	...	27·0	26·2	25·7	27·6
20.	28·0	...	...	29·7	28·7	27·3	26·4	...	26·6	26·6	...	27·4
21.	28·4	28·5	28·1	30·3	...	27·1	27·3	27·4	...	25·6	...	27·3
22.	...	27·8	30·1	29·9	...	26·8	...	27·7	25·9	...	25·1	26·3
23.	...	28·0	30·5	...	28·8	26·3	...	26·1	27·1	28·9	...	26·8
24.	27·8	28·2	30·2	...	28·3	26·6	...	27·1	27·6	28·7	28·7	27·6
25.	28·0	...	30·2	29·8	28·1	27·1	26·3	26·7	26·3	25·8	26·8	27·7
26.	27·5	28·1	29·8	30·2	28·5	...	26·7	27·2	...	25·2	27·2	...
27.	28·3	...	...	30·2	29·0	26·9	26·8	...	28·4	25·2	25·8	...
28.	27·6	28·1	30·7	30·2	27·8	26·8	...	26·2	28·8	27·9	...	26·9
29.	28·3	...	30·7	30·0	...	27·2	27·2	26·1	...	28·7	28·9	26·3
30.	...	...	29·8	30·3	28·1	26·8	26·8	26·0	26·4	...	26·9	26·5
31.	27·6	...	30·1	...	28·0	...	...		27·2	...	27·9	26·9
Average	28·15	28·45	29·25	29·75	28·9	27·7	26·05	26·45	27·2	26·85	27·7	27·3

TABLE II—*Surface Temperature, °C 1950*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	28·3	28·6	29 3	28·8	26·5	...	26·5	28·3	...	27·7	28·0
2.	...	27·7	28·2	...	29·6	26·2	...	27·1	28·4	...	27·5	28·0
3.	27·4	27·8	28·5	...	29·3	26·6	26·8	26·9	...	25·3	26·4	
4.	27·2	27·4	...	29·4	...	...	26·7	27·0	...	26·1	27·0	28·2
5.	28·3	...	...	29·2	29·3	27·2	26·1	26·2	25·7	26·5	...	27·9
6.	28·2	27·8	27·6	29·1	30 3	27·7	26·2	.	26·0	27·1	27·8	28·4
7.	25·6	28·3	28·7	...	...	27·8	26·0	23·7	25·2	26·9	29·0	28·1
8.	...	28·1	28 5	29·7	30·1	26·7	25·8	...	24·6	...	...	27·7
9.	25·8	27·8	27·7	...	30,5	26·4	...	...	24·6	27·3		27·9
10.	20·6	27·2	28·7	28·2	29·8	26·7	26·0	26·1	...	...	28·7	
11.	...	27·2	28·9	29·4	30·5	...	26·3	23·9	23·2	...	28·7	27·5
12.	28·0	...	..	29·4	30·2	29·1	25·7	26·8	25·0	...		
13.	...	28 0	29·1	...	30·1	26·1	25·6	...	25·2	28·1	29·2	27·7
14.	...	27·8	28·7	...	...	29·4	25·8	26·9	24·2	28·8	28.9	28·0
15.	...	...	28 8	29·6	29·4	...	25·2	...	...	...	29·1	28·5
16.	28·3	27.4	28·3	...	29·7	26 2	...	27·1	24·0	27·9	28·2	28·3
17.	27·4	28·3	28·6	29·4	29·9	...	...	27·6	...	27·5	28·5	...
18.	27·4	...	...	29·1	29·7	...	26·0	26·8	25·7	...	27·9	28·7
19.	27·2	...	...	29·7	28·7	26·4	26·4	...	25·8	...	...	28·2
20.	26·3	28·0	29·1	29·6	...	28·1	25·6	...	24·6	...	28·6	...
21.	...	27·9	28·8	29·8	...	28·3	25·5	26·4	24·6	...	29·2	28·5
22.	...	29·1	29·2	...	29·1	26·6	...	26·1	25·2	...	28·9	...
23.	27·2	29·2	29·3	...	30·3	27·4	...	27·3	...	...	28·3	28·1
24.	27 2	28·7	28·3	28 9	29 8	26·7	24·2	...	...	28·7	28·8	...
25.	28.1	28·8	29·3	28·7	28·3	....	25·1	...	...	29·1	28·3	...
26.	...	...	...	29·8	27·6	28·1	24·4	...	25·5	28·9		28·5
27.	...	28·4	...	28·7	27·3	28·2	24·0	...	26·0	28·5	28 5	28·6
28.	...	28·1	29 7	29·6	...	29·2	23·8	...	26·4	28·5	28·4	27·9
29..	...	...	29,5	29·4	26·4	6·7	24·1	27·2	25·0	...	28·1	28·4
30.	...	...	29·6	...	26 8	27·5	...	26·1	25·5	28·7	27·7	28·0
31.	28.5	..	29·1	...	27·1	...	27·2	27·1	...	27·8	...	...
Average	24·55	28·2	28·65	28·95	23·45	27·8	25·5	25·65	25·8	27·2	27·8	28·05

TABLE III—*Surface Temperature, °C 1951*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	29·3	...	...	28·6	27·6	...	24·1	22·7	21·5	29·6	28·3
2.	27·8	29·4	29·6	29·7	29·2	28·5	28·1	24·4	...	...	29·8	...
3.	28·6	29·3	29·8	28·9	29·8	...	27·7	26·0	23·1	...	30·5	29·1
4.	28·7	...	...	28·7	28·9	27·6	28·6	24·3	23·3	23·6	...	30·2
5.	28·5	29·6	30·1	29·4	29·3	27·4	25·7	...	...	24·2	30·7	29·2
6.	28·7	29·3	...	29·5	...	28·1	...	22·1	24·1	25·1	30·8	29·3
7.	...	28·5	29·7	29·6	28·8	27 3	26·7	22·9	24·4	...	30·4	28·6
8.	28·7	29·1	29·5	...	29·4	27·2	...	22·4	24·3	...	30·9	28·6
9.	28·3	29·2	29·9	29 6	29·7	26·7	25·8	23·4	...	...	30·5	...
10.	27·8	29·9	29·7	29·1	29·4	...	26·1	22·3	23·4	...	30·7	28·6
11.	28·7	...	...	27·3	29·3	28·4	25·7	21·7	...	23·1	...	28·2
12.	27·7	29·4	29·9	27·1	30·3	26·2	26·3	...	...	...	30·5	...
13.	...	29·4	28·8	27·4	...	26·4	26·1	22·5	...	23·7	30·2	28·0
14.	...	29·6	30·9	...	29·7	27·6	25·4	23·3	...	...	30·3	28·2
15.	...	29·5	29·3	...	28·4	26·1	...	...	24 8	25·8	30·2	28·3
16.	28·3	29·6	29·7	29·5	29·2	27·3	27·3	....	...	26·3	30·2	...
17.	28·1	...	28·9	30·2	29·4	...	26·2	22·3	25·7	28·4	..	28·5
18.	28·4	...	...	29·9	29·3	28·1	25·7	...	26·1	29·3	...	28·4
19.	28·8	28·9	29·1	29·7	...	27·7	24·1	...	26·3	29·5	29·5	28·7
20.	...	29·3	29·5	29·3	...	26·7	26·4	22·1	26·4	30·0	28 8	27·5
21.	...	29·3	29·3	...	29·5	26·4	...	20·1	28·7	...	29·2	28·0
22.	28·8	29·5	29·4	28·8	28·7	27·3	...	23·1	27·9	29·5	29·3	...
23.	29·1	29·4	...	28·4	29·9	...	23·5	23·3	...	30·1	28·8	...
24.	28·7	29·3	...	29·5	28·8	..	23·4	21·7	27·3	29·9	30·1	27·8
25.	29·0	...	...	30·2	29·2	27·9	25·7	...	26·3	30·3	...	...
26.	..	29·3	28·6	28·3	30·2	26·8	26·1	..	27·9	30·5	28·2	27·0
27.	29·0	29·3	29·3	29·4	...	27·1	26·3	21·2	28·7	30·4	30·2	27·3
28.	..	29·6	29·5	...	30·1	28·3	23·1	21·7	24·9	...	29·8	27·0
29.	28·8	...	29·3	29·6	29·3	28·7	..	22·1	21·2	...	30·0	28·0
30.	29·1	...	28·8	..	29·2	28·6	22·9	23·6	...	..	29·9	...
31.	28·7	...	29·3		29·0	...	23·7	22·3	...	30·7	...	26·4
Average	28·4	29·05	29·75	28·65	29·4	27·45	25·75	23·65	24·95	26·1	29·5	28·3

TABLE IV—*Surface Temperature, °C 1952*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	29·3	29·5	30·1	30·7	...	25·2	25·3	...	28·2	28 3	...
2.	26·5	28·1	...	30·3	30·6	27·6	25·0	22·8	...	...		26·7
3.	27·0		29·3	30·3	30·8	28·2	24·8	...	...	26·0	28·1	28 5
4.	27·2	27·9	29·0	30·1	...	28·4	24·7	24·1	...	27·2	28·1	28·5
5.	27·6	27·8	29·8	30·3	30·7	27·4	24·8	24·3	24·5	...	25·2	28·7
6.	...	28·0	29·3	...	29·1	27·3	...	26·1	24·2	...	24·1	28·6
7.	...	29·3	29·7	30·3	30·8	27·1	24·0	25 7		26·2	27·5	...
8.	28·2	29·0	29 6	30·4	30·8	...	25·1	28·4	24·7	26·4	27·1	28·5
9.	28·5	29·1	...	30·5	30 0	27·3	24·5	24·7	24·5	26·1	...	27·4
10.	28·4	...	28·8	30·4	31·3	27·6	24·7	...	...	26·8	26·3	27·5
11.	28·5	29·0	29·9	...	...	27·1	24·1	24·9	24·8	27·5	27·5	28·5
12.	...	28·9	29·5	30·4	31·5	27·9	23 5	23·4	24·5	...	27·8	28·7
13.	...	29·3	29·9	...	30·3	28·2		23·1	25·7	25·4	27·5	28·4
14.	...	29·1	29·9	30·6	30·2	27·1	23·7	25·2	...	26·5	27·6	...
15.	...	29·4	29·4	30·0	29·7	...	24·1		24·5	26·7	28·1	29·5
16.	28·7	...	...	30·0	29·9	26·7	24·7	23·7	23·8	27·1	...	27·0
17.	28·3	...	29·1	30·4	29·5	27·3	24 6	...	23·4	...	28·0	29·5
18.	28·4	29·1	29·8	30·5	...	26·8	24·1	23·1	...		29·0	29 0
19.	...	28·7	29·4	...	29·8	27·3		24·1	24·3	...	28·0	27·5
20.	...	29·5	29·9	...	30·1	27·8	...	23·7	...	25·5	28·0	...
21.	28·0	29·4	29·3	30·1	29·7	...	24·3	23·9	...	26·0	29·0	...
22.	27·2	29·9	...	30·7	28·6	...	24·4	23·8	23·5	27·0	...	29·0
23.	28·2	...	...	30·6	28·5	27·7	25·6	...	23·7	26·0		21 5
24.	28·3	...	30·2	30·1	...	..	25·9	...	23·9	26·0	28·0	28 5
25.	28·1	29·9	30·1	30·7	...	28·1	25·3	23·7	24·4	28·0	28·0	
26.	...	28·9	29·8	30·6	28·3	27·4	24·3	23·6	...	...	29·0	28·0
27.	...	28·9	29·7	...	28·1	26·4	...	23·8	...	27 0	28·1	...
28.	28 0	29·7	29·8	30·4	28·0	27·2	24·3	23·5	...	26·0	28·5	...
29.	28·5	29·7	29·9	30·5	27 7	...	25·8	25·2	23·9	29·0	27·5	28·5
30.	28·2	...	...	30·6	28·5	27·0	23 7	25·5	...	28·0	...	29·0
31.	28·0	...	30·2	...	28·7	...	24·1	...	...	29·0	...	29·0
Average	27·6	28·9	29·5	30·35	29·75	27·4	24·7	25·6	24·55	27·2	26·55	28·1

TABLE V—*Surface Temperature, °C 1953*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	...	...	29·5	30·0	29·0	26·0	24·5	27·2	...	...	29·2
2.	29·0	27·0	28·5	29·5	30·5	29·0	26·0	...	27·5	...	[illegible]	29·5
3.	29·0	27·5	28·0	...	...	29·4	27·5	24·5	26·0	29·0	[illegible]	29·0
4.	...	28·0	28·5	29·5	31·0	28·0	27·0	26·5	27·0	...	[illegible]	28·6
5.	27·5	27·5	28·0	...	29·5	28 0	...	27·0	26·0	28·0	...	27·5
6.	28·0	27·5	28·5	29·8	30·0	29·0	25·0	26·0	...	29·1	...	...
7.	27·6	27·5	28·2	29 8	29·0	...	25·5	27·0	26·5	...	30 0	27·0
8.	27·7	...	...	30·5	30·2	29·0	25·9	26·0	26·0	29·5	...	27·0
9.	29·0	28·0	29·5	29·5	29·0	28·0	26·0	...	27·0	30·0	29·0	26·0
10.	29·5	28·0	29·0	30·5	...	27·5	26·5	26·0	27·0	30·0	28·5	26·2
11.	...	27·5	30·5	30·0	29·5	27·5	27·0	26·0	26·0	...	29·0	26·0
12.	27·8	...	...	...	29·5	27·0	...	26·0	...	30·0	29·0	27·0
13.	...	27·0	30·2	30·0	30·5	28·0	25·7	27·0	...	29·5	29·0	...
14.	...	25·5	30·5	...	29·5	...	27·5	26·0	26·5	29·0	29·0	28·0
15.	28·5	...	...	30·2	29·0	28·5	26·5	...	28·0	...	...	28·0
16.	28·0	27·9	29·9	...	30·1	28·0	27 0	...	28·0	...	29·0	...
17.	28·5	28·5	29·8	...	...	27·5	27·0	25·5	28·0	...	29·0	28·0
18.	...	28·0	30·0	...	29·5	26·1	...	26·0	28·0	...	29·0	28·3
19.	29·5	27·8	29·9	...	30·0	25·4	...	26·0	...	29·0	29·0	...
20.	28·5	28·5	30·2	30·5	30·0	...	...	26·0	...	27·5	...	...
21.	29·0	...	...	29·0	29·5	26·0	25·7	...	28·5	28·0	29·0	27·3
22.	28·5	...	29·5	28·5	29 0	25·5	25·7	...	28·3	29·7	...	27·5
23.	28·5	28·0	30·2	29·5	...	25·7	25·8	...	28·5	30·0	27·4	27·3
24.	...	27·5	30·5	30·5	...	26·7	26·4	...	27·3	...	27·4	25·0
25.	...	28·5	31·2	31·0	29·5	27·0	25·7	...	27·0	...	28·0	...
26.	...	28·0	30·8	...	29·0	27·5	...	27·0	27·0	29·8	28·5	29·0
27.	28·5	29·0	30·0	29·5	29·0	...	26·0	27·0	...	30·0	28·2	...
28.	27·5	28·0	...	29·7	28·5	27·8	26·0	26 0	26·0	30·5	29·0	28·0
29.	28·0		29·0	29·5	29·0	28·0	24·5	26·0	27·0	30·5	...	28·0
30.	27·5	...	29·0	30·5	...	...	24·0	...	28·0	29·5	29·0	28·5
31.	28 0	...					24·0			29·5	...	29·0
Average	28·5	28·0	29·6	29·95	29·75	27·5	25·75	25·75	27·25	29·0	28·7	27·25

TABLE VI—*Surface Temperature, °C 1954*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	28·2	29·2	29·5	29·7	28·0	26·0	...	...	25·9	27·8	27·4
2.	29·0	28·3	29·4	29·0	...	26·5	25·5	24·5	23·8	...	26·4	27·4
3.	...	27·9	...	29·4	30·1	...	25·4	24·7	23·8	...	27·1	27·5
4.	28·0	28·0	29·2	...	29·9	26·4	...	23·5	23·5	25·5	28·2	27·3
5.	29·0	28·0	28·9	30·2	29·0	26·5	25·2	24·0	...	...	28·2	...
6.	29·0	28·5	28·5	30·3	29·7	...	25·4	23·7	24·0	...	28·1	27·4
7.	29·0	...	...	30·2	29·5	26·4	24·7	24·5	25·2	...	...	27·2
8.	29·0	28·0	28·6	30·2	29·6	26·0	24·2	...	26·8	27·7	27·5	27·7
9.	29·0	27·0	28·8	30·2	...	26·1	24·3	23·9	...	27·5	...	27·1
10.	...	28·2	29·0	30·0	29·1	25·2	25·7	...	...	...	26·4	27·3
11.	29·0	28·8	29·2	...	29·0	21·5	...	23·8	...	28·4	27·5	27·7
12.	29·0	28·3	29·0	31·0	29·7	26·4	25·5	23·9	...	28·2	27·4	...
13.	...	28·4	29·3	...	28·1	...	25·0	24·5	24·2	28·5	27·4	28·0
14.	...	...	...	...	28·7	27·5	25·2	...	25·2	28·3	...	28·2
15.	29·0	28·7	29·3	31·0	27·8	27·4	26·3	...	25·5	27·3	27·1	28·0
16.	28·0	28·5	30·2	...	...	26·5	25·6	24·4	25·7	28·0	27·0	..
17.	...	28·9	30·4	...	28·5	26·0	25·0	24·9	25·8	...	28·2	...
18.	27·5	29·4	30·4	...	29·2	26·5	...	25·8	26·0	27·2	28·2	...
19.	28·0	29·2	30·2	31·2	28·7	...	24·2	25·5	...	27·4	28·3	...
20.	27·5	...	...	30·3	29·6	...	24·1	24·5	25·1	...	..	...
21.	27·8	...	...	30·8	28·2	27·2	25·5	...	25·5	27·8	...	...
22.	27·5	29·0	30·2	30·0	...	28·0	25·7	...	24·4	27·3	27·9	...
23.	...	29·2	30·3	28·5	...	27·9	25·0	24·3	26·2	27·2	28·1	...
24.	...	28·2	29·3	27·8	28·0	26·1	...	24·5	24·5	...	28·3	...
25.	27·3	28·2	30·0	...	28·2	26·6	...	24·5	24·2	...	29·0	...
26.	...	27·5	30·4	30·0	28·0	26·1	26·5	25·0	...	...	28·0	...
27.	28·1	28·0	30·5	29·8	29·7	...	25·4	24·8	24·8	27·5	28·2	...
28.	27·9	...	...	30·0	29·7	25·1	26·2	24·5	24·2	28·1	28·0	...
29.	28·5	...	29·6	30·9	28·2	26·0	26·0	...	24·2	27·5	27·5	...
30.	28·4	...	29·6	30·1	...	25·8	26·0	24·0	23·7	27·6	27·5	...
31.	...	...	29·3	...	29·2	...	25·7	23·7	...	...	...	...
Average	28·15	28·2	29·5	29·5	28·95	24·75	25·3	24·65	25·15	27 0	27·7	27·3

TABLE VII—*Surface Temperature, °C 1955.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	29·0	29·2	30·3	...	27·4	25·3	25·5	...	27·4	29·3	28·0
2.	...	28·7	28·9	30·1	29·1	27·2	25·5	24·5	...	...	29·2	28·2
3.	28·2	29·2	29·2	...	28·7	28·2	...	24·5	25·4	27·8	28·1	27·6
4.	28·3	29·3	28·8	29·6	30·3	27·8	25·5	24·3	...	28·4	27·7	...
5.	...	29·4	29·3	30·5	29·1	...	...	25·0	25·0	28·2	28·1	28·1
6.	28·0	...	...	30·2	29·1	28·2	25·2	25·4	24·7	28·4	...	28·3
7.	27·9	29·4	29·1	30·3	29·5	28·3	26·6	...	26·4	28·5	27·8	28·4
8.	28·0	29·3	29·0	...	...	28·0	25·6	24·5	26·2	28·5	26·8	28·2
9.	...	28·5	29·5	30·5	30·0	28·3	25·8	24·6	...	...	26·7	27·7
10.	28·3	28·8	29·1	...	29·8	28·2	...	25·0	26·7	29·0	26·7	27·4
11.	29 0	28·7	29·3	30·7	29·2	26·2	25·6	24·5	...	28·8	27·0	...
12.	28·0	28·8	28·3	30·5	29·4	...	26·0	25·0	27·2	26·6	26·6	26·4
13.	...	...	...	29·2	28·4	26·0	28·3	25·5	26·4	26·5	...	26·6
14.	...	29·5	28·6	...	28·5	25·2	25·0	...	26·7	27·3	...	...
15.	27·9	29·7	28·4	30·2	...	25·0	25·5	...	25·5	...	26·8	26·4
16.	...	29·4	28·6	29·7	28·3	24·7	26·0	25·5	26·8	...	26·5	26·2
17.	28·2	29·3	29·0	...	28·0	24·6	...	24·5	26·4	27·0	26·6	26·4
18.	28·1	29·4	28·8	30·3	27·9	...	25·5	25·0	...	28·3	26 8	...
19.	28·0	...	...	30·5	26·3	...	25·5	25·5	...	28·1	...	26·2
20.	28·3	29·1	29·0	30·6	26·8	25·9	25·0	24·5	26·6	27·7	...	26·2
21.	28·3	28·9	28·9	31·1	...	25·2	25·5	...	26·6	27·7	26·9	26·1
22.	...	29 2	29·2	28·7	...	24·9	26·0	25·0	25·5	...	26·8	25·5
23.	...	29·1	29·2	...	28·0	24·9	...	25·3	28·4	...	27·5	25·8
24.	28·2	29·5	29·1	...	...	25·8	...	25·5	29·0	...	25·4	...
25.	28·0	29·2	29·3	28·9	28·3	25·6	24·5	25 5	...	...	25·9	...
26.	...	...	...	29·8	29·0	...	24·5	26·5	28·5	...	28·4	26 3
27.	28·1	29·6	29·6	30·1	28·5	25·7	24·3	25·5	26·1	...	...	26·2
28.	29·6	29·2	...	30·5	28·3	25·3	24·5	...	25·3	28·3	28·5	26·1
29.	29·2	...	...	30·3	...	25·9	24·3	...	28·5	...	28·3	26·2
30.	...	...	...	30·6	...	25·5	...	...	28·5	...	27·4	26·3
31.	28·8	...	...	30·7	28·5	...	...	...	...	28·4	...	26·2
Average	28·75	29·2	29·35	29·9	28·3	26·45	26·3	25·4	27·15	27·75	27·85	26·95

TABLE VIII—*Specific Gravity, 1949.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·0241	1·0241	1·0237	...	1·0237	...	1·0213	1·0163	...	1·0184	1·0228
2.	...	1·0238	1·0237	1·0243	1·0234	1·0238	1·0205	1·0193	1·0195	...	...	1·0234
3.	1·0238	1·0243	1·0241	...	1·0237	1·0200	...	1·0201	1·0185	...	...	1·0237
4.	1·0235	1·0239	1·0244	1·0237	1·0235	1·0193	1·0193	1·0220	...	1·0235	1·0212	...
5.	1·0236	1·0244	1·0246	1·0241	1·0242	1·0199	1·0176	1·0204	...	1·0195	1·0237	1·0246
6.	1·0231	...	1·0245	1·0624	1·0244	...	1·0192	1·0242	...	1·0203	...	1·0245
7.	1·0231	1·0236	1·0237	1·0243	1·0241	1·0210	1·0202	...	...	1·0235	1·0232	1·0240
8.	1·0235	1·0238	1·0229	1·0246	...	1·0196	1·0170	...	1·0147	1·0241	1·0233	1·0243
9.	...	1·0241	1·0236	1·0245	1·0239	...	...	1·0192	1·0151	...	1·0183	1·0240
10.	1·0232	1·0243	1·0241	...	1·0230	1·0206	...	1·0194	1·0163	1·0227	1·0192	1·0241
11.	...	1·0239	...	1·0240	1·0241	1·0211	1·0194	1·0202	...	1·0245	1·0233	...
12.	...	1·0236	1·0243	1·0239	1·0243	...	1·0196	1·0195	...	1·0212	1·0205	1·0246
13.	...	...	1·0233	...	1·0232	1·0205	1·0193	1·0213	1·0184	1·0204	...	1·0239
14.	...	1·0241	1·0242	...	1·0237	1·0214	1·0163	...	1·0171	1·0232	1·0234	1·0236
15.	...	1·0245	1·0239		...	...	1·0143	...	1·0163	1·0194	1·0222	1·0225
16.	...	1·0242	1·0246	1·0241	1·0238	1·0206	1·0154	1·0205	1·0216	...	1·0224	1·0241
17.	...	1·0238	1·0238	1·0237	1·0230	1·0207	...	1·0237	1·0193	1·197	1·0231	1·0245
18.	1·0235	1·0241	1·0241	1·0237	1·0239	...	1·0110	1·0213	...	1·0204	1·0201	...
19.	1·0235	...	...	1·0236	1·0232	...	1·0187	...	1·0223	1·0213	1·0228	1·0243
20.	1·0234	...	...	1·0240	1·0240	1·0240	1·0167	...	1·0213	...	...	1·0241
21.	1·0237	1·0232	1·0241	1·0232	...	1·0236	1·0170	...	1·0231	...	1·0191	1·0237
22.	1·0234	1·0234	1·0236	1·0237	...	1·0234	1·0192	1·0218	...	1·0226	1·0241	...
23.	...	1·0236	1·0240	...	1·0244	1·0238	...	1·0184	1·0230	...	1·0238	1·0241
24.	1·0236	1·0241	1·0236		1·0241	1·0237	...	1·0193	1·0227	1·0225	1·0235	1·0238
25.	1·0240	...	1·0241	1·0238	1·0238	1·0204	1·0198	1·0201	...	1·0193	1·0241	...
26.	1·0238	1·0239	1·0237	1·0241	1·0212	...	1·0160	1·0190	...	1·0217	1·0245	...
27.	1·0241	...	...	1·0241	1·0228	1·0139	1·0183	...	1·0197	1·0242	...	1·0234
28.	1·0236	1·0236	1·0246	1·0243	1·0243	1·0147	...	...	1·0204	1·0238	1·0232	1·0261
29.	1·0241	...	1·0246	1·0240	...	1·0203	1·0205	1·0203	...	1·0223	1·0237	1·0240
30.	...	...	1·0246	1·0243	1·0244	1·0196	1·0203	1·0207	...	...	1·0243	1·0239
31.	1·0238	...	1·0239	...	1·0232	...	...	1·0180	...	1·0217	...	...
Average	1·0236	1·02385	1·02395	1·0239	1·0228	1·0189	1·0157	1·0211	1·0188	1·0219	1·0214	1·0245

TABLE IX—*Specific Gravity, 1950.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·0243	1·0251	1·0243	1·0234	1·0191	...	1·0120	1·0220	...	1·0240	1·0250
2.	...	1·0248	1·0253	...	1·0252	1·0193	...	1·0110	1·0210	...	1·0240	1·0240
3.	1·0246	1·0237	1·0250	...	1·0250	1·0201	1·0200	1·0180	...	1·0260	1·0230	...
4.	1·0246	1·0250	...	1·0248	...	...	1·0230	1·0180	...	1·0230	1·0240	1·0230
5.	1·0252	...	...	1·0242	1·0247	1·0201	1·0200	1·0180	1·0220	1·0230	...	1·0230
6.	1·0249	1·0248	1·0243	1·0243	1·0280	1·0193	1·0190	...	1·0200	1·0230	1·0230	1·0250
7.	1·0241	1·0253	1·0247	...	...	1·0195	1·0190	1·0240	1·0210	1·0230	1·0240	1·0240
8.	...	1·0248	1·0248	1·0238	1·0278	1·0204	1·0180	1·0230	1·0210	...	...	1·0220
9.	1·0247	1·0248	1·0251	...	1·0279	1·0193	...	1·0190	1·0220	1·0220		1·0230
10.	1·0250	1·0250	1·0254	1·0241	1·0274	1·0191	1·0180	1·0160	...	...	1·0240	
11.	...	1·0241	1·0250	1·0239	1·0252	...	1·0120	1·0200	1·0230	...	1·0240	1·0220
12.	1·0246	...	...	1·0247	1·0281	1·0207	1·0110	1·0200	1·0220	1·0210	...	1·0240
13.	...	1·0250	1·0243	...	1·0263	1·0184	1·0110	...	1·0230	1·0210	1·0230	1·0250
14.	...	1·0247	1·0246	...	...	1·0186	1·0220	1·0210	1·0230	...	1·0240	1·0240
15.	...	...	1·0247	1·0249	1·0281	...	1·0230	...	...	...	1·0240	1·0250
16.	1·0246	1·0245	1·0247	...	1·0273	1·0181	...	1·0200	1·0250	1·0220	1·0230	1·0250
17.	1·0248	1·0252	1·0243	1·0242	1·0274	...	...	1·0210	...	1·0240	1·0240	...
18.	1·0237	...	...	1·0238	1·0278	...	1·0220	1·0210	1·0250	...	1·0220	1·0250
19.	1·0241	...		1·0238	1·0264	1·0180	1·0220	...	1·0240	...	...	1·0240
20.	1·0241	1·0251	1·0246	1·0247	...	1·0196	1·0200	...	1·0230	...	1·0250	...
21.	...	1·0248	1·0246	1·0244	...	1·0194	1·0210	1·0210	1·0250	...	1·0240	1·0240
22.	...	1·0234	1·0243	...	1·0264	1·0204	...	1·0190	1·0240	...	1·0250	...
23.	1·0247	1·0238	1·0246	...	1·0271	1·0194	...	1·0220	...	...	1·0220	1·0240
24.	1·0251	1·0245	1·0236	1·0239	1·0272	1·0186	1·0200	...	...	1·0230	1·0250	...
25.	1·0243	1·0247	1·0247	1·0243	1·0264	...	1·0200	...	...	1·0230	1·0250	
26.	...	...	...	1·0239	1·0253	1·0225	1·0250	...	1·0230	1·0220		1·0240
27.	...	1·0248	1·0240	1·0234	1·0243	1·0210	1·0180	...	1·0250	1·0230	1·0250	1·0250
28.	1·0231	1·0242	1·0238	1·0233	...	1·0220	1·0190	...	1·0240	1·0230	1·0260	1·0240
29.		...	1·0234	1·0234	1·0227	1·0200	1·0190	1·0190	1·0230	...	1·0240	1·0250
30.	...	...	1·0247	...	1·0224	1·0191	...	1·0180	1·0240	1·0230	1·0240	1·0240
31.	1·0248	...	1·0243	...	1·0233	...	1·0110	1·0190	...	1·0230	...	...
Average	1·0243	1·02435	1·0240	1·0241	1·02525	1·02025	1·0180	1·0175	1·0225	1·0235	1·0240	1·0235

TABLE X—*Specific Gravity, 1951*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·0240	...	...	1·0260	1·0220	...	1·0210	1·0230	1·0230	1·0200	1·0210
2.	1·0240	1·0250	1·0250	1·0270	1·0260	1·0230	1·0220	1·0220	...	...	1·0210	
3.	1·0250	1·0240	1·0240	1·0250	1·0250	...	1·0190	1·0240	1·0210	1·0210	1·0200	1·0210
4.	1·0230	...	...	1·0240	1·0240	1·0240	1·0210	1·0220	1·0220	1·0220	...	1·0220
5.	1·0240	1·0240	1·0260	1·0250	1·0270	1·0220	1·0250	...	...	...	1·0210	1·0220
6.	1·0250	1·0240	...	1·0260	...	1·0210	...	1·0230	1·0240	1·0240	1·0210	1·0210
7.	...	1·0230	1·0240	1·0240	1·0250	1·0230	1·0210	1·0230	1·0240	1·0230	1·0200	1·0220
8.	1·0240	1·0230	1·0250	...	1·0270	1·0220	...	1·0230	1·0230	1·0210	1·0200	
9.	1·0240	1·0240	1·0240	1·0260	1·0260	1·0220	1·0200	1·0240	...	...	1·0200	1·0210
10.	1·0230	1·0230	1·0240	1·0250	1·0250	...	1·0220	1·0230	1·0240	1·0240	...	
11.	1·0240	...	...	1·0220	1·0260	1·0230	1·0240	1·0230	1·0210	...	1·0220	
12.	1·0230	1·0250	1·0250	1·0210	1·0270	1·0240	1·0230	1·0210	...	...	...	1·0230
13.	...	1·0230	1·0230	1·0220	...	1·0230	1·0230	...	...	...	1·0220	
14.	...	1·0260	1·0250	...	1·0250	1·0250	1·0230	1·0230	...	...	1·0200	1·0230
15.	...	1·0250	1·0250	...	1·0240	1·0210	...	1·0190	...	...	1·0210	1·0210
16.	1·0220	1·0240	1·0240	1·0250	1·0250	1·0230	1·0240	...	1·0240	1·0240	1·0210	1·0230
17.	1·0210	...	1·0230	1·0260	1·0260	...	1·0230	1·0190	...	...	1·0200	
18.	1·0220	...	...	1·0270	1·0250	1·0240	1·0220	...	1·0250	1·0250	...	1·0230
19.	1·0200	1·0220	1·0240	1·0250	...	1·0260	1·0210	1·0190	1·0240	1·0240	...	1·0230
20.	...	1·0230	1·0250	1·0250	...	1·0240	1·0210	...	1·0250	1·0250	1·0200	1·0240
21.	...	1·0240	1·0240	...	...	1·0250	1·0210	1·0220	1·0250	1·0250	1·0200	1·0220
22.	1·0230	1·0260	1·0240	...	1·0270	1·0260	...	1·0180	1·0250	1·0250	1·0200	1·0220
23.	1·0230	1·0250	...	1·0250	1·0260	1·0250	1·0240	1·0230	1·0240	1·0240	1·0210	...
24.	1·0240	1·0240	...	1·0240	1·0240	...	...	1·0190	...	...	1·0190	...
25.	1·0230	...	...	1·0260	1·0250	1·0260	1·0200	1·0190	1·0230	1·0230	1·0210	1·0230
26.	...	1·0250	1·0220	1·0230	1·0240	1·0200	1·0190	1·0250	...	1·0240	...	...
27.	1·0220	1·0250	1·0250	1·0230	...	1·0210	1·0260	...	1·0220	1·0240	1·0210	1·0230
28.	...	1·0260	1·0250	1·0250	1·0240	1·0220	1·0210	1·0230	1·0250	1·0220	1·0200	1·0230
29.	1·0230	...	1·0240	...	1·0220	1·0230	1·0180	1·0230	1·0250	1·0280	1·0200	1·0230
30.	1·0240	...	1·0250	1·0260	1·0260	1·0230	...	1·0240	1·0240	1·0250	1·0210	1·0230
31.	1·0220	...	1·0240	...	1·0250	...	1·0230	1·0220	...	1·0240	1·0210	1·0230
							1·0200	1·0230	...	...	1·0200	
Average	1·0225	1·0240	1·0240	1·0240	1·0255	1·0230	1·0220	1·0310	1·0230	1·0245	1·0200	1·0225

TABLE XI—*Specific Gravity, 1952.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·0240	1·0240	1·0240	1·0260	...	1·0250	1·0240	...	1·0260	1.0230	...
2.	1·0220	1·0250	...	1·0250	1·0260	1·0240	1·0270	1·0230	...	...	...	1·0240
3.	1·0240	...	1·0240	1·0250	1·0270	1·0250	1·0270	...	...	1·0240	1·0240	1·0240
4.	1·0240	1·0240	1·0240	1·0250	...	1·0250	1·0250	1·0240	...	1·0260	1·0240	1·0240
5.	1·0240	1·0240	1·0240	1·0250	1·0260	1·0240	1·0250	1·0270	1·0250	...	1·0260	1·0240
6.	...	1·0250	1·0240	...	1·0250	1·0230	...	1·0200	1·0240	...	1·0240	1·0240
7.	...	1·0240	1·0230	1·0240	1·0270	1·0230	1·0250	1·0210	...	1·0190	1·0250	...
8.	1·0240	1·0250	1·0240	1·0260	1·0260	...	1·0230	1·0230	1·0250	1·0100	1·0240	1·0250
9.	1·0230	1·0240	...	1·0260	1·0220	1·0220	1·0280	1·0240	1·0250	1·0100	...	1·0200
10.	1·0220	...	1·0240	1·0260	1·0230	1·0240	1·0280	...	...	1·0120	1·0250	1·0250
11.	1·0240	1·0230	1·0250	..	..	1·0200	1·0260	1·0260	1·0260	1·0160	1·0250	1·0250
12.	...	1·0240	1·0240	1·0260	1·0240	1·0200	1·0250	1·0240	1·0260	...	1·0260	1·0240
13.	...	1·0250	1·0240	...	1·0240	1·0200	...	1·0260	1·0260	1·0110	1·0240	1·0240
14.	...	1·0240	1·0250	1·0260	1·0240	1·0260	1·0250	1·0260	...	1·0130	1·0240	...
15.	...	1·0250	1·0240	1·0260	1·0250	..	1·0240	...	1·0250	1·0230	1·0270	1·0230
16.	1·0240	...	...	1·0260	1·0240	1·0280	1·0250	1·0250	1·0250	1·0220	...	1·0250
17.	1·0240	...	1·0250	1·0270	1·0230	1·0260	1·0240	...	1·0260	...	1·0250	1·0250
18.	1·0230	1·0250	1·0250	1·0260	..	1·0260	1·0270	1·0260	...	...	1·0250	1·0260
19.	...	1·0240	1·0240	...	1·0240	1·0240	...	1·0210	1·0260	...	1·0240	1·0250
20.	...	1·0240	1·0250	...	1·0240	1·0250	...	1·0230	...	1·0260	1·0240	...
21.	1·0230	1·0240	1·0230	1·0260	1·0230	...	1·0230	1·0200	...	1·0240	1·0250	...
22.	1·0220	1·0250	...	1·0260	1·0240	...	1·0250	1·0230	1·0250	1·0250	...	1·0250
23.	1·0220	...	.	1·0260	1·0250	1·0250	1·0220	...	1·0260	1·0250	...	1·0250
24.	1·0230	...	1·0240	1·0250	...	.	1·0300	...	1·0260	1·0200	1·0240	1·0240
25.	1·0240	1·0240	1·0250	1·0270	...	1·0290	1·0290	1·0260	1·0250	1·0220	1·0250	...
26.	...	1·0240	1·0240	1·0260	1·0240	1·0280	1·0280	1·0250	...	...	1·0240	1·0230
27.		1·0230	1·0240	.	1·0240	1·0270	...	1·0260	...	1·0260	1·0260	...
28.	1·0230	1·0230	1·0240	1·0260	1·0250	1·0260	1·0280	1·0260	...	1·0260	1·0260	...
29.	1·0240	1·0240	1·0250	1·0250	1·0260	...	1·0200	1·0240	1·0260	1·0240	1·0240	1·0250
30.	1·0240	...	.	1·0260	1·0260	1·0260	1·0210	1·0250	...	1·0250	...	1·0250
31.	1·0230	...	1·0250		1·0250	...	1·0240	...	...	1·0260	...	1·0260
Average	1·0230	1·0240	1·0240	1·0255	1·0245	1·0245	1·0245	1·0235	1·0250	1·0185	1·0255	1·0230

TABLE XII—*Specific Gravity, 1953*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	...	...	1·0220	1·0260	1·0270	1·0200	·10210	1·0250	...	...	1·0240
2.	1·0240	1·0250	1·0260	1·0250	1·0260	1·0250	1·0250	...	1·0250	...	1·0260	1 0250
3.	1·0240	1·0260	1·0230	...	...	1·0270	1·0250	1·0220	1·0270	1·0250	1 0240	1·0240
4.	...	1·0260	1·0250	1·0260	1·0200	1·0260	1·0250	1·0250	1·0260	...	1·0250	1·0250
5.	...	1·0250	1·0250	...	1·0260	1·0250	...	1·0189	1·0250	1·0250	...	1·0250
6.	...	1·0250	1·0250	1·0240	1·0260	1·0250	1·0150	1·0230	...	...	1·0230	...
7.	...	1·0260	1·0240	1 0250	1·0240	...	1·0200	1·0220	1·0260	1·0220	...	1·0250
8.	...	...	...	1·0260	1·0220	1·0240	...	1·0250	1·0250	1·0250	1·0230	1·0250
9.	...	1·0230	1·0250	1·0270	1·0260	1·0270	1·0150	...	1·0250	1·0250	...	1·0250
10.	...	1·0250	1·0250	1·0260	...	1·0260	1·0150	1·0230	1·0260	1·0240	1 0240	10·250
11.	...	1·0230	1·0250	1·0250	1·0260	1·0240	1·0150	1·0240	1·0240	1 0240	1·0250	1·0250
12.	...	...	...	...	1·0240	1·0240	...	1·0230	...	...	1·0260	1·0250
13.	...	1·0240	1·0240	1·0270	1·0250	1·0260	1·0220	1·0220	...	1·0250	1·0260	1·0250
14.	...	1·0200	1·0200	...	1·0240	...	1·0170	1·0210	1·0260	1·0250	1·0260	...
15.	1·0260	...	...	1·0270	1·0250	1·0300	1·0220	...	1·0240	...	1·0260	1·0250
16.	1·0230	1·0240	1·0240	...	1·0250	1·0250	1·0240	1·0230	1·0250	...	...	1·0250
17.	1·0250	1·0250	1·0250	...	...	1·0250	1·0240	1·0210	1·0260	...	1 0250	...
18.	...	1·0250	1·0250	...	1·0250	1·0260	...	1·0210	...	...	1 0250	1 0240
19.	1·0260	1·0250	1·0250	...	1·0270	1·0270	...	1·0230	...	1·0230	1·0250	1·0250
20.	1·0250	1·0250	1·0250	1·0260	1·0260	...	...	...	...	1·0240	1·0250	...
21.	1·0240	'...	...	1·0240	1·0250	1·0240	1·0260	1·0250	1·0250	1·0200	...	1 0240
22.	1·0250	...	...	1·0230	1·0250	...	1·0250	...	1·0240	1·0200	1·0250	1·0240
23.	1 0250	1·0250	1·0250	1·0250	...	1·0240	1·0250	...	1·0250	1 0210	...	1·0250
24.	...	1·0250	1·0250	1·0240	...	1·0270	1 0250	...	1·0240	...	1·0260	1·0250
25.	...	1·0250	1·0250	1·0250	1·0250	1·0260	1·0240	...	1·0250	1·0240	1·0250	...
26.	...	1·0250	1·0250	...	1·0240	1·0230	1·0250	1·0250	1·0260	...	1·0250	1·0250
27.	1·0250	1·0260	1·0250	1·0260	1·0260	1·0260	...	1·0250	...	1 0210	1·0230	...
28.	1·0250	1·0260	1·0250	1·0240	1 0250	1·0250	1·0260	1·0250	1·0260	1·0220	1·0250	1·0240
29.	1·0240	...	...	1·0260	1·0260	...	1·0240	1·0240	...	1·0230	1·0250	...
30.	1·0240	...	1·0260	1·0250	1·0260	1·0230	1·0250	1·0230	1 0270	1·0220	...	1·0240
31.	1·0260	...	1·0260	...	...	1·0200	1·0260.	...	1·0230	1·0250	1·0240	1·0230
							1·0230	...	...	1·0240	...	1·0240
Average	1·0245	1·0245	1·0245	1·0235	1·0235	1·0235	1·0205	1 02195	1·0250	1·0225	1·0245	1 0240

TABLE XIII—*Specific Gravity, 1954.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·0250	1·0250	1·0250	1·0250	1·0220	1·0240	...	...	1·028	1·023	1·024
2.	1·0250	1·0250	1·0260	1·0260	...	1·0200	1·0250	1·0240	1·026	...	1·024	1·024
3.		1·0260	...	1·0250	1·0251	...	1·0230	1·0270	1·027	...	1·028	1·024
4.	1·0240	1·0250	1·0250	1·0260	1·0240	1·0190	...	1·0250	1·026	1·027	1·025	1·024
5.	1·0250	1·0260	1·0250	1·0240	1·0240	1·0180	1·0260	1·0220	...	...	1·024	...
6.	1·0240	1·0260	1·0260	1·0240	1·0252	...	1 0260	1·0220	1·027	...	1·024	1·024
7.	1·0250	...	...	1·0250	1·0250	1·0190	1·0220	1·0220	1·023	...	...	1·025
8.	1·0250	1·0250	1·0240	1·0250	1·0250	1·0170	1·0293	.	1·023	1·027	1·024	1·025
9.	1·0240	1·0250	1·0250	1·0250	...	1·0120	1 0296	1·0210	...	1·025	...	1·024
10.	...	1 0260	1·0240	1·0260	1·0246	1·0250	1·0470	...	...	...	1·023	1·025
11.	1·0230	1·0260	1·0240		1 0240	1·0220	...	1·0230	...	1·025	1·025	1·025
12.	1·0240	1·0260	1·0250	1·0260	1·0252	1·0230	1·0190	1·0280	...	1·025	1·025	...
13.	...	1·0260	1·0250	...	1 0242	...	1 0230	1·0250	1·028	1·025	1·025	1·025
14.	...	...	...	...	1·0247	1·0190	1·0230	...	1·029	1·025	...	1·025
15.	1·0250	1·0260	1 0270	1·0250	1·0250	1·0220	1·0230	...	1·027	1 024	1·024	1·025
16.	1·0250	1·0270	1·0270	...	...	1·0220	1·0200	1·0250	1 026	1·025	1·024	.
17.	...	1·0260	1 0260	...	1·0250	1·0180	1 0230	1·0244	1·027	...	1·026	...
18.	1·0260	1·0260	1·0260	...	1 0254	1·0240	...	1 0230	1·026	1 026	1·024	...
19.	1·0250	1·0230	1·0250	1·0252	1·0250	...	1·0260	1·0230	...	1·027	1·026	...
20.	1·0250	...	...	1·0250	1·0254		1·0270	1·0260	1·029	...	...	...
21.	1·0250	...	...	1·0251	1·0250	1·0200	1·0210	...	1·028	1·024	...	...
22.	1·0240	1·0250	1·0250	1·0250	...	1·0200	1·0250	...	1·026	1·023	1·025	...
23.	...	1·0250	1·0250	1·0243	...	1·0207	1·0250	1·0280	1·027	1·022	1·025	...
24.	...	1·0250	1·0250	1·0242	1·0250	1·0260	...	1·0270	1·026	...	1·025	...
25.	1·0260	1·0240	1·0250	...	1·0250	1·0260	...	1·0204	1·025	...	1·025	...
26.	...	1·0250	1·0250	1·0250	1·0248	1·0260	1·0280	1·0250	...	...	1·024	...
27.	1·0260	1·0250	1 0250	1·0252	1·0254	...	1·0240	1·0260	1·025	1·023	1·026	...
28.	1·0260	...	...	1·0253	1·0256	1 0260	1·0210	1·0250	1·026	1·023	1·024	...
29.	1·0260	...	1·0240	1·0256	1·0250	1·0250	1·0230	...	1·028	1·023	1·024	...
30.	1·0260	...	1·0250	1·0254	...	1·0230	1·0200	1·0280	1·028	1·023	1·024	...
31.	...	...	1·0250	...	1·0260	...	1·0230	1·0260	..	...	...	...
Average	1·0250	1·0250	1·0260	1·0250	1·0250	1·0215	1·0243	1·0260	1·026	1·025	1·0255	1·026

TABLE XIV—*Specific Gravity, 1955.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·024	1·025	1·026	...	1·022	1·022	1·024	...	1·025	1·019	1·025
2.	...	1 025	1·025	1·026	1·028	1·021	1·023	1·024	...	...	1·020	1·025
3.	1·024	1·025	1·026	...	1·028	1·021	...	1·024	1·025	1·026	1·021	1·025
4.	1·025	1·024	1·025	1·026	1·029	1·022	1·024	1·025	...	1·018	1·020	...
5.	...	1 026	1·025	1·026	1·028	...	...	1·024	1·024	1·019	1·021	1·024
6.	1·024	...	...	1·026	1·024	1·022	1·025	1·025	1·024	1·025	...	1·024
7.	1·025	1·026	1·026	1·027	1·025	1·022	1·025	...	1·022	1·024	1·020	1·026
8.	1·026	1·025	1 025	...	...	1·023	1·025	1·024	1·022	1 024	1·024	1·025
9.		1·026	1·024	1·025	1·029	1·023	1·025	1·026	...	...	1·025	1·026
10.	1·023	1·026	1·026	...	1·027	1·022	...	1·024	1·024	1·027	1·024	1·023
11.	1·025	1·025	1·026	1·026	1·025	1·029	1·024	1·024	...	1·026	1·023	...
12.	1·024	1·026	1·025	1·025	1·027	...	1·024	1·025	1·025	1·026	1·024	1·024
13.	...	...	...	1·025	1·026	1·029	1·025	1·025	1·024	1·026	...	1 023
14.	...	1·027	1·025	...	1·026	1·029	1·025	...	1·025	1·026	...	...
15.	1·026	1·026	1·025	1·026	...	1·030	1·024	...	1·025	...	1·023	1·023
16.	...	1·026	1·025	1·026	1·027	1·029	1·024	1·025	1·024	...	1·024	1·025
17.	1·025	1·026	1·024	...	1·026	1·031	...	1·024	1·025	1·024	1·023	1·024
18.	1·024	1·026	1·025	1·026	1·027	...	1·024	1·025	...	1·026	1·023	...
19.	1·025	...	...	1·024	1·028	...	1·025	1·025	...	1·024	...	1·025
20.	1·023	...	...	1·024	1·028	1·023	1·025	1·027	1·025	1·024	...	1·024
21.	1·025	1·025	1·025	1·026	...	1·023	1·024	...	1·025	1·025	1·023	1·024
22.	...	1·026	1·026	1·027	...	1·025	1·023	1·024	1·025	...	1·023	1·024
23.	...	1·024	1·026	...	1·020	1·025	...	1·025	1·023	...	1·024	1·023
24.	1·024	1·026	1·025	...	...	1·024	...	1·025	1·024	...	1·022	...
25.	1·023	1·027	1·025	1·026	1·022	1·025	1·027	1·023	...	...	1·024	...
26.	...	1·025	1·026	1·028	1·023	...	1·024	1·024	1·024	...	1·024	1·024
27.	1·024	...	...	1·028	1·022	1·026	1·025	1 024	1·024	...	...	1·025
28.	1·024	1·026	1·024	1·039	1·023	1·023	1·024	...	1·024	1·024	1·024	1·025
29.	1·024	...	1·025	1·030	...	1·025	1 025	...	1·018	...	1·024	1·024
30.	...	...	1·026	1·021	1·022	1·022	...	...	1·018	...	1·024	1·024
31.	1·025	...	1·026	...	1·022	...	...	...	...	1·022	...	1·026
Average	1·0245	1·0255	1·025	1·0275	1·0245	1·026	1·0245	1·025	1·0215	1·0225	1·022	1·0245

XVII. MARITIME METEOROLOGY AND HYDROGRAPHY OF TUTICORIN BAY, GULF OF MANNAR, 1950-1954—BY P. I. CHACKO AND A. D. ISAAC RAJENDRAN.

In this report the daily observations on the maximum and minimum air temperature and on the temperature, specific gravity and pH of the surface waters of Tuticorin Bay, recorded at the Marine Biological Station, Tuticorin are presented (*vide* Tables I—XX). From the atmospheric temperature records it can be said that Tuticorin enjoys a salubrious climate, the maximum temperature not reaching 100°F. The warmest period is April-June, and the coldest is December-January. The temperature of the surface waters of the Tuticorin Bay shows a similar variation, the maximum being 30·0—32·8°C in April-June and the minimum being 24·0 — 27·0°C in December-January. The specific gravity is generally high in the second half of the year. The pH does not show much variation.

TABLE I—*Showing Maximum and Minimum Air temperature, °F, recorded at the Marine Biological Station, Tuticorin, 1950*

Date	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	...	...	82·0	80·0	84·0	80·0	86·0	82·0	90·0	88·0	92·0	89·0
2.	84·0	81·0	80·0	78·0	84·0	79·0	86·0	80·0	90·0	88·0	90·0	88·0
3.	...	...	82·0	80·0	83·0	80·0	85·0	81·0	90·0	88·0	90·0	88·0
4.	98·0	98·0	82·0	80·0	84·0	81·0	86·0	82·0	89·0	87·0	90·0	88·0
5.	82·0	80·0	81·0	79·0	84·0	80·0	86·0	81·0	90·0	88·0	90·0	88·0
6.	80·0	78·0	82·0	79·0	84·0	81·0	86·0	82·0	92·0	90·0	90·0	88·0
7.	81·0	79·0	82·0	78·0	84·0	81·0	86·0	81·0	90·0	87·0	92·0	89·0
8.	82·0	80·0	82·0	80·0	84·0	82·0	86·0	79·0	92·0	89·0	94·0	90·0
9.	...	...	83·0	80·0	86·0	83·0	86·0	79·0	90·0	88·0	92·0	89·0
10.	81·0	80·0	82·0	80·0	86·0	81·0	86·0	82·0	89·0	87·0	90·0	89·0
11.	80·0	78·0	84·0	80·0	86·0	82·0	86·0	79·0	90·0	88·0	90·0	88·0
12.	81·0	78·0	82·0	79·0	87·0	83·0	88·0	82·0	92·0	87·0	90·0	88·5
13.	80·0	78·0	82·0	80·0	83·0	84·0	87·0	83·0	94·0	87·0	92·0	90·0
14.	80.0	78·0	82·0	78·0	86·0	84·0	90·0	83·0	94·0	88·0	92·0	90·0
15.	...	...	82·0	78·0	87·0	83·0	88·0	82·0	92·0	89·0	92·0	90·0
16.	82·0	80·0	81·0	78·0	86·0	82·0	89·0	83·0	90·0	88·0	90·0	88·0
17.	80·0	78·0	82·0	78·0	86·0	83·0	90·0	82·0	93·0	86·0	90·0	88·0
18.	80·0	78·0	82·0	80·0	86·0	84·0	89·0	82·0	92·0	88·5	92·0	90·0
19.	82·0	78·0	82·0	80·0	85·0	84·0	90·0	82·0	92·0	89·0	90·0	87·0
20.	80·0	78·0	84·0	80·0	86·0	84·0	89·0	82·0	94·0	90·0	92·0	89·0
21.	80·0	78·0	81·0	79·0	86·0	84·0	89·0	83·0	92·0	88·0	92·0	88·0
22.	80·0	78·0	84·0	80·0	87·0	84·0	89·0	84·0	90·0	88·0	92·0	89·0
23.	82·0	78·0	84·0	80·5	88·0	84·0	89·0	84·0	90·0	87·0	94·0	90·0
24.	80·0	78·0	84·0	81·0	88·0	84·0	90·0	85·0	90·0	86·0	93·0	85·0
25.	82·0	78·0	84·0	80·0	89·0	84·0	90·0	88·0	92·0	88·0	92·0	86·0
26.	80·0	78·0	84·0	80·5	88·0	83·0	89·0	86·0	90·0	88·0	93·0	87·0
27.	80·0	78·0	84·0	81·0	86·0	82·0	89·0	86·0	90·0	88·0	94·0	88·0
28.	80·0	78·0	84·0	80·0	86·0	82·0	90·0	88·0	90·0	88·0	93·0	89·0
29.	80·0	78·0	84·0	80·0	86·0	82·0	90·0	88·0	92·0	90·0	94·0	89·0
30.	80·0	78·0	...	...	86·0	82·0	90·0	88·0	92·0	88·0	93·0	88·0
31.	82·0	78·0	...	...	86·0	82·0	...	...			...	...

Date	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	94·0	88·0	94·0	86·0	90·0	84·0	90·0	84·0	86·0	81·0	80·0	78·0
2.	93·0	89·0	94·0	87·0	90·0	85·0	88·0	83·0	88·0	82·0	80·0	79·0
3.	94·0	90·0	93·0	86·0	92·0	84·0	88·0	82·0	88·0	82·0	80·0	79·0
4.	94·0	88·0	93·0	85·0	93·0	84·0	86·0	81·0	87·0	81·0	80·0	77·0
5.	92·0	87·0	94·0	86·0	94·0	85·0	88·0	80·0	88·0	82·0	81·0	80·0
6.	90·0	86·0	94·0	87·0	90·0	84·0	88·0	82·0	88·0	81·0	81·0	81·0
7.	90·0	85·0	94·0	86·0	91·0	85·0	88·0	82·0	88·0	82·0	80·0	79·0
8.	92·0	86·0	92·0	85·0	92·0	85·0	88·0	82·0	86·0	83·0	79·0	78·0
9.	90·0	85·0	93·0	84·0	92·0	86·0	89·0	83·0	86·0	82·0	80·0	78·0
10.	92·0	87·0	94·0	86·0	90·0	86·0	91·0	84·0	85·0	82·0	82·0	74·0
11.	93·0	85·0	92·0	85·0	92·0	84·0	90·0	84·0	83·0	78·0	80·0	78·0
12.	92·0	84·0	94·0	85·0	91·0	84·0	88·0	82·0	83·0	79·0	82·0	74·0
13.	93·0	86·0	93·0	86·0	91·0	85·0	88·0	80·0	81·0	79·0	81·0	74·0
14.	93·0	85·0	90·0	84·0	92·0	85·0	86·0	80·0	81·0	80·0	81·0	75·0
15.	92·0	86·0	92·0	85·0	90·0	84·0	86·0	80·0	80·0	79·0	82·0	77·0
16.	90 0	85·0	93·0	85·0	...	...	85·0	78·0	80·0	79·0	81·0	72·0
17.	90·0	84·0	92·0	84·0	94·0	82·0	86·0	79·0	81·0	80·0	81·0	75·0
18.	91·0	85·0	92·0	85·0	94·0	82·0	...	...	84·0	82·0	81·0	75·0
19.	93·0	86·0	92·0	84·0	88·0	85·0	84·0	80·0	85·0	82·0	81·0	74·0
20.	94·0	86·0	88·0	80·0	86·0	84·0	86·0	80·0	87·0	80·0	82·0	73·0
21.	92·0	84·0	84·0	81·0	88·0	82·0	84·0	80·0	83·0	80·0	82·0	74·0
22.	93·0	85·0	88·0	81·0	89·0	82·0	85·0	79 0	82·0	80·0	81·0	74·0
23.	94·0	86·0	90·0	83·0	88·0	82·0	86·0	79·0	80·0	79·0	80·0	74·0
24.	94·0	85·0	90·0	82·0	88·0	82·0	88·0	80·0	81·0	79·0	81·0	74·0
25.	92·0	84·0	90·0	83·0	88·0	82·0	86·0	81·0	82·0	79·0	81·0	75·0
26.	90·0	82·0	92·0	84·0	89·0	82·0	84·0	80·0	80·0	79·0	81·0	75·0
27.	93·0	85·0	90·0	83·0	90·0	83·0	85·0	81·0	80·0	79·0	82·0	74·0
28.	92·0	85·0	90·0	84·0	88·0	82·0	86·0	80·0	80·0	78·0	82·0	75·0
29.	92·0	85·0	90·0	84·0	88·0	82·0	86·0	82·0	80·0	79·0	82·0	75·0
30.	94·0	86·0	88·0	82·0	87·0	80·0	86·0	82·0	80·0	78·0	82·0	75·0
31.	94·0	83 0	89·0	82·0	...	...	85·0	82·0	...	...		

TABLE II—*Showing Maximum and Minimum Air Temperature, °F, Recorded at the Marine Biological Station, Tuticorin, 1951.*

Date	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	81·0	74·0	82·0	76·0	82·0	76·0	88·0	82·0	88·0	82·0	92·0	86·0
2.	81·0	75·0	82·0	77·0	82·0	77·0	88·0	81·0	90·0	82·0	92·0	86·0
3.	81·0	75·0	82·0	78·0	83·0	78·0	88·0	82·0	92·0	82·0	92·0	86·0
4.	81·0	74·0	82·0	76·0	84·0	78·0	88·0	83·0	92·0	84·0	93·0	84·0
5.	81·0	75·0	80·0	76·0	84·0	79·0	88·0	84·0	90·0	84·0	92·0	84·0
6.	81·0	74·0	82·0	76·0	83·0	80·0	88·0	84·0	90·0	82·0	91·0	84·0
7.	80·0	75·0	82·0	77·0	85·0	80·0	88·0	84·0	90·0	84·0	92·0	84·0
8.	81·0	75·0	82·0	77·0	84·0	80·0	88·0	83·0	90·0	84·0	93·0	83·0
9.	82·0	76·0	80·0	76·0	85·0	80·0	88·0	82·0	92·0	84·0	92·0	82·0
10.	82·0	76·0	82·0	77·0	85·0	81·0	89·0	82·0	92·0	86·0	90·0	82·0
11.	82·0	76·0	82·0	78·0	85·0	79·0	88·0	84·0	94·0	88·0	90·0	82·0
12.	82·0	76·0	82·0	78·0	85·0	81·0	88·0	78·0	94·0	88·0	88·0	84·0
13.	82·0	76·0	82·0	77·0	86·0	81·0	86·0	76·0	94·0	88·0	92·0	82·0
14.	82·0	77·0	82·0	77·0	87·0	82·0	84·0	76·0	94·0	88·0	92·0	84·0
15.	81·0	77·0	82·0	77·0	86·0	81·0	84·0	74·0	94·0	88·0	92·0	84·0
16.	82·0	76·0	82·0	76·0	84·0	78·0	84·0	77·0	94·0	88·0	90·0	84·0
17.	82·0	76·0	82·0	77·0	86·0	79·0	...	...	94·0	88·0	90·0	82·0
18.	82·0	77·0	81·0	76·0	86·0	81·0	...	...	94·0	88·0	92·0	84·0
19.	84·0	77·0	82·0	76·0	86·0	80·0	...	...	94·0	88·0	94·0	84·0
20.	84·0	77·0	82·0	77·0	88·0	82·0	...	...	94·0	88·0	94·0	84·0
21.	84·0	77·0	82·0	77·0	89·0	83·0	88·0	80·0	94·0	88·0	94·0	84·0
22.	84·0	76·0	82·0	77·0	88·0	83·0	88·0	82·0	94·0	82·0	90·0	82·0
23.	82·0	77·0	84·0	77·0	89·0	82·0	88·0	83·0	94·0	84·0	90·0	82·0
24.	82·0	78·0	82·0	76·0	90·0	82·0	...	...	94·0	84·0	90·0	82·0
25.	82·0	77·0	83·0	77·0	...	...	88·0	82·0	92·0	86·0	91·0	84·0
26.	82·0	76·0	83·0	78·0	92·0	82·0	88·0	83·0	92·0	86·0	92·0	84·0
27.	81·0	78·0	84·0	78·0	...	...	90·0	82·0	92·0	86·0	92·0	85·0
28.	82·0	74·0	84·0	76·0	...	...	90·0	83·0	92·0	86·0	94·0	84·0
29.	82·0	75·0	...	...	...	...	88·0	82·0	92·0	86·0	93·0	86·0
30.	82·0	76·0	...	...	87·0	80·0	90·0	83·0	92·0	86·0	94·0	84·0
31.	...	...	...	...	88·0	82·0	...	...	92·0	86·0	...	...

Date	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	94·0	82·0	...	...	90·0	84·0	89·0	84·0	86·0	80·0	87·0	78·0
2.	94·0	84·0	94·0	82·0	90·0	84·0	88·0	84·0	86·0	80·0	...	...
3.	94·0	82·0	94·0	84·0	94·0	83·0	92·0	82·0	86·0	78·0	86·0	76·0
4.	94·0	84·0	95·0	84·0	94·0	86·0	91·0	84·0	...	...	86·0	76·0
5.	90·0	84·0	96·0	86·0	94·0	86·0	93·0	84·0	...	...	82·0	77·0
6.	91·0	82·0	94·0	84·0	92·0	86·0	94·0	86·0	...	...	82·0	74·0
7.	90·0	82·0	94·0	82·0	94·0	86·0	93·0	84·0	86·0	80·0	82·0	76·0
8.	92·0	84·0	94·0	86·0	94·0	87·0	94·0	86·0	87·0	80·0	82·0	77·0
9.	90·0	84·0	94·0	86·0	95·0	86·5	94·0	86·0	87·5	82·0	82·0	78·0
10.	90·0	84·0	93·0	86·0	94·0	84·0	91·0	83·0	88·0	82·0	83·0	78·0
11.	94·0	86·0	95·0	86·0	...	...	94·0	84·0	...	...	83·0	78·0
12.	93·0	84·0	96·0	87·0	...	...	91·0	84·0	86·0	80·0	83·0	78·0
13.	90·0	85·0	96·0	87·0	...	...	91·0	84·0	88·0	78·0	84·0	77·0
14.	93·0	85·0	95·0	86·0	...	...	91·0	84·0	89·0	80·0	83·0	77·0
15.	92·0	84·0	90·0	81·0	...	...	89·0	82·0	90·0	82·0	83·0	78·0
16.	93·0	82·0	90·0	81·0	...	...	89·0	84·0	92·0	84·0	84·0	79·0
17.	92·0	84·0	89·0	84·0	...	...	89·0	84·0	...	...	84·0	78·0
18.	90·0	84·0	92·0	84·0	...	...	90·0	84·0	...	...	81·0	76·0
19.	89·0	84·0	92·0	84·0	...	...	90·0	84·0	...	...	82·0	78·0
20.	93·0	84·0	95·0	84·5	89·0	84·0	89·0	84·0	94·0	88·0	83·0	77·0
21.	93·0	84·0	91·0	85·0	88·0	84·0	89·0	82·0	...	...	82·0	76·0
22.	90·0	84·0	94·0	86·0	88·0	84·0	89·0	80·0	...	...	82·0	76·0
23.	90·0	84·0	91·0	84·0	88·0	81·0	89·0	81·0	...	...	82·0	76·0
24.	90·0	83·0	89·0	84·0	89·0	82·0	87·0	81·0	...	...	...	...
25.	90·0	84·0	90·0	84·0	88·0	80·0	87·0	80·0	90·0	84·0	82·0	76·0
26.	89·0	84·0	89·0	85·0	87·0	82·0	86·0	80·0	88·0	80·0	80·0	74·0
27.	90·0	82·0	89·0	83·0	88·0	84·0	87·0	81·0	86·0	82·0	82·0	77·0
28.	95·0	85·0	89·0	83·0	88·0	84·0	87·0	81·0	87·0	83·0	82·0	76·0
29.	94·0	84·0	90·0	84·0	89·0	84·0	87·0	81·0	88·0	82·0	...	...
30.	94·0	84·0	89·0	83·0	...	...	...	...	...	...	82·0	76·0
31.	95·0	85·0									80·0	74·0
											82·0	77·0
											82·0	77·0
											82·0	76·0
											...	...

TABLE III—*Showing Maximum and Minimum Air Temperature, °F, Recorded at the Marine Biological Station, Tuticorin, 1952.*

Date	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	...	...	...	...	82·0	77·0	88·0	82·0	92·0	84·0	92·0	86·0
2.	82·0	77·0	84·0	78·0	80·0	76·0	88·0	82·0	92·0	84·0	94·0	86·0
3.	82·0	76·0	84·0	78·0	84·0	77·0	88·0	82·0	92·0	84·0	92·0	84·0
4.	82·0	77·0	84·0	76·0	86·0	79·0	...	...	92·0	82·0	92·0	84·0
5.	82·0	78·0	83·0	76·0	...	...	...	...	94·0	82·0	94·0	86·0
6.	82·0	78·0	84·0	78·0	85·0	77·0	...	...	94·0	84·0	94·0	86·0
7.	84·0	77·0	84·0	78·0	86·0	79·0	...	...	92·0	82·0	94·0	84·0
8.	84·0	76·0	84·0	78·0	84·0	77·0	88·0	82·0	92·0	82·0	92·0	84·0
9.	84·0	77·0	84·0	80·0	85·0	77·0	90·0	84·0	92·0	84·0	92·0	84·0
10.	84·0	76·0	84·0	79·0	84·0	77·0	90·0	82·0	94·0	82·0	...	...
11.	82·0	78·0	84·0	79·0	86·0	79·0	90·0	82·0	94·0	82·0	...	...
12.	84·0	76·0	84·0	78·0	86·0	78·0	88·0	82·0	94·0	82·0	92·0	84·0
13.	82·0	78·0	84·0	79·0	86·0	82·0	88·0	82·0	92·0	82·0	92·0	86·0
14.	84·0	79·0	84·0	79·0	86·0	79·0	88·0	82·0	90·0	82·0	92·0	86·0
15.	84·0	78·0	84·0	78·0	86·0	82·0	90·0	84·0	88·0	80·0	92·0	84·0
16.	84·0	78·0	84·0	78·0	86·0	80·0	88·0	84·0	90·0	82·0	92·0	84·0
17.	84·0	78·0	84·0	78·0	88·0	82·0	90·0	84·0	90·0	82·0	92·0	84·0
18.	82·0	76·0	84·0	78·0	88·0	84·0	88·0	82·0	90·0	82·0	92·0	84·0
19.	82·0	76·0	82·0	76·0	88·0	84·0	88·0	82·0	...	...	92·0	84·0
20.	82·0	78·0	82·0	76·0	88·0	82·0	88·0	82·0	93·0	86·0	92·0	84·0
21.	82·0	77·0	82·0	76·0	88·0	82·0	88·0	82·0	92·0	84·0	...	...
22.	82·0	77·0	80·0	76·0	86·0	81·0	90·0	82·0	92·0	86·0	...	...
23.	82·0	77·0	82·0	76·0	88·0	82·0	88·0	82·0	90·0	84·0	92·0	86·0
24.	82·0	77·0	80·0	74·0	88·0	82·0	90·0	84·0	90·0	84·0	92·0	86·0
25.	82·0	78·0	80·0	74·0	88·0	82·0	90·0	84·0	90·0	86·0	92·0	86·0
26.	82·0	77·0	82·0	76·0	88·0	82·0	90·0	84·0	90·0	86·0	92·0	86·0
27.	82·0	78·0	82·0	74·0	88·0	81·0	90·0	84·0	92·0	86·0	92·0	86·0
28.	82·0	77·0	82·0	77·0	88·0	82·0	...	...	...	...	...	...
29.	82·0	78·0	...	...	88·0	82·0	...	...	92·0	84·0	92·0	86·0
30.	83·0	76·0	...	...	88·0	82·0	...	...	90·0	84·0	92·0	86·0
31.	83·0	79·0	...	...	88·0	82·0	...	...	...	...	...	...

Date	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	92·0	84·0	92·0	86·0	...	...	90·0	75·0	86·0	70·0	...	...
2.	92·0	84·0	92·0	86·0	...	...	...	...	...	...	84·0	68·0
3.	92·0	86·0	...	...	...	...	88·0	74·0	86·0	70·0	84·0	70·0
4.	92·0	84·0	...	...	92·0	84·0	88·0	72·0	86·0	72·0	84·0	68·0
5.	92·0	84·0	...	...	88·0	80·0	...	...	86·0	70·0	84·0	68·0
6.	90·0	82·0	...	...	86·0	82·0	...	...	86·0	70·0	84·0	68·0
7.	90·0	82·0	...	...	...	...	87·0	72·0	84·0	70·0	...	...
8.	90·0	82·0	...	...	87·0	80·0	86·0	70·0	86·0	70·0	84·0	70·0
9.	90·0	82·0	...	...	85·0	73·0	87·0	72·0	...	...	84·0	70·0
10.	90·0	82·0	...	...	88·0	74·0	91·0	72·0	88·0	72·0	86·0	70·0
11.	88·0	80·0	...	...	86·0	72·0	88·0	70·0	88·0	70·0	82·0	70·0
12.	89·0	80·0	...	...	88·0	74·0	...	...	86·0	70·0	84·0	70·0
13.	89·0	80·0	...	...	...	...	92·0	74·0	86·0	72·0	...	...
14.	90·0	82·0	...	...	88·0	72·0	92·0	74·0	84·0	70·0	...	...
15.	...	...	...	...	90·0	74·0	88·0	74·0	...	...	84·0	68·0
16.	...	...	...	...	88·0	72·0	88·0	72·0	84·0	70·0	82·0	68·0
17.	88·0	80·0	...	...	...	...	...	...	86·0	72·0	82·0	68·0
18.	90·0	82·0	...	...	88·0	75·0	...	...	82·0	70·0	80·0	68·0
19.	90·0	82·0	...	...	...	...	...	...	80·0	70·0	84·0	68·0
20.	90·0	82·0	...	...	...	...	87·0	72·0	84·0	70·0	...	...
21.	88·0	80·0	...	...	90·0	75·0	86·0	70·0	...	...	...	...
22.	90·0	88·0	...	...	88·0	74·0	86·0	72·0	84·0	70·0	82·0	68·0
23.	90·0	86·0	...	...	90·0	74·0	88·0	72·0	84·0	70·0	82·0	66·0
24.	92·0	80·0	...	...	...	...	88·0	74·0	84·0	70·0	84·0	66·0
25.	94·0	86·0	...	...	...	...	...	...	84·0	68·0	...	...
26.	92·0	84·0	...	...	...	...	88·0	72·0	82·0	70·0	82·0	66·0
27.	92·0	86·0	...	...	90·0	74·0	86·0	72·0	84·0	70·0	...	...
28.	92·0	86·0	...	...	...	...	88·0	72·0	...	...	82·0	66·0
29.	92·0	86·0	...	...	...	...	86·0	72·0	...	...	84·0	66·0
30.	92·0	86·0	...	...	...	...	...	...	...	...	...	...
31.	...	...	...	...	...	...						

TABLE IV—*Showing Maximum and Minimum Air Temperature, °F, Regarded at the Marine Biological Station, Tuticorin, 1953*

Date	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	...	...	...	...	...	...	90·0	88·0	88·5	86·0	94·0	86·5
2.	82·0	68·0	82·0	66·0	84·0	70·0	86·0	84·0	89·0	87·0	92·0	86·5
3.	82·0	66·0	84·0	66·0	88·0	82·0	...	...	89·5	87·5	91·5	85·5
4.	...	...	84·0	66·0	88·0	84·0	86·0	82·0	92·0	88·5	92·0	88·0
5.	82·0	66·0	84·0	68·0	86·0	68·0	...	...	92·5	89·0	92·0	88·5
6.	82·0	68·0	82·0	66·0	84·0	70 0	86·0	82·0	91·5	86·0	91·5	87·0
7.	84·0	68·0	...	...	86·0	79·0	82·0	85·0	92·5	86·5	91·0	89·5
8.	82·0	66·0	...	...	...	...	86·0	84·0	92·0	89·0	93·5	88·0
9.	82·0	66·0	82·0	66·0	82·0	66·0	86·0	84·0	91·5	88·0	93·0	88·5
10.	82·0	66·0	84·0	66·0	84·0	66·0	85·5	82·5	92·0	87·5	91·5	88 0
11.	...	...	82·0	66 0	82·0	79·0	85·0	82·5	90·5	86·0	91·5	88·0
12.	84·0	66·0	...	...	84·0	70·0	...	...	91·5	86·5	91·0	88·0
13.	...	...	84·0	66·0	84 0	70·0	...	...	91·5	88·0	...	...
14.	...	...	84·0	66·0	84·0	70·0	86·0	82·5	91·5	89·5	91·5	88·0
15.	82·0	66·0	..	...	...	...	86·5	82·0	90·0	88·0	93·5	87·5
16.	84·0	66·0	82·0	66·0	...	...	86·0	82·0	92·0	89·5	91·5	87·0
17.	84·0	68·0	84·0	66·0	84·0	82·0	...	...	91·5	88·0	91·5	86·5
18.	...	...	84·0	68·0	86·0	84·0	...	...	...	...	91·5	87·5
19.	84·0	68·0	84·0	68·0	84·0	78·0	...	...	...	...	...	...
20.	84·0	68·0	...	...	81·0	72·0	86·0	81·5	90·0	88·0	...	...
21.	84·0	68·0	...	...	...	...	86·5	84·0	91·5	88·0	91·5	88·0
22.	84·0	68·0	...	...	...	...	87·0	83·5	91·5	89·5	91·5	88·5
23.	84·0	68·0	84·0	70·0	...	...	88·5	83·5	...	...	89·5	86·5
24.	84·0	68·0	86·0	70·0	83·0	76·0	...	...	...	...	92·5	89·0
25.	...	...	84·0	70·0	84·0	78·0	87·0	84·5	90·0	88·0	91·5	88·5
26.	...	...	84·0	68·0	84·0	78·0	88·0	85·5	91·5	89·0	91·0	89·0
27.	84·0	66·0	84·0	70·0	...	...	88·5	85·5	92·5	89·5	...	...
28.	82·0	66·0	84·0	70·0	...	...	89·0	86·5	93·5	90·5	91·0	89·0
29.	82 0	66·0	...	...	..	...	...	...	91·5	89·5	91·5	89·0
30.	82·0	66·0	...	...	...	...	...	...	...	...	...	...
31.	84·0	66·0	...	...	...	...	...	...	...	...	...	...

Date	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	91·5	88·0	87·5	85·0	88·0	84·5	...	...	84·5	82·0	81·5	79·0
2.	91·0	88·0	...	...	90·5	87·5	...	...	86·0	83·0	81·0	79·0
3.	90·0	86·5	90·5	87·5	90·0	86·5	88·5	86·0	85·5	84·0	81·0	78·5
4.	91·0	87·0	90·0	86·5	...	...	...	...	...	...	80·5	77·5
5.	...	...	90·5	87·0	91·5	87·0	92·0	88·5	...	...	81·0	78·5
6.	91·0	86·5	91·0	88·5	...	...	88·5	86·0	86·5	84·5	...	...
7.	84·5	82·0	91·5	88·0	91·5	86·5	...	...	86·0	82·5	...	...
8.	84·0	82·5	89·0	86·5	91·0	87·0	88·0	86·5	85·5	83·0	81·5	78·5
9.	88·5	86·0	...	...	91·5	88·0	88·5	86·0	86·0	82·5	81·5	79·0
10.	89·0	87·5	89·5	87·5	88·0	86·5	88·0	85·5	84·0	82·0	81·0	79·5
11.	...	...	90·0	86·5	90·0	86·0	...	...	83·5	80·0	80·0	77·5
12.	91·0	88·5	91·5	88·5	...	...	86·0	83·5	...	...	80·0	76·5
13.	88·0	86·5	90·0	88·0	...	...	85·5	83·0	84·0	82·0	...	...
14.	88·0	84·5	90·5	88·0	88·5	85·0	...	...	83·5	80·5	...	...
15.	88·5	86·5	...	...	88·0	85·5	...	...	80·0	78·0	...	...
16.	88·5	86·0	...	...	91·5	87·5	...	...	80·0	78·0	...	...
17.	91 0	88·5	92·0	90·5	88·5	85·0	...	...	81·0	78·5	...	...
18.	...	...	91·0	87·5	88·0	86·0	84·0	82·5	80·0	78·5	81·0	78·5
19.	...	...	91·5	88·0	...	...	86·5	83·0	81·0	79·0	80·5	77·0
20.	90·5	88·0	92·0	88·5	...	...	86·0	83·5	...	...	...	...
21.	91·5	88·5	...	...	89·0	86·5	86·0	82·0	82·0	80·5	81·0	77·5
22.	90·0	87·5	...	...	91·5	88·0	86·0	83·0	...	...	80·0	77·5
23.	91·5	88·0	...	...	89·5	86·5	...	...	81·0	78·5	80·0	77·0
24.	88·5	86 0	...	...	90·0	86·5	...	...	82·5	80·0	80·5	78·0
25.	88·0	86·0	92·0	89·0	89·5	86·0	85·0	82·0	81·5	78·5	79·5	76·0
26.	...	...	92·0	88·5	90·5	87·0	86·0	84·0	82·0	79·5	...	...
27.	89·5	87·5	89·5	87·0	...	...	86·5	84·0	82·5	80·0	...	...
28.	90·0	88·0	86·5	84·0	90·0	86·5	88·0	84·0	83·0	80·5	...	...
29.	88·0	86·5	...	...	90·5	88·0	86·0	82·0	...	...	...	...
30.	88·0	86·0	...	...	90·0	89·5	86·0	82·0	82·0	79·0	80·0	78·0
31.	88·5	85·5	...	...	...	...	84·0	83·0	...	...	81·5	78.5

TABLE V—*Showing Maximum and Minimum Air Temperature, °F, Recorded at the Marine Biological Station, Tuticorin, 1954.*

Date	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	...	...	81·5	79·0	84·0	81·5	83·5	80·0	86·5	85·0	96·0	88·0
2.	83·0	80·5	80·0	77·5	83·5	80·5	85·0	82·5	...	...	94·0	88·0
3.	...	...	80·5	78·5	...	...	86·0	84·5	88·0	86·0	...	...
4.	80·0	78·0	81·0	79·0	84·0	81·5	...	...	88·5	87·0	94·5	88·5
5.	81·0	78·5	80·5	78·0	82·0	79·0	86·0	84·0	88·0	86·0	94·0	90 0
6.	...	...	81·5	79·0	81·5	78·0	88·5	85·0	90·0	86·0	...	...
7.	...	...	...	...	...	...	88·0	85·5	...	...	94·0	88·0
8.	...	...	81·0	78·5	83·5	80·0	88·0	86·0	90·0	86·0	93·5	87·5
9.	...	...	81·0	78·0	82·0	78·5	88·0	85·0	90·0	88·0	92·0	89·5
10.	...	...	81·0	77·5	81·5	79·0	88·0	86·0	93·0	88·0	93·0	88·0
11.	...	...	81·5	79·0	80·5	78·0	...	...	92·0	88·0	92·0	88·0
12.	...	...	81·5	79·0	...	...	87·5	86·0	91·0	88·0	90·0	87·5
13.	...	...	...	...	83·0	81·0	...	...	...	...	93·0	86·0
14.	...	...	82·0	79·0	...	...	88·0	85·5	91·0	87·0	93·0	88·0
15.	81·5	78·0	81·5	78·0	...	...	90·0	86·0	90·0	88·0	94·0	88·0
16.	81·0	78·5	81·0	78·0	86·0	82·5	...	...	92·0	86·0	94·0	88·0
17.	...	...	81·5	79·0	86·0	83·0	...	...	90·0	87·0	94·0	88·0
18.	80·0	77·5	81·0	78·5	85·5	82·0	...	...	92·0	88·0	...	...
19.	...	...	...	...	84·5	81·5	93·0	90·5	92·0	86·0	...	...
20.	81·5	79·0	...	...	...	...	87·5	88·0	...	...	...	...
21.	81·5	79·0	...	...	...	...	86·5	83·0	...	...	94·0	84·0
22.	81·0	79·5	81·0	78·0	83·5	81·0	82·0	80·0	...	...	92·0	88·0
23.	...	...	82·0	79·0	86·5	84·0	86·0	84·5	93·0	86·0	94·0	88·0
24.	...	...	81·5	78·0	84·5	82·0	...	...	94·0	86·0	94·0	88·0
25.	81·0	78·5	83·0	79·0	84·0	81·0	86·0	84·0	94·0	88·0	92·5	88·0
26.	...	...	...	...	85·0	81·5	86·0	85·5	96·0	90·0	...	...
27.	81·0	78·5	...	...	84·0	81·5	88·0	86·0	86·0	90·0	89·5	87·5
28.	80·0	78·5	...	...	...	...	84·5	85·5	...	...	90·5	88·0
29.	81·0	78·5	...	...	...	...	88·0	87·0	...	...	91·5	89·0
30.	80·5	78·0	...	...	...	...	87·0	88·5	92·0	87·0	...	...
31.	...	...	...	...	...	...	...	...	...	...	...	...

Date	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	93·0	88·0	...	...	90·5	85·5	86·0	82·0	84·5	83·0	82·5	80·0
2.	92·0	86·0	89·0	83·0	94·0	86·0	...	...	83·0	82·0	81·0	78·0
3.	92·0	86·0	87·0	82·0	94·0	86·0	...	...	83·5	82·0	81·5	78·0
4.	...	...	88·0	82·0	...	...	87·0	82·5	84·5	82·0	82·5	78·0
5.	92·0	86·0	90·0	82·0	90·5	88·0	...	...	84·0	82·5	...	...
6.	88·0	84·0	87·0	83·0	91·5	87·5	...	...	83·0	81·5	80·0	78·0
7.	87·0	86·0	90·0	82·0	...	...	...	...	...	...	81·0	78·0
8.	90·0	85·0	...	...	...	...	87·0	83·5	82·5	81·0	81·5	78·0
9.	92·0	86·0	90·0	83·0	...	...	85·0	81·0	...	...	78·5	76·0
10.	92·0	86·0	...	...	88·5	86·0	...	...	83·0	81·5	78·0	75·0
11.	...	...	92·0	84·0	87·5	86·0	85·0	82·0	81·5	78·5	78·0	76·0
12.	94·0	84·0	88·0	84·0	...	...	84·0	81·0	82·0	80·0	...	...
13.	88·0	82·5	88·0	85·0	86·5	84·5	83·0	82·0	...	...	82·0	80·0
14.	90·0	86·0	...	...	90·5	88·0	84·0	82·0	83·5	82·0	81·0	78·5
15.	91·0	85·5	...	...	93·0	84·0	84·0	82·0	83·5	81·0	80·0	78·5
16.	92·0	89·0	88·0	84·0	92·0	84·0	85·0	82·0	82·0	78·0	79·0	77·0
17.	...	...	92·0	86·0	90·0	84·0	85·0	81·0	82·0	77·0	79·0	77·0
18.	88·6	86·0	89·0	87·5	...	...	...	...	80·0	76·0	...	...
19.	90·0	86·0	89·0	86·0	...	...	84·0	81·0	...	...	...	...
20.	92·0	84·0	86·0	84·0	92·0	84·0	83·0	81·0	...	...	80·0	78·5
21.	92·0	84·0	...	...	92·0	84·0	83·0	80·0	...	...	81·0	79·0
22.	92·0	84·0	...	...	92·0	84·0	82·0	80·0	80·0	78·0	82·0	80·0
23.	92·0	85·0	88·0	86·5	93·0	83·0	83·5	81·0	82·0	80·0	82·5	80·0
24.	...	...	88·5	84·0	93·0	85·0	85·0	81·0	92·0	88·0	...	...
25.	...	...	89·0	85·0	93·0	85·0	...	...	80·0	77·5	...	...
26.	90·0	84·0	88·0	84·0	...	...	...	...	82·5	79·0	...	...
27.	92·0	84·0	90·0	85·0	90·0	85·0	85·0	82·0	81·5	79·0	82·0	79·5
28.	90·0	86·0	88·0	84·0	89·5	87·0	82·5	81·0	...	...	82·5	80·0
29.	88·0	82·0	...	...	92·0	84·0	83·5	81·5	82·0	78·5	80·5	79·0
30.	89·0	82·0	87·5	86·0	88·0	84·0	82·0	81·0	82·0	78·0	81·0	79·0
31.	91·0	83·0	91·0	86·0	...	...	...	...	...	...	81·0	80·0

TABLE VI—*Showing Surface Temperature, °C, of Tuticorin Bay, 1950.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	24·6	26·4	28·4	...	...	26·8	27·6	28·1	29·6	28·8	25·1
2.	23·1	...	27·3	27·4	...	26·2	26·2	27·8	28·0	29·9	28·9	25·0
3.	...	25·9	27·5	29·0	29·8	26·8	26·5	26·8	28·2	28·4	28·4	26·0
4.	26·3	26·1	27·7	29·8	30·8	27·8	26·3	26·1	28·5	28·6	29·2	26·7
5.	24·5	25·6	27·1	...	...	28·2	26·4	26·4	27·0	28·7	28·6	27·2
6.	23·9	25·8	29·4	30·1	30·6	28·8	27·0	26·0	26·8	27·8	...	26·9
7.	23·3	26·7	27·4	28·8	30·2	28·9	...	26·6	26·2	27·8	...	25·6
8.	23·4	26·6	29·6	29·1	...	26·6	...	26·8	26·0	27·6	29·3	25·1
9.	...	...	28·1	29·4	30·1	26·8	26·8	25·6	26·1	27·4	29·7	24·3
10.	24·2	...	30·3	...	30·0	26·2	...	26·1	26·2	27·6	29·1	24·4
11.	25·1	27·9	30·2	29·2	30·3	26·3	26·3	26·3	26·5	27·2	26·8	...
12.	24·6	26·9	29·1	...	30·3	26·1	25·2	26·6	26·4	27·4	27·4	26·5
13.	24·8	...	...	...	30·6	26·2	...	26·4	26·2	27·0	28·4	25·1
14.	24·2	26·5	29·6	...	30·7	26·2	26·0	26·3	...	28·4	26·6	26·6
15.	24·4	27·5	29·9	...	...	25·8	25·9	26·8	26·4	28·1	25·7	28·9
16.	24·2	26·4	...	30·6	30·2	26·0	26·2	27·4	26·3	27·8	26·3	28·7
17.	24·2	26·6	29·5	...	29·6	25·9	26·1	27·3	26·8	28·0	28·8	24·8
18.	24·3	...	28·4	...	30·3	25·8	25·8	27·5	26·3	...	29·3	24·9
19.	24·4	26·9	29·2	...	31·0	25·6	26·2	26·6	26·8	28·1	28·6	25·1
20.	24·6	25·8	...	31·5	30·5	25·8	26·0	26·4	26·6	27·6	28·8	24·5
21.	25·4	29·6	29·3	30·7	31·5	...	25·8	27·1	27·8	27·8	27·0	23·8
22.	25·1	26·5	29·7	31·5	...	26·2	25·6	27·0	27·8	28·2	26·7	24·9
23.	24·7	...	28·8	29·6	30·6	25·6	25·9	27·3	27·4	28·0	26·9	25·2
24.	25·6	29·1	...	31·6	29·8	25·4	26·1	...	27·2	27·6	26·0	25·1
25.	26·9	30·4	30·7	30·5	28·4	25·4	26·0	26·8	27·9	27·8	25·4	24·1
26.	25·8	28·9	29·1	30·4	29·2	...	25·2	26·6	28·6	28·4	24·6	25·1
27.	26·1	...	30·2	...	27·2	25·6	26·0	26·8	28·2	28·6	24·6	25·5
28.	...	26·8	30·3	30·5	26·5	25·8	26·1	27·8	28·0	28·9	26·4	25·4
29.	25·6	...	30·8	30·2	27·8	25·9	25·2	27·9	29·4	28·8	25·9	24·7
30.	...	...	...	30·4	26·7	27·1	25·5	28·1	29·7	28·7	25·4	24·2
31.	26·2	...	28·4	...	26·6	...	26·4	28·3	...	28·6	...	24·4

TABLE VII—*Showing Surface Temperature, °C of Tuticorin Bay, 1951*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	24·5	24·7	24·2	25·5	28·4	29·7	26·9	26·5	26·7	27·5	27·5	27·5
2.	23·4	24·8	24·5	29·5	29·2	30·0	26·5	26·7	27·5	27·0	26·9	...
3.	24·5	25·2	26.0	30·5	28·5	28·7	25 9	26·0	26·7	26·0	27·0	28·5
4.	24·1	24·7	27·0	30·4	29·7	26·5	27·8	25·7	26·5	27·8	...	25·3
5.	24·4	25·8	27·3	29·5	28·5	26·7	26·5	25·0	25·9	26·7	26·7	25·4
6.	24·1	24·5	27·5	25·7	28·9	27·0	27·5	25·7	26·0	27·0	27·0	25·5
7.	24·4	24·3	27.1	27·4	29·8	27·5	27·5	25·8	26·5	...	27·2	25·6
8.	24·6	24·1	27·2	28·2	28·7	...	27·5	26·0	27·4	...	26·8	25·6
9.	23·8	25·0	27·1	27·9	28·9	26·5	27·6	26·2	27·2	27·0	27·9	25·4
10.	24·2	24·7	27·0	27·8	31·0	25·9	28·5	25·7	26·9	26·9	26·9	25·7
11.	24·0	24·5	25·1	25·1	31·7	25·7	27·6	27·5	27·0	27·5	...	26·1
12.	23·7	24·7	25·6	25·1	29 9	25·4	25·5	27·0	...	26·7	27·5	25·9
13.	23·9	25·7	29·5	25·4	28·4	26·7	25·7	27·8	...	27·5	27·9	25·7
14.	23·7	24·5	27·2	26·7	28·7	25·4	24·9	27·9	...	28·5	28·0	27·5
15.	23·4	24·2	27·6	27·4	29·1	25·5	27·5	27·5	...	27·9	28·2	27·0
16.	25·2	26·5	27·1	27·4	30·1	26·3	27·8	26·7	...	28·5	28·5	28·0
17.	25·6	25·1	27·5	...	30·0	26·0	25·0	25·9	...	27·9	...	27·9
18.	25·7	23·8	28·1	...	31·0	25·9	27·5	25·5	...	28·5	...	26·5
19.	25·8	24·1	27·5	...	30·5	25·8	25·0	27·5	27·6	27·9	...	27·0
20.	25·3	25·5	29·1	...	31·2	...	26·3	27·0	27·5	28·5	...	27·6
21.	25·7	26·0	28·5	27·9	30·7	25·9	26·5	27·5	27·0	27·9	28·0	26·5
22.	24·8	24·2	28·5	28·9	29·7	25·4	27·5	27·0	27·5	27·0	...	25·5
23.	25·2	24·7	27·7	29·7	30·0	26·0	25·5	26·0	27·4	27·5	...	24·7
24.	24·9	24·5	28·0	28·7	29·9	25·8	25·0	27·0	27·0	28·0	...	24·5
25.	25·7	24·5	...	29·7	29·8	25·5	25·5	27·5	26·9	27·5	...	...
26.	25·4	25·1	27·8	28·9	29·5	25·5	24·8	27·5	26·9	28·0	27·8	24·0
27.	25·2	...	...	29·5	28·9	25·9	25·5	28·5	27·7	27·5	26·8	24 5
28.	24·8	24·6	...	29·7	32·5	26·1	25·1	28·5	26·9	28·0	27·2	24·7
29.	25·1	...	...	29·5	30·7	27·5	26·7	27·5	26·5	26·9	28·0	25·5
30.	24·5	...	29·5	29·4	30·5	27·0	26 5	27·0	26·7	26·7	27·5	24·6
31.	24·7	...	28·9	...	30·7	...	25·7	26·5	...	26·9	...	24·7

TABLE VIII—*Showing Surface Temperature, °C, of Tuticorin Bay, 1952.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	25·7	24·7	29·7	...	29·5	27·5	25·7	...	28·5	...	...
2.	24·7	24·5	25·1	29·9	...	29·9	28·1	26·1	...	...	...	26·0
3.	24·9	25·7	24·9	30·1	31·4	30·0	27·7	...	...	28·9	28·6	26·6
4.	24·5	27·7	28·0	...	31·0	30·7	28·0	...	25·3	27·6	28·4	26·5
5.	24·7	24·5	...	...	32·0	29 7	28·5	...	26·6	...	27·0	25·2
6.	25·7	25·5	28·1	...	32·7	30·0	29·0	...	26·8	...	26·6	25·4
7.	24·9	24·7	28·5	...	31·7	30·5	27·9	...	...	26·6	28·8	...
8.	24·7	25·4	27·9	...	30·9	31·7	27·1	...	26·6	27·5	27·1	25·1
9.	25·7	26·6	28·1	...	31·7	31·5	28·1	...	27·3	26·6	...	27·6
10.	27·1	25·0	28·7	31·0	32·0	31·7	27·5	...	...	27·6	28·1	27·2
11.	26·5	26·5	29·5	31·5	31·9	...	26·9	...	27·5	27·5	28·1	27·1
12.	26·7	27·0	29·7	31·0	30·7	...	27·1	...	26·9	...	29·2	25·9
13.	25·5	24·7	29·9	30·0	31·7	29·1	27·9	...	27·5	28·1	25·8	...
14.	26·5	25·9	28·9	30·5	30·0	30·0	...	...	...	28·9	28·6	...
15.	27·4	26·5	29·7	30·7	29·7	31·0	...	...	27·1	28·4	25·6	25·4
16.	26·7	25·7	30·5	31·0	29·5	27·0	...	...	28·0	28·7	...	25·3
17.	26 1	24·7	31·0	29·5	28·7	27 4	26·7	...	28·1	...	26·1	24·4
18.	25·2	25·6	31·5	30·7	29·7	25·7	27·1	...	...	...	25·8	24·6
19.	24·1	25·9	35·7	32·5	...	26·1	28·0	...	28·1	...	24·5	24·4
20.	23·7	26·0	30·5	31·5	...	25·4	27·5	...	...	27 5	27·4	...
21.	23·5	24·7	30·1	30·5	27·1	...	...	...	...	26·9	26·6	...
22.	23·7	24·5	30·7	31·9	26·5	...	...	...	29·1	28·2	...	26·7
23.	23·5	24·5	30·2	30·5	26·7	24·7	26·5	...	29·1	28·5	...	25·0
24.	24·5	24·6	30·6	31·0	25·1	25·6	27·4	...	28·1	28·8	...	25·6
25.	26·5	24·0	31·0	30·7	27·0	25·7	26·7	...	28·9	28·9	26·0	...
26.	24·7	24·7	31·1	32·5	25·7	26·0	26·9	...	29·9	...	26·9	25·8
27.	25·5	25·8	29·9	32·3	26·8	26·7	25·7	...	...	27·7	26·2	...
28.	24·5	26·5	29·5	32·1	26·5	...	25·7	...	...	27·8	26·1	...
29.	25·0	25·7	29·9	...	...	27·5	25·8	...	...	...	25·8	25·8
30.	26·0	24·9	29·6	...	26·9	27·1	25·1	...	29·7	26·6	26·0	24·9
31.	...	...	29·6	...	26·7	...	26·5	...	...	...	...	24·6

TABLE IX—*Showing Surface Temperature, °C, of Tuticorin Bay, 1953.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	...	...	...	30·6	31·6	29·6	28·6	28·8	...	...	27·9
2.	24·8	24·3	29·2	27·2	30·2	29·8	29·4	...	28·2	...	29·2	28·1
3.	24·2	25·3	28·2	...	29·9	30·2	29·6	28·4	28·6	28·7	28·8	28·6
4.	...	24·9	29·8	...	30·3	30·6	30·2	28·2	...	...	28·2	28·6
5.	23·7	25·1	29·7	...	30·4	29·9	...	28·6	28·2	28·9	...	28·2
6.	24·5	24·0	28·7	29·9	30·3	30·1	29·6	28·2	...	28·4	...	...
7.	24·9	...	31·9	29·8	29·9	...	29·8	29·4	28·6	...	29·1	...
8.	25·6	...	...	30·2	30·1	29·8	28·9	...	28·2	28·8	28·6	28·2
9.	25·2	24·8	27·8	29·0	...	29·6	29 2	29·2	28·6	28·9	29·1	28·1
10.	25·4	24·6	28·7	29·8	30·6	29·2	29·6	28·8	29·2	28·7	28·9	...
11.	...	24·0	28·2	28·8	30·4	30·1	30·2	28·4	29·1	...	28·4	27·4
12.	24·9	...	29·8	...	30 2	30·2	...	28·8	...	27·8	28·1	26·7
13.	...	23·9	29·8	...	30 1	30·4	...	28·7	29·6	28·6	27·9	...
14.	...	24·3	30·8	28·9	30·6	...	29·8	...	29·2	28·4	...	...
15.	25·0	...	...	28·9	30·8	30·6	29·6	...	...	...	27·4	...
16.	26·0	23·6	...	29·5	...	30·1	28·2	...	28·9	...	27·6	...
17.	26·3	25·5	32·8	...	29·6	30·4	28·6	28·2	28·6	...	27·4	26·2
18.	...	26·4	...	...	30·2	29·9	28·8	28·6	29·2	27·9	27·2	26·8
19.	25·9	26·2	...	32·8	30·8	30·2	...	28·2	...	28·2	...	...
20.	25·4	26·2	29·6	33·0	30·2	...	...	28·8	...	27·8	27·2	...
21.	25·9	...	29·4	32·6	30·4	29·9	29·6	...	28·8	27·8	28·6	26·8
22.	26·7	..	...	31·8	...	30·4	28·2	...	28·6	...	...	26·8
23.	25·7	26·9	27·9	32·8	...	29·2	28·6	...	28·8	29·2	28·2	26·7
24.	...	27·7	29·8	32·4	...	29·6	28·6	...	28·9	...	28·6	26·2
25.	...	27·9	...	...	32·6	29·8	28·8	29·6	28·7	...	28·4	26·0
26.	...	26·3	...	30·1	32·4	29·7	...	29·8	28·9	28·8	28·7	26·4
27.	24·2	27·7	...	30·8	32·2	...	28·6	29·2	...	29·1	28·4	...
28.	23·6	27·5	...	30·1	32·2	29·8	28·8	...	28·7	28·7	27·6	...
29.	23·8	...	...	30·2	32·6	28·6	28·8	...	28·8	28·6	...	...
30.	24·6	...	...	...	32·4	...	27·8	...	28·6	27·3	27·4	27·1
31.	24·2	...	...	...	...	...	28·2	...	...	29·2	...	26·8

TABLE X—*Showing Surface Temperature, °C, of Tuticorin Bay, 1954.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	26·8	27·6	27·6	28·6	29·7	28·6	27·4	...	28·4	...	26·7
2.	27·6	27·0	28·1	28·4	...	29·8	27·0	27·9	29·5	...	29·1	26·4
3.	...	26·9	...	28·1	29·4	...	28·4	27·8	28·2	...	29·4	26·8
4.	26·8	27·0	27·2	...	28·6	30·1	...	27·3	28·0	28·2	29·2	26·5
5.	27·0	26·9	27·6	27·9	30·8	29·0	27·9	27·1	...	...	...	...
6.	...	27·2	28·2	28·4	30·8	...	27·4	27·1	28·9	...	28·3	27·1
7.	...	...	...	28·6	29·8	29·7	28·2	...	28·5	...	...	26·9
8.	...	26·8	30·4	28·8	29·5	28·4	27·6	26·6	...	28·5	...	26·4
9.	...	26·4	30·2	28·8	...	28·7	27·5	...	...	27·9	...	25·9
10.	...	26·8	...	28·1	30·9	28·4	28·4	28·2	29·1	...	...	25·2
11.	...	26·1	...	...	30·7	27·9	...	28·4	28·8	28·4	28·0	25·7
12.	...	26 4	...	28·7	32·0	...	28·4	27·6	...	27·9	28·1	...
13.	...	26·7	...	...	30·7	...	28·4	...	29·2	27·6	29·2	26·2
14.	...	...	...	30·1	30·5	28·7	27·4	...	29·7	29·9	...	27·4
15.	...	28·0	...	30·7	31·1	28·8	28·7	29·4	28·8	29·9	27·9	26·8
16.	26·7	27·9	...	...	...	28·9	29·3	29·2	.	30·2	28·4	26·4
17.	...	27·8	...	...	29·4	28·7	28·5	29·8	29·1	...	25·3	27·0
18.	26·2	27·1	...	...	30·3	...	...	29·8	...	30·4	24·5	...
19.	...	27·4	...	31·4	30·3	...	29·4	28·8	...	29·9	25·3	...
20.	27·4	...	...	31·8	30·6	...	30·2	30·5	29·1	27·0	...	27·1
21.	27·1	...	...	30·9	29·6	29·3	29·6	...	29·2	28·3	.	27·6
22.	...	28·2	...	27·9	...	28.9	30·1	...	27·7	28·1	26·8	27·2
23.	...	28·6	...	28·7	..	28·6	29·0	...	28·5	27·9	27·6	26·8
24.	...	28·7	...	29·3	29·7	27·4	...	30·1	29·1	...	28·2	..
25.	26·9	29·4	...	...	29·6	28·8	...	29·8	27·3	...	27·8	...
26.	...	...	...	30·1	28·1	26·7	28·4	29·3	...	...	28·2	.
27.	27·2	...	...	30·0	29·5	...	29·2	29·2	28·2	29·6	27·6	27·2
28.	27·6	...	...	29·6	30·6	...	29·4	28·5	...	...	...	27·4
29.	26·8	...	...	28·7	29·6	28·4	27·7	...	...	29·7	26·2	27·1
30.	26·4	...	...	29·2	...	...	27·6	29·5	29·2	...	26·7	27·4
31.	...	...	...	...	29·3	...	28·5	29·2	...	...	...	27·6

TABLE XI—*Showing Specific Gravity of Tuticorin Bay, 1950*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·026	1·023	1·026	...	...	1·028	...	1·029	1·031	1·028	1·026
2.	1·024	...	1·022	1·027	...	1·028	1·029	...	1·028	1·030	1·029	1·027
3.	...	1·025	1·024	1·027	1·025	1·028	1·028	...	1·029	1·030	1·028	1·027
4.	1·023	1·024	1·023	1·028	1·027	1·027	1·031	1·028	1·030	1·029	1·029	1·027
5.	1·025	1·024	1·023	...	...	...	1·029	1·029	1·029	1·028	1·029	1·027
6.	1·024	1·025	1·022	1·028	1·028	1·028	1·028	1·029	1·029	1·029	...	1·025
7.	1·025	1·025	1·023	1·028	1·026	1·028	...	1·028	1·030	1·029	...	1·021
8.	1·023	1·026	1·023	1·027	...	1·027	...	1·026	1·030	1·028	...	1·022
9.	...	...	1·024	1·026	1·027	1·028	1·028	1·027	1·029	1·029	...	1·023
10.	1·026	...	1·024	...	1·028	1·029	...	1·027	1·031	1·028	1·027	1·025
11.	1·025	1·025	1·025	1·026	1·029	1·028	1·029	1·028	1·032	1·028	1·021	1·023
12.	1·025	1·024	1·025	...	1·028	1·028	...	1·026	1·032	1·028	...	1·025
13.	1·026	...	..	...	1·026	1·029	...	1·027	1·032	1·026	1·028	1·021
14.	1·024	1·027	1·025	...	1·027	1·028	1·029	1·026	1·032	1·028	1·025	1·022
15.	...	1·026	...	1·026	...	1·028	...	1·028	1·032	1·026	1·026	1·023
16.	1·025	1·026	1·026	...	1·024	1·029	1·029	1·027	...	1·027	1·025	1·025
17.	1·026	1·026	1·026	...	1·025	1·026	1·028	1·027	1·031	1·026	1·026	1·025
18.	1·025	...	1·025	...	1·026	1·026	1·028	1·027	1·030	...	1·025	1·025
19.	1·026	1·026	...	1·027	1·026	1·026	...	1·026	1·030	1·029	...	1·025
20.	1·025	1·024	...	1·027	1·025	...	1·028	1·026	1·030	1·030	1·027	1·024
21.	1·024	1·025	1·026	1·026	...	1·027	1·029	1·027	1·029	1·031	1·027	1·023
22.	1·024	1·026	1·026	1·026	1·026	1·028	1·030	1·027	1·030	1·032	1·027	1·023
23.	1·026	...	1·025	1·027	1·027	1·029	...	...	1·031	1·029	1·025	1·024
24.	1·025	1·023	...	1·027	1·029	1·027	...	1·026	1·028	1·027	1·027	1·025
25.	1·027	1·025	1·026	1·026	1·029	...	1·028	1·027	1·031	1·026	1·027	1·023
26.	1·025	1·025	1·027	...	1·028	1·028	1·029	1·028	1·027	1·028	1·028	1·023
27.	1·024	...	1·026	1·026	1·028	1·031	1·028	1·028	1·027	1·028	1·026	1·028	1·023
28.	...	1·022	1·027	1·025	1·028	1·029	1·029	1·028	1·026	1·030	1·026	1·029	1·024
29.	1·024	...	1·027	1·025	1·028	1·028	1·028	1·030	1·030	1·031	1·027	1·025	1·022
30.	...	...	...	...	1·027	...	1·028	1·028	1·028	...	1·027	...	1·024
31.	1·026	...	1·027	...								

TABLE XII—*Showing Specific Gravity of Tuticorin Bay, 1951.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	1·023	1·023	1·022	1·023	1·022	1·024	1·026	1 026	1·025	1·026	1·025	1·024
2.	1·023	1·022	1·023	1·022	1·020	1·025	1·025	1·025	1·025	1·025	1·026	...
3.	1·023	1·023	1·024	1·022	1·023	1·025	1·026	1·025	1·025	1·026	1·024	1·023
4.	1·023	1·023	1·023	1·022	1·022	1·027	1·026	1·026	1·025	1·025	...	1·020
5.	1 024	1·022	1·024	1·022	1·022	1·028	1·027	1·025	1·025	1·026	1·025	1·020
6.	1·024	1·022	1·023	1·023	1·023	1·027	1·026	1·025	1·025	1·025	1·025	1·020
7.	1·024	1·023	1·023	1·023	1·022	1·027	1·024	1·025	1·026	...	1·025	1·022
8.	1·024	1·025	1·022	1·022	1·022	...	1·027	1·025	1·028	...	1·026	1·020
9.	1·025	1·022	1·022	1·023	1·022	1·024	1·027	1·026	1·025	1·026	1·024	1·021
10.	1·023	1·022	1·022	1·024	1·023	1·027	1·027	1·027	1·025	1·025	1·026	1·020
11.	1 023	1·022	1·021	1·020	1·022	1·026	1·028	1·027	...	1·025	1·025	1·021
12.	1·022	1·023	1·022	1·020	1·022	1·025	1·027	1·027	...	1·026	...	1·020
13.	1 022	1·024	1·022	1·022	1·025	1·025	1·026	1·026	...	1·025	1·024	1·022
14.	...	1·022	1·023	1·021	1·022	1·025	1·026	1·026	...	1·026	1·025	1·020
15.	...	1·023	1·023	1·020	1·023	1·027	1·026	1·025	...	1·025	1·025	1·022
16.	1·019	1·023	1·022	1·020	1·022	1·026	1·026	1·025	...	1·026	1·025	1·020
17.	1·021	1·022	1·022	...	1·022	1·025	1·028	1·025	...	1·026	1·025	1·022
18.	1·020	1·022	1·022	...	1 022	1·027	1·027	1·025	...	1·025	1·025	1·021
19.	1·022	1·022	1·023	...	1·022	1·027	1·027	1·026	...	1·024	...	1·020
20.	1·020	1·023	1·023	...	1·023	...	1·026	1·025	1·026	1·025	...	1·020
21.	1·021	1·024	1·023	1·022	1·023	1·027	1·027	1·026	1·025	1 025	...	1·022
22.	1·021	1·023	1·023	1·023	1·022	1·026	1·028	1·026	1·025	1·024	...	1·022
23.	1·022	1·022	1·023	1·020	1·022	...	1·027	1·026	1·026	1·025	1·026	1·021
24.	1·021	1·023	1·022	1·020	1·023	1·026	1·027	1·027	1·025	1·025	...	1·022
25.	1·022	1·022	...	1·021	1·025	1·026	1·026	1·024	1·024	1·026	...	1·023
26.	1 022	1·023	1·022	1·020	1·024	1·026	1·026	1·026	1·025	1·027	...	1·024
27.	...	...	...	1·021	1·025	1·026	1·027	1·027	1·024	1·025	1·026	1·020
28.	1·022	1·022	...	1·022	1·024	1·026	1·026	1·026	1·025	1 024	1·027	1·022
29.	1·023	...	...	1·020	1·024	1·026	1·026	1·026	1·025	1·025	1·025	1·022
30.	1·025	...	1·021	1·020	1·023	1·026	1·026	1·026	1·025	1·025	1·026	1·021
31.	1·023	...	1·023	1·021	1·023	1·026	1·025	1·026	1·024	1·024	1·026	1·022
									1·025	1·025	...	1·023

TABLE XIII—*Showing Specific Gravity of Tuticorin Bay, 1952.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·022	1·022	1·020	...	1·023	1·026	1·020	...	1·027	...	...
2.	1·022	1·023	1·022	1·020	...	1·024	1·026	1·025	...	...	...	1·026
3.	1·021	1·023	1·021	1·020	1·023	1·024	1·025	...	...	1·025	1·024	1·026
4.	1·023	1·023	1·019	...	1·023	1·024	1·025	...	1·026	1·025	1·025	1·027
5.	1·022	1·021	...	...	1·023	1·024	1·025	...	1·026	...	1·027	1·030
6.	1·022	1·020	1·020	...	1·024	1·024	1·025	...	1·029	...	1·027	1 026
7.	1·022	1·022	1·020	...	1·023	1·024	1·024	...	...	1·026	...	...
8.	1·023	1·023	...	...	1·023	1·025	1·024	...	1·025	1·026	...	1·027
9.	1·023	1·022	...	...	1·023	1·025	1·024	...	1·028	1·026	...	1·028
10.	1·023	1·021	1·020	...	1·023	1·025	1·025	...	...	1·026	...	1·026
11.	1·022	1·021	1·020	...	1·024	...	1·024	...	1·026	1·026	...	1·027
12.	1·022	1 021	1·020	1·022	1·024	...	1·024	...	1·027	...	...	1·026
13.	1·022	1·022	1·018	1·022	1·024	1·025	1·024	...	1·024	1·026	...	...
14.	1·022	1·022	1·019	1·020	1·024	1·025	1·024	...	...	1·027	...	...
15.	1·022	1·022	1·019	1·020	1·024	1·024	1·025	...	1·026	1·027	...	1·027
16.	1·023	1·022	1·020	1·020	1·024	1·025	...	...	1·027	1·027	...	1·026
17.	1·023	1·023	1·020	1·021	1·024	1·026	1·025	...	1·027	...	1·027	1·026
18.	1·022	1·022	1·020	1·021	...	1·025	1·024	...	1·027	...	1·029	1 025
19.	1·022	1·022	1·020	1·020	1·020	1·025	1·024	...	1·028	...	1·228	1·024
20.	1·023	1·021	1·020	1·020	1·020	1·026	1·024	...	...	1·026	1·029	..
21.	1·022	1·021	1·020	1·021	1·021	1·026	...	...	1·029	1·030	1·025	...
22.	1·023	1·022	1·020	1·020	1 026	...	...	...	1·028	1·030	...	1·024
23.	1 022	1.020	1·020	1·020	1·026	...	1·025	...	1·026	1·028	...	1·023
24.	1·023	1·021	1·020	1·020	1·026	1·026	1·025	...	1·029	1·029	1·027	1·024
25.	1·023	1·021	1·020	1·020	1·026	1·026	1·025	...	...	1·030	1·029	
26.	1·022	1·022	1·021	1·020	1·026	1·026	1·025	...	1·025	...	1·027	1·022
27.	1·023	1·021	1·020	1·021	1·025	1·027	1·026	...	...	1·027	1·029	...
28.	1·022	1·022	1·017	1·021	1·025	1·025	1·026	...	...	1·026	1·028	...
29.	1·023	1·022	1·019	..	...	...	1·026	...	1·026	...	1·027	1·022
30.	...	...	1·019	...	1·024	1·025	1·025	...	1·027	1.030	...	1·022
31.	...	...	1·020	...	1·024	...	1·025	...	...	...	...	1·022

TABLE XIV—*Showing Specific Gravity of Tuticorin Bay, 1953.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	1·022	1·022	...	1·025	1·025	1·027	1·028	1·029	...	1·028	1·025
2.	1·022	1·022	1·023	1·023	1·026	1·024	1·027	...	1·029	...	1·027	1·024
3.	1·022	1·023	1·024	...	1·025	1·025	1·027	1·028	1·030	1·028	1·028	1·025
4.	...	1·022	1·022	...	1·024	1·026	1·028	1·028	...	...	...	1·024
5.	1·022	1·022	1·023	...	1·025	1·024	...	1·028	1·029	1·028	...	1·023
6.	1·023	...	1·020	1·024	1·026	1·025	1·028	1·028	...	1·029	...	...
7.	1·023	...	1·020	1·023	1·024	...	1·028	1·029	1·029	...	...	...
8.	1·023	1·022	...	1·024	1·026	1·025	1·027	1·022	1·030	1·027	1·027	...
9.	1·022	1·023	1·022	1·025	..	1·026	1·027	1·029	1·029	1·028	...	1·024
10.	1·022	1·022	1·024	1·025	1·024	1·025	1·028	...	1·029	1·028	1·028	1·024
11.	...	1·022	1·022	1·023	1·026	1·024	1·028	1·029	1·029	...	1·027	1·023
12.	1·022	...	1·022	...	1·024	1·025	...	1·028	...	1·029	1·026	1·023
13.	...	1·023	1·024	...	1·025	1·025	1·027	1·027	...	1·027	1·026	...
14.	...	1·022	1·022	1·020	1·025	...	1·027	1·028	1·028	1·028	1·026	...
15.	1·023	..	...	1·025	1·025	1·026	1·027	1·029	1·029	...	...	...
16.	1·022	1·023	...	1·025	...	1·026	1·027	...	1·030	...	1·025	1·024
17.	1·020	1·021	1·022	...	1·026	1·025	1·027	..	1·028	..	1·026	1·024
18.	...	1·021	...	...	1·026	1·025	...	1·027	1·028	...	1·025	...
19.	1·021	1·021	...	...	1·026	1·026	...	...	1·029	1·025	1·025	...
20.	1·021	1·023	1·025	1·023	1·026	...	1·028	1·027	1·029	1·028	...	
21.	1·022	...	1·023	1·026	1·026	...	1·028	1·028	1·030	1·028	1·026	1·023
22.	1·021	...	...	1·025	1·026	1·026	1·027	1·026	1·029	...	..	1·023
23.	1·022	1·022	1·024	1·025	...	1·026	1·028	1·027	...	1·027	1·026	1·024
24.	...	1·022	1·024	1·026	...	1·027	1·027	1·028	1·029	...	1·025	1·023
25.	...	1·023	...	1·025	1·026	1·027	1·027	1·028	1·030	...	1·025	1·023
26.	...	1·023	...	...	1·026	1·028	...	1·028	1·029	1·028	1·025	...
27.	1·022	1·022	...	1·025	1·025	1·026	1·028	...	1·029	1·028	1·024	...
28.	1·023	1·022	...	1·024	1·025	...	1·028	1·027	1·029	1·027	1·025	...
29.	1·023	...	...	1·025	1·025	1·027	1·028	1·028	1·028	....	...	1·023
30.	1·022	...	...	1·023	1·025	1·027	1·027	1·029	1·028	...	1·024	1·024
31.	1·022	...	...	...	...	...	...	1·028	...	...	...	...

TABLE XV—*Showing Specific Gravity of Tuticorin Bay, 1954.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	1·024	1·023	1·024	1·025	1·022	1·025	1·027	1·026	...	1·025	...	1·024
2.	...	1·024	1·023	1·024	...	1·023	1·027	1·027	1·027	...	1·026	1·023
3.	1·023	1·024	...	1·025	1·023	...	1·026	1·026	1·027	1·025	1·022	1·024
4.	1·024	1·023	1·024	...	1·023	1·025	...	1·026	1·030	...	1·024	1·025
5.	...	1·024	1·023	1·025	1·021	1·026	1·027	1·026	...	...	...	...
6.	...	1·024	1·024	1·025	1·022	...	1·027	1·026	1·029	1·026	1·026	1·025
7.	...	1·024	...	1·024	1·023	1·024	1·026	1·027	1·028	1·026	...	1·026
8.	...	1·024	1·024	1·025	1·022	1·026	1·026	...	...	...	...	1·026
9.	...	1·025	1·025	1·025	...	1·025	1·027	1·026	1·027	1·023	...	1·026
10.	...	1·026	1·023	1·024	1·022	1·026	...	1·028	1·027	1·022	1·026	1·028
11.	...	1·025	...	...	1·022	1·027	1·027	1·027	..	1·022	1·026	..
12.	...	...	1·024	1·025	1·022	...	1·027	1·026	1·028	1·023	1·025	1·027
13.	...	1·024	...	...	1·023	1·027	1·026	1·026	1·027	1·022	...	1·025
14.	...	1·024	...	1·024	1·024	1·026	1·026	1·027	...	...	1·026	1·027
15.	...	1·025	1·023	1·022	...	1·026	1·027	...	1·027	1·027	1·026	1·027
16.	1·024	1·024	1·024	...	1·025	...	...	...	1·027	...	1·026	1·026
17.	...	1·025	1·024	...	1·025	1·026	...	1·027	1·027	1·027	1·014	1·025
18.	1·024	1·024	1·023	1·025	1·025	...	1·027	1·027	1·027	...	1·020	1·025
19.	...	...	...	1·025	1·026	...	1·027	1·026	...	1·028	1·023	...
20.	1·024	...	1·024	1·023	1·025	1·025	1·027	...	1·027	1·027	1·022	1·025
21.	1·023	1·024	1·023	1·025	...	1·026	1·027	...	...	1·027	1·022	1·025
22.	...	1·024	1·024	1·025	1·026	1·026	...	1·026	1·027	1·027	1·022	1·026
23.	...	1·024	...	1·022	1·025	1·026	1·027	1·027	1·027	1·027	1·023	1·026
24.	...	1·025	1·024	...	1·025	1·026	1·027	1·027	1·027	1·027	1·020	1·026
25.	...	1·024	1·024	1·024	1·025	1·026	1·027	1·027	1·027	1·027	1·014	1·025
26.	1·023	1·025	1·024	1·023	1·025	1·026	1·027	1·027	1·027	...	1·020	1·025
27.	1·024	1·024	1·024	1·025	1·025	...	1·027	1·027	1·027	1·028	1·023	...
28.	1·024	...	1·024	1·025	1·026	1·025	1·027	1·027	1·026	1·027	1·022	1·025
29.	1·023	...	1·024	1·025	...	1·026	1·027	...	...	1·027	1·022	1·025
30.	1·024	...	1·024	1·022	1·026	1·026	...	1·026	...	1·027	...	1·024
31.	...	...	...	...	1·025	1·026	1·027	1·028	1·027	1·028	...	1·025
					1·024	1·027	1·027	1·027	1·028	1·027	1·053	1·024
											...	1·026
											1·025	1·026
											1·023	1·025
											1·025	1·026
											1·026	1·025
											...	1·026
												1·025

TABLE XVI—*Showing pH of Tuticorin Bay, 1950.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	8·4	8·5	8·5	...	...	8·4	8·4	8·5	8·4	8·5	8·3
2.	8·2	...	8·5	8·5	...	8·4	8·2	8·4	8·4	8·2	8·4	8·4
3.	...	8·2	8·3	8·6	8·5	8·4	8·3	8·2	8·4	8·3	8·4	8·4
4.	8·3	8·3	8·3	8·5	8·6	...	8·2	8·3	8·2	8·2	8·2	8·6
5.	8·3	8·2	8·5	...	...	8·4	8·3	8·4	8·3	8·2	8·4	8·2
6.	8·2	8·3	8·4	8·5	8·4	8·3	8·3	8·2	8·4	8·2	...	8·5
7.	8·3	8·3	8·4	8·5	8·4	8·2	8·3	8·3	8·4	8·2	...	8·5
8.	8·2	8·2	8·5	8·5	...	8·2	8·4	8·4	8·3	8·2	8·5	8·4
9.	...	...	8·4	8·5	8·5	8·4	8·4	8·3	8·2	8·3	8·3	8·5
10.	8·3	...	8·5	8·4	8·6	8·3	8·4	8·4	8·2	8·3	8·5	8·4
11.	8·3	8·4	8·5	8·4	8·5	8·2	8·4	8·4	8·3	8·2	8·1	8·4
12.	8·3	8·4	8·4	...	8·5	8·4	8·4	8·4	8·3	8·2	8·4	8·4
13.	8·2	...	...	...	8·4	8·4	...	8·2	8·3	8·2	8·4	8·5
14.	8·2	8·4	8·5	...	8·4	8·4	8·2	8·4	8·3	8·2	8·4	8·4
15.	8·3	8·4	8·4	...	8·4	8·4	8·3	8·3	8·4	8·4	8·2	7·9
16.	8·2	8·3	...	8·6	8·4	8·4	8·2	8·4	...	8·5	8·2	8·2
17.	8·2	8·4	8·5	...	8·5	8·3	8·4	8·2	8·3	8·3	7·9	8·2
18.	8·3	...	8·4	...	8·6	8·1	8·4	8·2	8·3	...	8·3	8·4
19.	8·4	8·4	8·5	...	8·4	8·0	8·3	8·2	8·3	8·4	8·2	8·2
20.	8·4	8·2	...	8·5	8·5	8·2	8·4	8·1	8·2	8·2	8·3	8·2
21.	8·2	8·3	8·4	8·4	8·6	...	8·2	8·2	8·3	8·2	8·4	8·4
22.	8·2	8·4	8·5	8·4	...	8·2	8·2	8·3	8·2	8·2	8·3	8·4
23.	8·3	...	8·5	8·4	8·5	8·3	8·4	8·4	8·2	8·4	8·2	8·4
24.	8·4	8·5	...	8·4	8·6	8·4	8·4	8·2	8·4	8·4	8·2	8·4
25.	8·2	8·4	8·4	8·4	8·4	8·0	8·4	8·2	8·3	8·4	8·5	...
26.	8·2	8·5	8·4	8·4	8·5	8·1	8·4	8·2	8·2	8·5	8·5	8·4
27.	8·3	...	8·5	...	8·4	8·0	8·4	8·3	8·3	8·4	8·5	8·5
28.	...	8·4	8·6	8·4	8·5	8·2	8·4	8·4	8·4	8·5	8·5	8·2
29.	8·3	...	...	8·4	8·4	8·2	8·4	8·6	8·4	8·5	8·5	8·4
30.	...	...	8·4	8·4	8·4	8·3	8·2	8·2	8·4	8·5	8·5	8·4
31.	8·4	...	...	...	8·4	...	8·4	8·2	...	8·5	...	8·5
												8·6

TABLE XVII—*Showing pH of Tuticorin Bay, 1951.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	8·4	8·3	8·4	8·3	8·2	8·4	8·0	8·3	8·4	8·2	8·3	8·3
2.	8·4	8·4	8·5	8·2	8·4	8·4	8·2	8·4	8·2	8·3	8·4	...
3.	8·5	8·5	8·6	8·2	8·5	8·4	8·0	8·3	8·2	8·4	8·3	8·4
4.	8·4	8·2	8·5	8·2	8·5	8·3	8·3	8·2	8·3	8·4	...	8·2
5.	8·2	8·2	8·6	8·2	8·6	8·3	8·3	8·3	8·4	8·5	8·3	8·2
6.	8·2	8·3	8·2	8·3	8·5	8·3	8·2	8·2	8·3	8·2	8·4	8·2
7.	8.4	8·4	8·2	8·2	8·4	8·3	8·3	8·4	8·3	8·4	8·4	8·4
8.	8·2	8·5	8·3	8·4	8·4	...	8·2	8·2	8·2	8·2	8·2	8·3
9.	8·6	8·5	8·4	8·3	8·2	8·4	8·3	8·3	8·3	8·4	8·4	8·4
10.	8·5	8·4	8·4	8·2	8·2	8·2	8·3	8·3	8·3	8·3	8·3	8·3
11.	8·5	8·4	8·2	8·2	8·2	8·3	8·4	8·4	8·3	8·4	...	8·2
12.	8·5	8·4	8·4	8·3	8·2	8·2	8·4	8·4	8·3	8·3	8·3	8·4
13.	8·4	8·4	8·5	8·2	8·4	8·2	8·3	8·2	8·4	8·5	8·3	8·2
14.	8·5	8·4	8·3	8·0	8·2	8·2	8·4	8·2	8·4	8·4	8·3	8·3
15.	8·4	8·3	8·2	8·0	8·4	8·2	8·4	8·3	8·4	8·4	8·4	8·4
16.	8·4	8·4	8·2	...	8·2	8·2	8·4	8·2	8·4	8·3	8·3	8·3
17.	8·2	8·4	8·3	...	8·4	8·2	8·2	8·3	8·4	8·3	8·5	8·3
18.	8·4	8·3	8·3	...	8·4	8·2	8·2	8·4	8·4	8·4	...	8·3
19.	8·4	8·4	8·4	...	8·4	8·3	8·2	8·2	8·4	8·3	...	8·2
20.	8·2	8·5	8·2	...	8·2	8·2	8·2	8·4	8·4	8·4	...	8·4
21.	8·4	8·4	8·3	8·4	8·2	...	8·2	8·3	8·4	8·5	8·3	8·4
22.	8·2	8·5	8·3	8·4	8·4	8·2	8·2	8·2	8·2	8·4	...	8·3
23.	8·3	8·4	8·2	8·4	8·4	8·0	8·2	8·3	8·4	8·2	...	8·2
24.	8·3	8·5	8·3	8·4	8·5	8·0	8·2	8·2	8·4	8·3	...	...
25.	8.4	8·4	...	8·4	8·2	8·2	8·2	8·2	8·4	8·4	...	8·2
26.	...	8·5	8·2	8·4	8·3	8·0	8·2	8·3	8·4	8·3	...	8·2
27.	8·5	...	...	8·4	8·2	8·2	8·3	8·2	8·3	8·4	8·3	8·3
28.	...	8·4	...	8·4	8·3	8·4	8·2	8·2	8·2	8·3	8·3	8·4
29.	8·5	...	...	8·5	8·3	8·0	8·3	8·3	8·3	8·2	8·3	8·3
30.	8·3	...	8·3	8·4	8·4	8·2	8·2	8·3	8·3	8·3	8·4	8·3
31.	8·4	...	8·3	...	8·3	...	8·3	8·2	...	8·4	...	...

TABLE XVIII—*Showing pH of Tuticorin Bay, 1952.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	8·3	8·4	8·6	...	8·4	8·2	8·4	...	8·6	...	...
2.	8·2	8·4	8·5	8·6	8·5	8·4	8·2	8·4	...	...	...	8·2
3.	8·3	8·4	8·4	8·6	8·5	8·5	8·4	...	...	8·5	8·3	8·3
4.	8·2	8·5	8·5	...	...	8·5	8·4	...	8·4	8·3	8·3	8·5
5.	8·3	8·5	...	...	8·5	8·4	8·5	...	8·3	...	8·4	8·6
6.	8·5	8·4	8·5	...	8·6	8·6	...	...	8·4	..	8·5	8·4
7.	8·4	8·5	8·4	...	8·6	8·4	8·4	...	...	8·4	8·4	...
8.	8·3	8·4	8·4	8·4	8·6	8·5	8·5	...	8·5	8·2	8·5	8·5
9.	8·5	8·5	8·5	8·5	8·6	8·4	8·5	...	8·2	8·4	...	8·5
10.	8·4	8·5	8·4	8·4	8·5	8·4	8·4	...	...	8·4	8·4	8·5
11.	8·5	8·5	8·5	8·5	8·6	...	8·2	...	8·3	8·2	8·5	8·5
12.	8·4	8·5	8·4	8·5	...	...	8·4	-	8·3	...	8·4	8·3
13.	8·5	8·5	8·5	8·5	8·6	8·5	...	...	8·2	8·5	8·5	...
14.	8·4	8·5	8·3	8·5	8·6	8·6	...	...	...	8·4	8·4	...
15.	8·5	8·5	8·3	8·5	8·6	8·5	...	...	8·2	8·5	8·4	8·4
16.	8·5	8·4	8·4	8·5	8·6	8·2	8·2	...	8·4	8·6	...	8·5
17.	8·5	8·5	8·5	8·5	8·6	8·2	8·2	...	8·5	...	8·3	8·5
18.	8·4	8·4	8·4	8·6	8·6	8·4	8·4	...	—	...	8·4	8·4
19.	8·3	8·5	8·5	...	...	8·4	...	...	8·6	...	8·1	8·5
20.	8·4	8·4	8·4	...	...	8·4	...	...	—	8·2	8·2	...
21.	8·4	8·4	8·5	8·6	8·5	...	8·3	...	8·4	8·4	8·4	...
22.	8·5	8·3	8·4	8·6	8·5	...	8·2	8·5	8·5	8·5	...	8·5
23.	8·4	8·3	8·5	8·5	8·3	8·3	....	8·5	8·3	8·5	8·3	8·4
24.	8·2	8·3	8·3	8·5	. .	8·2	...	8·4	8·5	8·4	...	8·4
25.	8·2	8·3	8·4	8·5	...	8·2	8·3	8·5	...	...	8·2	...
26.	8·3	8·4	8·5	8·6	8·3	8·2	8·2	-	...	...	8·4	8·3
27.	8·5	8·5	8·4	...	8·3	8·2	8·3	...	...	8·3	8·4	...
28.	8·2	8·5	8·6	8·5	8·2	...	...	8·4	...	8·4	8·3	...
29.	8·3	8·6	8·6	...	...	8·2	8·3	...	...	...	8·5	...
30.	8·4	...	8·6	...	8·4	8·2	8·3	8·4	...	8·6	8·5	8·3
31.	...	...	8·5	...	8·5	...	8·4	...	...	8·4	...	8·4
										...	...	8·4

TABLE XIX—*Showing pH of Tuticorin Bay, 1953.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	...	...	...	8·4	8·45	8·5	8·5	8·45	...	...	8·4
2.	8·4	8·3	8·4	8·3	8·4	8·5	8·5	...	8·5	...	8·5	8 4
3.	8·5	8·3	8·3	...	8·5	8·5	8·5	8·5	8·45	8·5	8·45	8·4
4.	...	8·4	8·5	...	8·5	8·5	8·5	8·5	...		8·5	8·4
5.	8·4	8·4	8·6	8·5	8·4	8·5	...	8·5	8·5	8·45	...	8·4
6.	8·3	8·4	8·4	8·4	8·4	8·5	8·45	8·5	...	8·5	...	...
7.	8·3	...	8·3	8·4	8·4	...	8·45	8·5	8·45	...	8·45	...
8.	8·4	...	...	8·6	8·4	8·45	8·45	8·5	8·5	8·45	8·45	8·4
9.	8·4	8·4	8·4	8·3	8·4	8·5	8·5	...	8·45	8·45	8·5	8·4
10.	8·4	8·3	8·4	8·4	...	8·5	8·5	8·5	8·5	8·5	8·5	8·4
11.	...	8·5	8·3	...	8·4	8·45	8·5	8·5	8·5	...	8·5	8·4
12.	8·3	...	8·5	...	8·4	8·5	...	8·5	...	8·4	8·5	8·4
13.	...	8·4	8·4	...	8·4	8·45	8·5	8·5	...	8·5	8·4	
14.	...	8·3	8·6	8·4	8·4	8·5	8·5	8·5	8·5	8·5	...	...
15.	8·4	...	...	8·4	8·5	...	8·5	...	8·45	...	8·4	...
16.	8·4	8·5	...	8·4	8·4	8·5	8·5	...	8·5	...	8·4	...
17.	8·4	8·4	8·4	...	8·4	8·5	8·5	8·45	8·5	...	8·4	8·4
18.	...	8·4	...	...	8·4	8·5	...	8·45	8·45	...	8·4	8·4
19.	8·4	8·5	...	...	8·4	8·45	...	8·45	...	8·5	8·4	...
20.	8·3	8·4	8·6	8·4	8·4	...	8·5	8·45	...	8·4	...	...
21.	8·4	...	8·5	8·4	8·4	...	8·5	...	8·5	8·45	8·45	8·4
22.	8·4	...	...	8·4	...	8·5	8·5	...	8·5	8·5	...	8·4
23.	8·4	8·5	...	8·5	...	8·45	8·5	...	8·5	8·5	8·4	8·4
24.	...	8·4	...	8·4	8·5	8·5	8·5	...	8·5	...	8·4	8·4
25.	...	8·5	...	8·5	8·5	8·5	8·5	8·5	8·5	...	8·4	8·4
26.	...	8·4	8·5	...	8·5	8·5	...	8·5	8·5	8·5	8·45	...
27.	8·5	8·5	8·4	8·4	8·5	8·45	8·5	8·45	...	8·5	8·45	...
28.	8·5	8·4	...	8·4	8·4	...	8·5	8·45	8·5	8·5	8·45	...
29.	8·4	...	...	8·5	8 5	8·5	8·3	8·5	8·45	8·4	...	...
30.	8·5	...	...	8·4	8·5	8·45	8·5	...	8·5	8·4	8·4	8·35
31.	8·5	...	...	...	...	...	8·5	...	...	...	...	8·4

TABLE XX—*Showing pH of Tuticorin Bay, 1954.*

Date	January	February	March	April	May	June	July	August	September	October	November	December
1.	...	8·4	8·4	8·4	8·4	8·4	8·5	8·5	...	8·4	...	8·5
2.	8·4	8·4	8·4	8·4	...	8·4	8·6	8·4	8·5	...	8·4	8·4
3.	...	8·4	...	8·4	8·2	...	8·5	8·4	8·6	...	8·4	8·5
4.	8·4	8·4	8·4	...	8·3	8·4	...	8·4	8·5	8·4	8·4	8·4
5.	8·4	8·4	8·4	8·4	8·4	8·3	8·5	8·4	...	...	...	...
6.	...	8·45	8·4	8·4	8·2	...	8·4	8·4	8·6	...	8·5	8·5
7.	...	...	...	8·4	8·2	8·5	8·4	...	8·5	...	...	8·5
8.	...	8·4	8·7	8·4	8·4	8·4	8·5	8·5	...	8·5	...	8·5
9.	...	8·4	8·4	8·4	...	8·4	8·4	...	...	8·5	...	8·4
10.	...	8·4	8·4	8·4	8·4	8·4	8·4	8·4	8·6	...	...	8·5
11.	...	8·4	8·4	...	8·4	8·4	...	8·4	8·4	8·4	8·4	8·5
12.	...	8·4	...	8·4	8·4	...	8·5	8·5	...	8·4	8·5	...
13.	...	8·4	8·4	...	8·4	8·4	8·4	8·5	8·5	8·4	8·4	8·5
14.	...	...	...	8·4	8·5	8·4	8·5	...	8·5	8·6	...	8·6
15.	...	8·45	...	...	8·5	8·4	8·4	...	8·4	8·5	8·4	8·5
16.	8·5	8·4	...	...	...	8·5	8·5	8·4	...	8·6	8·4	8·6
17.	...	8·4	...	...	8·4	...	8·5	8·4	8·5	...	8·4	8·5
18.	8·45	8·4	...	...	8·3	...	...	8·5	...	8·5	8·4	...
19.	...	8·45	...	8·6	8·2	...	8·5	8·5	...	8·6	8·4	...
20.	8·45	...	...	8·4	8·3	8·4	8·4	8·5	8·4	8·4	...	8·5
21.	8·4	...	...	8·6	8·2	8·4	8·5	...	8·5	8·4	...	8·6
22.	...	8·4	8·4	8·4	...	8·5	8·4	...	8·5	8·5	8·4	8·5
23.	...	8·4	8·4	8·4	...	8·6	8·4	...	8·5	8·5	8·4	8·6
24.	...	8·4	8·4	8·4	8·4	8·5	...	8·5	8·6	...	8·6	...
25.	8·4	8·4	8·4	8·5	8·5	8·3	...	8·5	...	...	8·6	...
26.	...	...	8·4	8·4	8·2	8·5	8·5	8·5	8·5	...	8·5	...
27.	8·45	...	8·4	8·4	8·5	...	8·4	8·5	...	8·4	8·6	8·6
28.	8·4	...	8·4	8·4	8·4	...	8·5	8·6	...	...	...	8·5
29.	8·4	...	...	8·4	8·4	8·4	8·5	...	...	8·6	8·6	8·6
30.	8·4	...	...	8·4	8·4	...	8·4	8·5	8·6	...	8·6	8·5
31.	...	...	...	...	8·4	...	8·4	8·4	...	...	...	8·5

XVIII. ON SOME ABNORMAL SHARKS PRESERVED AT THE MARINE BIOLOGICAL STATION, WEST HILL.

BY M. D. MENON.

While going through the various collections of fishes at the museum of the Marine Biological Station, West Hill, an opportunity was available to examine four interesting and abnormal specimens of sharks amongst them. A fifth specimen was given to me by Sri U. Sundar Kini, Oil Chemist, Government Shark Liver Oil Factory, Kozhikode. These five interesting abnormalities are described in this paper. One of these has already been recorded by me in 1945 and a popular note on it was published then. (1)

The five specimens recorded are the following :—

1. Double monster of the shark—*Scoliodon palasorrah* (C.)
2. Double monster of the shark—*Carcharinus temmincki* (M.H.)
3. The split headed monster of *Carcharinus menisorrah* (M.H.)
4. Pug snouted fused eyed *Hypoprion macloti* (M H.)
5. Thumb snouted Albino of the shark *Carcharinus dussumieri* (M.H.)

1. DOUBLE MONSTER OF SCOLIODON PALASORRAH—FIG. 1

The specimen was secured from the womb of one specimen of *Scoliodon palasorrah* measuring 3′9″ in length along with four other normal embryos on 12th October 1945.

External features.—The monster measures 245 mm. It appears to be the union of two equal embryos. The two members are united just at the region of the 5th gill cleft. There are five gill clefts for each head on its outer side where as on the inner edge where the two heads have united, there are only four separate gill clefts on each head with the fifth gill cleft being common to both. The monster has two distinct and separate anterior dorsal fins and two posterior dorsals of similar size and shape. There are only one pair each of the pectorals and ventrals. The anal also is not doubled. The caudal is single but there are two ridges on its dorsal side. Only a single placental chord was present entering between the pectorals. It would thus appear that the two members of the union maintained their separate individuality dorsally in its external features where as ventrally the union seems to have been complete. All the external features of the head are normal, each head having the usual characters in normal shape and position. In the X-ray photograph of this specimen it is seen that both the individuals are having separate vertebral columns until just before the

caudal pit where they coalesce together. As the monster is viewed with the dorsal aspect of the heads facing the viewer, it is seen that the head of the left partner is united with the right partner at an angle of 40°. From the cranium of the left partner the vertebral column runs down at the same angle towards the vertebral column of the right partner. But at about the level of the pectoral fins these two vertebral columns run straight down parallely until the caudal pit where they fuse together and form one caudal portion of the column.

INTERNAL ORGANS — FIG. 2.

The internal viscera show the following peculiarities. There are two stomachs each lying on either side of the body cavity. The stomach of the left partner (i.e., when viewed from above) is slightly larger than that of the right partner. The duodenum of the two stomachs open into a common median intestine. The duodenum of the right partner opens on the dorsal aspect of the intestine while that of the left partner opens on the ventral aspect. The median intestine passes into a rectum. There is only a single anal opening. The liver is paired, i e., there are four lobes of the liver. The right lobe of the right liver mass and the left lobe of the left one are long and narrow, where as the left lobe of the right one and the right lobe of the left one are very small and lie close to each other. The right lobe of the right liver mass is larger than the left lobe of the left one. The gall bladder is single and it is embedded in the left lobe of the left mass. The spleen and pancreas are duplicated and lie in the respective duodenal lobes. The right pancreas is slightly smaller in size than the left one. There are two bile ducts. The right one opens behind the junction of the right duodenum and the intestine. The yolk sac opens at the front end of the intestine. There are two hearts, each one situated adjacent to each other in one pericardial cavity, but separated by a thin septum. The posterior walls of the chambers are cartilaginous. In the arterial system the variations are only those consequent to the presence of two stomachs, two liver masses, two pancreas and two spleens. The two dorsal aortae join together in the middle of the abdominal cavity slightly posterior to the region of the pectoral fins. The urinogenital system is not duplicated. There is only one set of these and it follows the usual type.

A hand section across the tail slightly behind the posterior dorsals is shown diagrammatically in Fig. 3. It is seen that the two members retain their identities as far as the centrum, spinal chord and haemal arches are concerned. The actual union of these takes place slightly further down at the limit of the caudal pit as is seen in the X ray photographs.

The monster thus appears to be the union of two embryos. But unlike the one described by Ford, the two embryos appear to be of like

and similar nature. The identity is still further expressed in the normal nature of the general pigmentation.

2. DOUBLE MONSTER OF CARCHARINUS TEMMINCKI — FIG. 4

This specimen appears to be formed of the fusion of two partners unequal in size, one of 130 mm. and another of 120 mm. When viewed dorsally with the heads away from the viewer the right partner is the smaller one. The snout of the left partner is normal. That of the right partner is slightly curved to the right creating a puggy nature and the snout tip is alightly to the right of the median line. The eyes, nasal apertures and mouths are normal. Externally the fusion seems to have been ventrolaterally at the level of the pectorals. The bigger left partner has five gill clefts on either side. The smaller right partner has only four gill clefts on either side. Again the bigger left partner has two pectorals, the right pectoral being very much reduced in size and placed at the junction of the two heads. The right partner has only one pectoral, the right one, well developed and similar in size and shape as the left pectoral of the left partner. Each partner has the first and second dorsal fins. The ventrals are only one pair for the monster. There is also only one anal fin. Posterior to the fusion of the two heads the body of the monster is fairly triangular in cross section. In Fig. 5 the disposition of the various fins are diagrammatically represented.

The caudal presents a peculiur condition. It appears to be that of the smaller right partner with the characteristic upper and lower lobes. On the left side of the upper lobe of this caudal there is a ridge for its full length with a small fringe on it. This appears to be the upper lobe of the caudal of the left partner.

Internal viscera.—The alimentary canal of this monster present ade similar condition as seen in the specimen of *Scoliodon palasorrah*, described earlier. The stomach of this right partner was smaller than that of the left partner. The duodenum of the left partner opened ventrally at the anterior end of the intestine and the duodenum of the right partner on the dorsal aspect. The intestine has a normal spiral valve. All the digestive glands like pancreas, liver and spleen are duplicated. The liver mass of the right partner is very much reduced in size, much smaller than the liver mass of the right partner. There are two hearts and the two dorsal aortae join together just at the region of the pectoral fins. In Fig. 6 a diagrammatic representation of the disposition of the vertebral columns of the specimen is given. This has been taken from the X ray photograph of the specimen. It can be seen that the vertebral column of the right specimen bends towards the vertebral column of the left partner and almost fuses with it. But from this position it diverges slightly away and runs down in slight convolu-

tions and fuses with the vertebral column of the partner just behind the region of the second dorsal fin.

3. SPLIT HEADED MONSTER OF CARCHARINUS MENOSORRAH

This is a 290 mm. long specimen coiled around at the post-anal region. The specimen was given to me by Sri U. Sundar Kini, Oil Chemist, Government Shark Liver Oil Factory, Kozhikode, from the small collection of sharks that are displayed at the factory. No data on the parent of the specimen or on the date and place of capture, etc. are available. The specimen is a very interesting one in that unlike two described above, this appears to be more a case of cephalic fission than that of post cephalic fission. Actually the two heads are not separate and distinct as is in the previous cases. The mouth, the eyes and the nasal aperture are all duplicated. It appears to be rather a case of incomplete halving of the cephalic region, all the characteristics duplicating but the two halves remaining fused. The left eyes of the left half and the right eyes of the right half are normal in shape and position and are situated on either sides of the "combined" head. The right eye of the left half and the left eye of the right half are pulled down ventrally on either side of the medioventral line of the combined head. The right nasal aperture of the right half and the left nasal apperture of the left half of the head are normal in nature and disposition. The right nasal aperture of the left haif and the left nasal aperture of the right half are normal in shape but are placed in a ventrolateral position on the head. The head in a cross section presents a rhomboidal shape, with the broad end dorsally. The mouths are separate. The upper jaw in each half is placed ventrolaterally. But the lower jaw is pulled down ventrally and at right angles to the upper jaw and the lower jaws appear as two protuberant humps placed on either of the medioventral line.

The dorsal fins, ventral fins, pectorals, pelvics and the anal are all normal in shape and disposition as in the case of a single individual. The gill clefts also are only 5 in number on either side of the specimen. The two lobes of the caudal fin are separate and quite distinct. The caudal, ends in the upper lobe. The lower lobe is situated in the loop of the coil of the tail portion and is very curved.

Internal viscera.— The two mouths open into one and the same buccal cavity. There is a single pharynx and from there onwards the alimentary canal has the characteristics of a single individual. The heart also is single and there is only a single dorsal aortae.

4. PUG SNOUTED HYPOPRION MACLOTI (M.H.) - FIG. 8

This specimen is a female 230 mm. long. It was secured on 9-11-1948 from the womb of its mother which was 2-10" long. This

monster has its snout very much shortened The two eyes are displaced and are situated midventrally just in front of the mouth. The two eyes are fused together to form the monstrosity

External characters.—The colour of the formalin preserved specimen is greyish in the upper half of the body and dull pinkish in the lower half. The caudal has a black posterior and lower edge. The first dorsal shows a slightly blackish edge. All the other fins have a light edge. In the disposition and nature of fins the specimen exhibits all the type characteristics except the complete absence of the anal.

The pre-oral portion of the head is very much shortened and curved above the eyes forming a small hump, and it stops in a point just in front and above the fusion of the eyes.

The eye.— The eyes are fused together forming one big eyeball. The fused eye is located ventrally beneath the cervical hump and just in front of the mouth above the upper jaw. There are two separate pupils in the middle of two cornea. Though the cornea appear separate, they too are fused in the middle (vide Fig. 9). Normally the iris, in the type is strongly pigmented. But in this monster specimen it is completely without any pigment and is whitish in colour. There is only one long nictitating membrane.

In the X ray photograph it is noticed that the cranium is bent at its anterior end. The olfactory capsules are very much reduced and are almost negligible. The dorsolateral cartilages are bent and very disproportionately reduced. The ventro median cartilage is also shortened and runs almost straight down (vide Fig. 10).

There is no difference from the type in any of the internal viscera.

It appears that this malformation is probably the result of undue compression of the anterior end of the embryo in the uterus bending down the region. As a result of this undue compression the developing eyes got squeezed under the hump and got fused together.

5. THUMB SNOUTED ALBINO OF CARCHARINUS DUSSUMIERI. FIG. 11.

As in the case of the previous specimen here also the eyes are displaced. They are situated ventrally just in front of the mouth and opposed to each other. But unlike the previous specimen the two eyeballs are separate and they fuse on their sides at a small region only. The cornea and the pupils are all separate. Both the eyes are without pigments in the major portion. Only the pupil is edged black. The nictitating membrane is single but has a deep notch in the middle of its edge. The snout is prolonged above the eye and is thumb shaped. It is a bit spongy to the touch. The nasal apertures are minute and are situated anteroposteriously at either ends of a small longitudinal line beneath the spongy snout, nearer to its tip than to the eyes (vide Fig. 12). All internal viscera and other external features do not show any departure from the type.

In the X ray the cranium does not show any abnormalities. Only the dorsolateral cartilage of the rostrum show a slight bent at its beginning in keeping with the curve of the thumb like snout.

ACKNOWLEDGMENTS

My thanks are due to Sri U. Sundar Kini for kindly lending me the specimen of *Carcharinus menisorrah*. I am also deeply indebted to The X Ray Centre, Kozhikode—2 for the beautiful X-ray photographs they took of the five specimens.

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2. Ford, E. — 1930—Some abnormal fishes received at the Plymouth Laboratory. Jour. Mar. Biol. Ass. of U. K. Vol. XVII. No. 1, pp. 53—64.

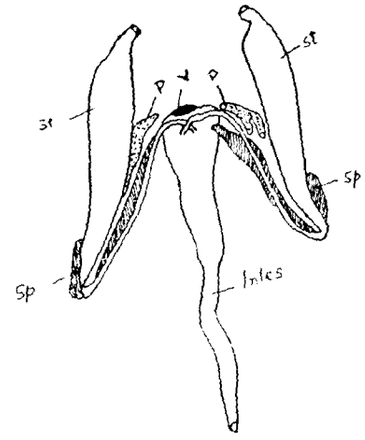


Fig. 2. Showing diagrammatically the Alimentary canal system of the double monster Scoliodon palasorrah.

St. Stomach
Intes. Intestine
P. Pancreas
Sp. Spleens
Y. Opening of internal yolk sac.

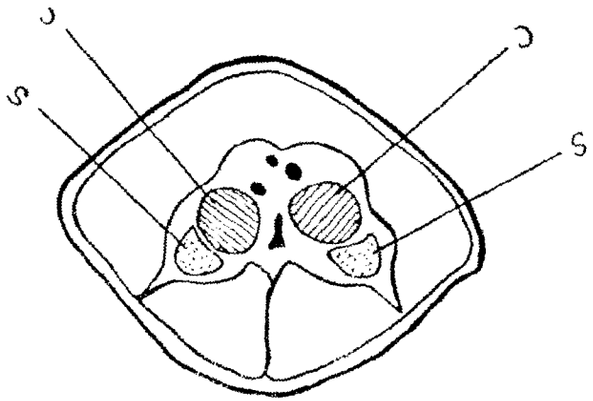


Fig.3. Hand section of double monster across body just behind second dorsal.

S - Spinal cords
C - Centra

Fig.3A showing the disposition of the vertebral columns of the double monster Scoliodon palasorrah

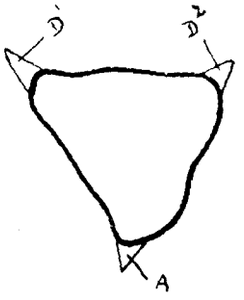


Fig.5. Diagrammatic section across the body of double monster Carcharhinus temminckii to show disposition of fins.
D^2 - Second dorsal fins A - Anal

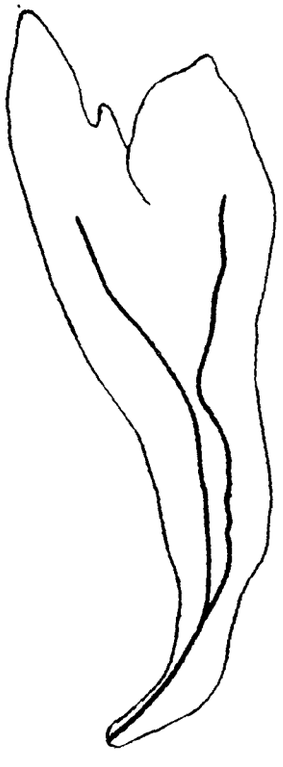


Fig.6. Showing the disposition of the vertebral columns of the double monster Carcharhinus temminckii.

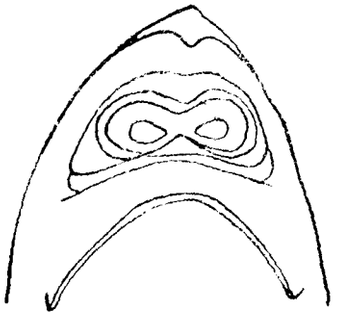


Fig.9. Ventral view of head of Hypoprion macloti (M.H.) to show the fusion of the cornea.

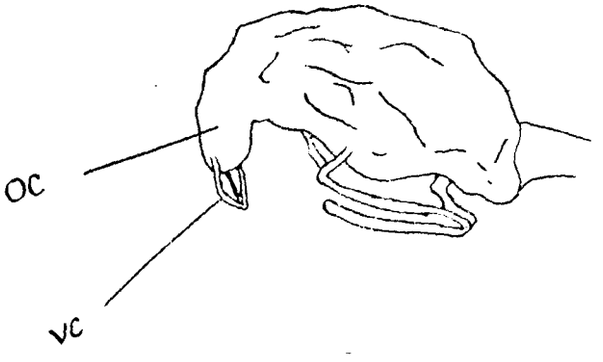


Fig.10. Diagrammatic representation of the cranium of Hypoprion macloti reconstructed from X ray photograph.

OC - Olfactory capsule
VC - Ventro-median cartilage

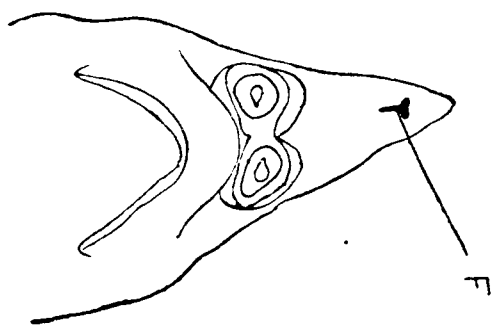


Fig.12. Ventral viewof the head portion of Carcharhinus dussumieri (M.H.) showing the fusion of the eyes and the location of the nasal apertures.

F - Ferro of Nasal apertures

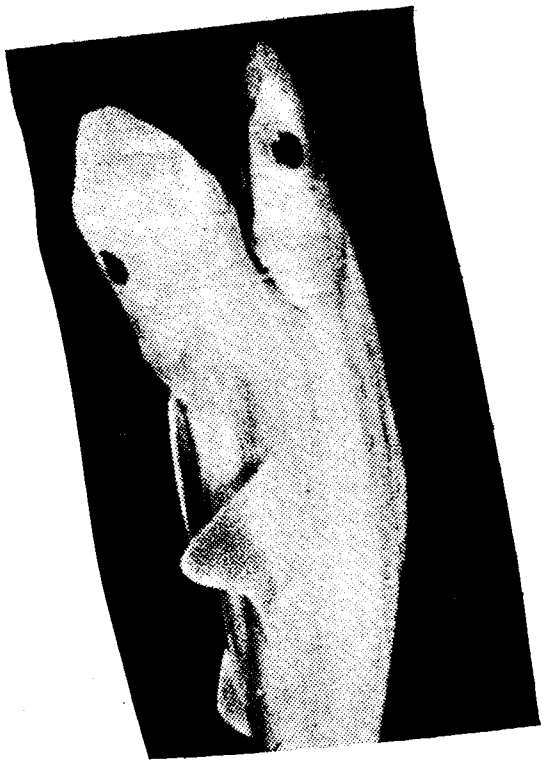
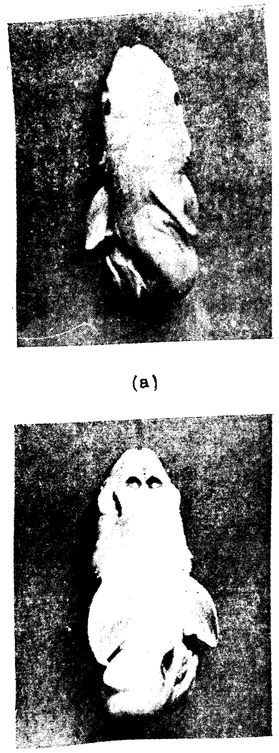


Fig.1. Double monster of Scoliodon palasorrah.

Fig.4. Double monster of Carcharhinus temminckl



(a)

(b)

Fig.7. Split headed monster of Carcharhinus menisorrah

(a) Dorsal view
(b) Ventral view

Fig.8. Pug snouted Hypoprion macloti

ventral view of the head portion
to show the fusion of the eyes.

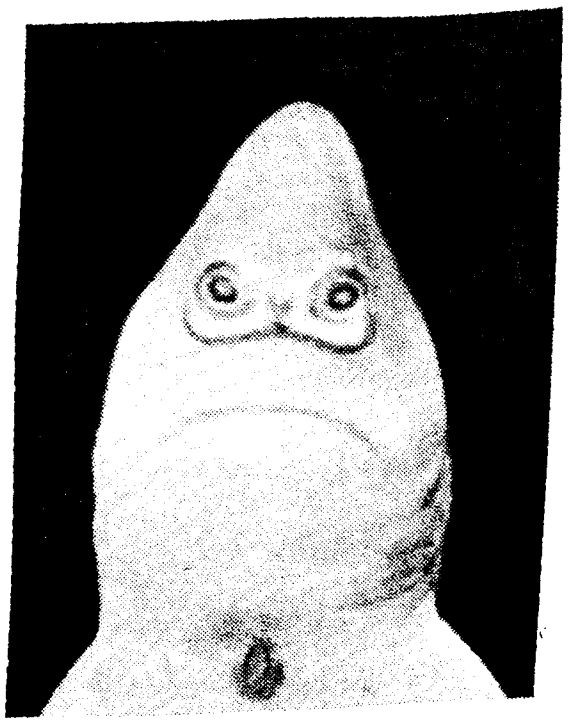


Fig.11. The thumb snouted albino of *Carcharhinus dussumieri*.

Ventral view of head portion to show the fusion of the eyes.

XIX. THE OCCURRENCE OF METAPENAEUS MONOCEROS IN THE UPPUTERU RIVER, WEST GODAVARI.

BY A. SREENIVASAN.

Prawns occur in great numbers immediately following the floods in the forty mile stretch of the small river Upputeru, which, starting from the Collair Lake, enters the sea. The bulk of the catches are mainly *Metapenaeus monoceros*, which constitute nearly 80% of the crop. The catches increase from August, reaching the peak in October and thereafter decrease below normal from December onwards. The periodicity in the occurrence of these prawns in this locality is correlated with the environmental conditions of which, dissolved oxygen, salinity and alkalinity play a part as indicated in the table below :—

Table showing the chemical conditions of the River Upputeru.

Date.	Parts per million			Dissolved oxygen mg/L.	Salinity % (gram per liter Nacl)
	Free C°_2	C°_3	HC°_3		
23— 8—47	...	12·0	238·0	2·8	0·1135
27— 9—47	...	6·0	184·6	5·8	0·1071
7—10—47	...	6·0	167·8	5·3	0·1105
28—10—47	...	9·0	118·9	6·4	0·1187
9—11—47	...	4·5	179·9	5·9	0·1252
7—12—47	...	3·0	198·3	6·0	0·1574
18— 1—48	...	3·6	190·9	5·4	0·1631
4— 2—48	1·760	...	210·5	3·6	0·1780
25— 2—48	1·10	...	247·1	1·9	0·2530
5— 3—48	...	3·0	271·5	2·8	0·3313
16— 3—48	...	9·0	248·6	4·3	0·3577
15— 4—48	...	...	...	...	2·3640
30— 4—48	...	...	...	...	4·2000
8— 7—48	...	1·6	282·4	6·3	6·5100
31— 7—48	...	...	...	...	0·6240
2— 9—48	...	1·5	195·7	4 4	0·1640

From August to the middle of March the water of Upputeru is almost sweetish and the salinity is very low. When floods cease, the salinity slowly increases, to the maximum in July.

The year can be divided into two periods from the data for dissolved oxygen. The first period starting after the floods, where the dissolved oxygen is generally more than 5 mg./L continues upto January. The second period starts from January and lasts upto August or till floods commence and during this period the dissolved oxygen is less than 5·0 Mg./L. During the first period *Metapenneus monoceros* are found in abundance and in the latter period are scarce. The absence in large numbers during the second period may be correlated with low Oxygen tension. The observations regarding salinity corroborate those of Panikkar that *M. monoceros* gets completely acclimatized to freshwater conditions even in a low salinity, viz., 0·1071.

References

1. Panikkar, N. K. (1948), Curr. Sci. 17, 58.

STATISTICS OF FISH LANDINGS OF TUTICORIN, GULF OF MANAAR, IN 1955.—BY P. I. CHACKO AND E. PALANI.

A statistical analysis of the fish landed at Tuticorin in the calendar year 1955 is given in the appended table. The total landings during the year was 1,223·64 tons. The peak period was in June-July when about 144·38 and 197·0 tons of fish were landed. March-June and November-December were the lean periods.

Of the different groups of fishes, sardines in general formed the bulk (54·8 per cent) of the landings. Sharks and rays formed 7·73 per cent; and the other varieties together were 37·47 per cent of the landings.

Among the sardines, the chalai (*Sardinella fimbriata*) formed the major landings of about 19·6 per cent of the total landings. Next in importance was *Sardinella gibbosa* (11·3 per cent), *S. leiogaster* (6·9 per cent). The Anchovies, *Engraulis spp.* (local name: poruva) was also important, contributing to 9·0 per cent of the total landings. All these clupeoids were available throughout the year with a peak in June-July.

As indicated by the heavy landings of the pelagic forms, the operation of the gill-net, Kolavalai, yielded good results throughout the year. A noteworthy feature of the fishery of the year was the availability of fair numbers of tunnies, particularly *Thynnus macropterus*.

Statistics of Fish Landings at Tuticorin — 1955

Kind of fish	January	February	March	April	May	June	July
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sardinella fimbriata	28400	61200	28300	33600	24800	122500	52200
S. gibbosa	1100	5500	23600	31100	18800	18700	59200
S. ciogaster	48200	8930	20450	7400	...	200	3000
Dussumieria hasselti	700	1600	34800	19500	12100	12300	20600
Engraulis Spp.	6400	32400	27600	2860	17800	14900	94800
Leiognathus Spp.	750	5900	3820	1000	2350	4550	5945
Upeneoides Spp.	200	...	1330	1200	2500	4550	6850
Pellona Spp.	...	...	...	...	...	...	12800
Serranus miniatus	5780	10800	5690	4090	946	1241	1879
S. undulosus	13800	20160	7730	5620	1999	2383	10260
S. Salmoides	890	4100	550	240	67	325	340
Lethrinus nebulosus	27730	35160	6370	8090	3767	2116	6834
Cybium Spp.	3190	5720	3480	5090	8126	19680	10152
Caranx rottleri	...	...	...	...	602	127	...
Caranx Spp.	5790	7150	2750	2610	3842	6370	18302
Sphyraena Spp.	960	2570	1630	380	413	911	1012
Chorinemus Spp.	1720	390	2780	1960	5282	3206	1731
Lutjanus rivulatus	7430	2180	1370	2370	572	243	3313
Lutjanus Spp.	4680	7200	1310	...	806	3964	10534
Aprion pristipoma	1430	17040	1740	1550	2777	3599	20246
Thynnus macropterus	...	...	...	...	...	...	...
Thynnus Spp.	3160	3720	480	3750	1650	5200	2089
Chirocentrus dorab	620	210	760	2890	61630	65940	42357
Stromateus Spp.	100	30	70	20	105	226	346
Sharks	5680	9680	4780	5300	8672	12389	34964
Rays	2100	8760	2070	9440	7824	7432	8184
Miscellaneous fishes	...	...	...	4630	9439	10349	13335
Total lbs.	173810	250810	183570	154790	196869	373401	441278
,, tons.	77·59	111·79	81 95	69·1	87·89	144·38	197·0

Kind of fish	August	September	October	November	December	Total	Percentage
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Sardinella fimbriata	28800	64600	42300	21600	28700	537000	19·6
S. gibbosa	16000	15700	26200	6600	88325	310325	11·3
S. ciogaster	17000	19200	42000	23850	400	190630	6·9
Dussumieria hasselti	7900	2550	6000	4400	1100	123650	4·5
Engraulis Spp.	11400	6700	14300	9650	8710	247520	9·0
Leiognathus Spp.	2050	3200	2900	2150	450	35070	1·25
Upeneoides Spp.	5700	5200	8400	2900	250	39080	1·45
Pellona Spp.	1700	...	3200	1550	2400	21650	0·8
Serranus miniatus	2629	2283	5158	1666	846	43009	1·5
S. undulosus	7666	12222	13920	5928	3801	105489	3·9
S. Salmoides	826	710	428	265	610	9351	0·4
Lethrines nebulosus	5859	10624	9272	4350	4549	124721	4·5
Cybiun Spp.	10442	6376	3360	3709	4089	83415	3·1
Caranx rottleri	...	12	...	...	...	741	0·04
Caranx Spp.	12286	10203	5464	1239	2578	78584	2·9
Sphyraena Spp.	617	1084	791	1157	1170	12694	0·5
Chorinenus Spp.	826	1608	368	95	759	20815	0·7
Lutjanus rivulatus	2227	8495	4083	1154	1490	34927	1·2
Lutjanus Spp.	9906	3164	10046	2726	2701	57037	2·05
Aprion pristipoma	14226	23607	2170	222	180	88787	3·2
Thynnus macropterus	...	20225	12680	...	3165	36070	1·36
Thynnus Spp.	8117	4432	657	437	4084	37776	1·40
Chirocentrus dorab	11820	7078	4724	5508	829	204366	7·5
Stromateus Spp.	962	99	72	452	143	1925	0·08
Sharks	27238	14100	11560	2293	2527	139183	5·13
Rays	4096	7570	9072	1605	881	72054	2·6
Miscellaneous fishes	11712	10162	8996	8144	8331	85097	3·15
Total lbs.	260704	260704	248122	113650	173068	2740965	
,, tons.	98·79	116·39	110·76	50·74	77·26	1223·64	

XXI. A STATISTICAL ANALYSIS OF THE CHANK FISHERY OF TUTICORIN, GULF OF MANAAR IN 1955

BY P.I. CHACKO AND E. PALANI.

A brief account of the chank fisheries of Tuticorin has been given by Chacko and Rajendran (1956). In this note a statistical analysis of the operations in the calendar year 1955 is given, with a view to ascertain the catch-efforts and earnings of the divers.

From the appended table it would be seen that there was a total number of 132 days of actual diving operations in January - May and October - December, the period June - September being the off-season. The strength of the diving force varied from month to month but the average number of divers per day as 215. A total number of 480,209 chanks comprising of 433,358 full-sized, 33,357 under-sized and 13,494 wormed chanks were fished during the year. The latter two categories which formed nearly 9·7 per cent of the total catches were not paid for by the department and therefore were not remunerative to the divers. The average number of full-sized chanks fished by a diver was 15 per day, which gave him an earning of Rs. 5-10-0 per day of diving. It was however, not uncommon on certain days to see some of the best divers obtaining more than 100 chanks a day.

REFERENCE

Chacko, P. I. and Rajendran, A.D.I. 1956. A survey of the fishing industry of Tuticorin, Gulf of Manaar. *Madras Fisheries Station Reports and Year Book*, 1954-55, 177-193.

Table Showing Statistics of Chanks Fished off Tuticorin in 1955

S. No.	Name of Chank Bed	Number of days of diving operations	Total Number of divers	Number of Chanks Fished			
				Full-sized	Wormed	Under-sized	Total
1.	Sayathombathu par ...	7	1890	28247	671	2660	31578
2.	Kilathi par ...	4	484	4979	501	596	6076
3.	Ooduthu par ...	2	473	4294	478	528	5300
4.	Melanbathu par... ...	16	6233	108187	1440	8014	117641
5.	Vadaombathu par ...	10	2916	47078	682	3981	51741
6.	Janatha par ...	5	1603	25894	445	2257	28596
7.	Athombathu par ...	1	185	1396	90	311	1797
8.	Siluvai par ...	7	1361	17358	870	1625	19853
9.	Vadavelipathu par ...	4	1298	28200	523	3167	31890
10.	Pulipoondu par ...	1	349	4714	117	410	5241
11.	Aluva par ...	2	733	13004	290	1124	14418
12.	Nilankilipatharai par ...	5	1453	37521	780	1644	39945
13.	Pudu par ...	1	418	5305	103	369	5777
14.	Kanava par ...	2	673	7617	380	637	8634
15.	Kadayam par ...	2	666	7860	203	486	8549
16.	Sultan par ...	1	527	6418	42	439	6899
17.	Thollayiram par ...	39	2193	17765	1314	...	19079
18.	Koothadiyar par ...	2	130	1720	176	...	1896
19.	Kathithirukkai par ...	3	653	6540	541	495	7576
20.	Karaithundan par ...	1	132	657	59	55	771
21.	Navarai par ...	5	1115	20466	1976	1386	23828
22.	Vadathundan par ...	4	689	8067	394	818	9279
23.	Pasi par ...	5	1318	16632	852	1205	18689
24.	Patharai par ...	2	591	7848	414	666	8898
25.	Sayathukilathe par ...	1	306	5621	153	484	6258
	TOTAL ...	132	28389	433358	13494	33357	480209

NOTE :—The names of the pearl banks adjacent to the respective chank beds are given in the table as there are no specific names for the chank beds.

XXII. ON THE "POSSIBLE FORAGE FISH" *TILAPIA MOSSAMBICA*. II. *ITS GROWTH*.—BY M. D. MENON, B. K. MURTHI AND T. B RAMACHANDRAN*

The second consideration that was taken up for investigation on the re-examination of the utility of *Tilapia mossambica* in fish cultural operations has been the rate of growth of the fish. One of the prime considerations in selecting a fish for cultural work is as pointed out by Menon and Murthi (1) that it should be comparatively quick growing. In the case of *Tilapia mossambica* the consideration in its examination had to be broadened still wider with the introduction or suggestion of the issue that because of the rapid multiplication of *Tilapia*, the question of population pressure will come into the picture affecting adversely the growth and possibly the population dynamics itself of the *other* indigenous fishes, mainly the economically and commercially important carps. Fortunately or unfortunately, the indigenous South Indian major carps have not been observed to breed in the small tanks and ponds that form the mainstay of the fish cultural work in South India. Naturally the investigation did not bring in, neither did it envisage, the possible incursions into it of succeeding generations of the indigenous carps also to create double pronged or counteracting population pressures. The question had thus necessarily narrowed down to the examination of the following points :—

(1) The rate of growth of *Tilapia mossambica* alone and the differential rates of growth of sexes,

(2) the effect of increasing population in a water not subjected to repeated harvesting on the growth of the individuals of respective generations that succeeded one another,

(3) the effect of *tilapia mossambica* on the growth of the indigenous fishes.

In the examination of the food and feeding of Tilapia in combination with some of the major indigenous carps, Menon and Murthi (1955) found that in the face of competition from fishes belonging to a feeding niche similar to that of Tilapia, the latter switched over its feeding to a niche where there was no competition. In other words, it was found that the problem of food and feeding could not play a vital part in whatever adverse effects that might come in the case of a combined culture of Tilapia and the major indigenous carps of South India, at least positively on Tilapia. The question, then, that was examined was the effect of such a combined culture on the indigenous carps from the point of view of their growth.

* It is with deepest regret that we record the sudden death of Sri T. B. Ramachandran during these investigations.

GROWTH OF TILAPIA IN PURE CULTURE

The growth rate of *Tilapia mossambica* alone was investigated under different ecological conditions, like a natural pond fed by rain water, a natural pond fed by river and irrigation well. Such comparative studies were initiated to find out the effect of different types of waters on the growth of the fish and incidentally to find out the utility of various types of waters available in South India for culture of *Tilapia Mossambica*

Methods.—The larvae of Tilapia were hatched from one and the same brood of eggs in the laboratory and when they reached a size of 40 mm. they were introduced into the pieces of waters as follows :—

	Size and depth.	No. stocked.
1. Pond fed by rains	.. 120′ × 35′ × 3½′	50
2. Pond fed by river	.. 150′ × 45′ × 4′	100
3. Irrigation well	.. 50′ × 50′ × 2½′	24

The rate of stocking has been kept at the usual rate of 1,000 fingerlings per acre of water of an average depth of 6 ft. that had been followed in the experimental work on the growth of carps in this station. In the case of the ponds and the well, only the lowest depths which these pieces of waters maintain have been taken into consideration in fixing the number that was stocked The ponds and irrigation well were netted with the same closed meshed cast net once a month. The number of efforts in the catching of fish each time was fixed according to the area of the water spread as follows :—

1. Pond fed by rains .. 20 times
2. Pond fed by river .. 40 do
3. Irrigation well .. 10 do

Such a fixed number of fishing effort taking into consideration the area of the waterspread and the original number stocked obviated the possible error of differential efforts in the waters. All the fishes that were caught were measured for their lengths to the nearest millimeter and weighed to the nearest gm. The sexes also were noted in each case. Close watch was kept for any eggs inside the mouths of the fishes examined and records of these observations also were maintained. Since the cast net did not bring in it specimens below 25 mm., catching the fry below this size by Velon screen hauls also were done. The Velon screen also was used only for a fixed number of hauls each time as follows.

1. Pond fed by rains...6 times
2. Pond fed by river...12 „
3. Irrigation wells.....3 „

In using the Velon screen it was specifically enforced that the hauls were taken only in the marginal regions of the ponds and irrigation well nearer the surface. In nature it is found that the very small fry that get released from the mouths of the parent either by accident or by time factor, resort to the very fringes of the water line of the ponds or the irrigation well, keeping themselves just 25 to 50 mm. below surface. So in using the Velon screen it has specifically enforced that the hauls were taken only along the water line at the surface. This necessarily brought in the hauls only those size groups that were not represented in the cast net catches. All these were measured for their lengths in mm. It was not possible to weigh each one of these small fry and so all the fry below 25 mm. were weighed together for each water piece at each time.

Hydrobiological conditions of the three waters. (1) *Pond fed by rains* :—It is a rectangular pond 120′ long and 35′ broad. The tank retains a minimum depth of 3½′ of water at the height of summer. During the rains the water has a maximum depth of 9′ of water. Except for the month of November to January when the rains bring in freshets and increase the depth of water, in all other months the water maintains a depth of 3½′ to 4½′.

(2) *Pond fed by river water* :—This also is a rectangular pond 150′ long and 45′ broad. The water to this pond is fed by a sub-channel taking off from the main channel of the river Bhavani. Except for the month of May, water can be drawn into the tank at all times. In the month of May there is no possibility of drawing water since the main channel does not work. So except in the month of May, whenever the water level goes down to 5¼′, water is let into the tank and the level of 6′ 3″ is maintained. In May the water went down to a level of 4′ and only early in June water could be drawn in again.

3. *Irrigation well* :—This has more or less a square shape of 50′ on each side. The well is sunk deep into the earth to 65½′. Water is received normally only from springs but during rains water from out-lying fields also flow into the well. The well has for an appreciable portion a rocky bottom with stretches of sand and mud in between. The water is pumped by a motor every day in the forenoon for irrigation and when the depth of water lowers down to 2½′ the pumping is stopped. The water in the well is never brought down to lower than 2½′. In the afternoon the well gets replenished from the springs and again reaches its maximum depth of 6′. But rains in this area are very occasional and spread over the year. The 30′ level was reached only in October 1955 and the level went down very fast and in 14 days the original maximum normal level of 6′ was reached. So for all practical purposes the range of depth can be taken as 2½′ to 6′.

The range of physico-chemical factors of these three pieces of waters are furnished in Table 1.

TABLE I. - *Showing the range of hydrobiological factors in the 3 pieces of waters*

	Pond fed by rains and springs	Pond fed by river water	Irrigation well
Surface temperature ...	26.8—34.6 C	26.0—33.2 C	26.0—31.2 C
Turbidity ...	7.8—30	11.2—30	18.0—30
Dissolved oxygen ...	0.6—105	55 —110	13.0—66.09
pH ...	7.8—9.1	7.8 —9.4	7.4—8.8
Phosphates ...	Nil—0.194	Nil—0.0009	Traces
Nitrates ...	Nil	Nil	Nil to traces
Silicates ...	0.48—3.4	1.0—2.8	1.8—7.0
Chlorides ...	12.0 —38.0		9.2—25.0

From the table it will be seen that but for the occurrence of a very low percentage saturation of oxygen, in the tank fed by springs and rain in the range given in the table, there is virtually not much of a great variation in similar factors of the three pieces of waters. All the waters are tending from fairly alkaline to very alkaline condition as revealed by the pH. Because of the periodic replenishment of water from the channels of the river in the case of Pond II and the daily replenishment and consequent mixing up of waters in the case of irrigation well, the oxygen saturation in these two cases have not gone down to such low limits as in the pond fed by springs and rains. The chloride content is fairly high in this pond and the irrigation well, most possibly due to the periodic influx of a certain amount of organic pollution.

Biological factors.—All the three pieces of waters contained uniformly high production of algae. The qualitative and quantitative analysis of the aquatic organisms in the 3 pieces of waters are furnished in Appendix I. A perusal of this will show that there is not much of a variation in the food available for the fish in these three pieces of waters as to seriously affect the comparability of the observations in them.

In all the three pieces of waters, Tilapia of the same size group was introduced. The size group selected was 35 mm. to 45 mm. with the peak at 40 mm. The number introduced in each piece of water has been furnished earlier. The fish were netted once a month and their lengths and weights measured to the nearest mm. and gm. respectively. As the experiments progressed the original stock and later the subsequent stocks bred and several generations came into the picture in the period of one year. In the case of the specimens measuring below 45 mm. differentiation of sex was a bit difficult and as such in using the

data for noting the differential growth rates of sexes, the growth data after 45 mm. alone has been noted. All the data are furnished in Tables II to IV and these have been shown as frequency curves in Figs. I to III. It can be seen from the frequency curves of Tilapia of all the three pieces of waters that while it is possible to follow the succession of the growth modes of two generations definitely or three generations with certain amount of doubt, it has not been possible to follow the growth modes of the subsequent generations. The recruitment of later generations into the population appears to be so rapid and in such large numbers that these length groups flatten out in the graphs making it difficult to seggregate them from the different model peaks.

(continued on page 216)

TABLE II—*Showing the length frequencies of Tilapia grown in pond fed by rains and springs.*

Length in mm.	Number of days of growth						
	Start	60	120	180	240	300	360
10	...	...	...	6	3	1	2
15	...	...	3	4	2	2	4
20	...	...	5	3	1	2	3
25	...	...	9	1	2	1	4
30	...	...	11	2	2	2	3
35	26	...	6	2	3	2	4
40	64	...	5	3	6	5	4
45	10	...	9	3	4	4	3
50	...	...	6	5	3	4	2
55	...	...	6	6	3	6	2
60	...	...	7	3	4	4	2
65	...	...	5	4	5	4	2
70	...	2	2	3	6	3	1
75	...	4	4	6	5	5	1
80	...	9	1	5	4	4	2
85	...	13	...	7	3	6	2
90	...	5	...	2	2	7	3
95	...	9	...	1	4	4	2
100	...	18	1	3	4	3	3
105	...	22	3	7	3	1	3
110	...	18	7	7	2	2	2
115	...	...	6	1	2	1	3
120	...	...	3	1	3	2	4
125	...	...	1	3	3	2	2
130	...	...	...	4	3	3	3
135	...	...	...	4	2	2	2
140	...	...	...	1	2	1	2
145	...	...	...	...	4	1	3
150	...	...	...	1	2	1	3
155	...	...	...	...	1	2	2
160	...	...	...	...	2	1	1
165	...	...	...	...	1	2	2
170	...	...	...	...	...	1	1
175	...	...	...	...	...	...	2
180	...	...	...	...	...	1	2
185	...	...	...	...	...	...	1
190	...	...	...	...	...	...	2
195	...	...	...	...	...	...	...
200	...	...	...	...	...	...	1
205	...	...	...	...	...	...	...
210	...	...	...	...	...	...	...
215	...	...	...	...	...	...	...
220	...	...	...	...	...	...	...
225	...	...	...	...	...	...	...
230	...	...	...	...	...	...	...

TABLE III—*Showing the length frequencies of Tilapia grown in Pond fed by river.*

Length in mm.	Number of days of growth						
	Start	60	120	180	240	300	360
10	...						
15	...	32					
20	...	...	...	11	...	10	3
25	...	...	...	...	9	...	2
30	...	...	...	...	8	4	4
35	...	...	...	...	6	6	2
40	17	12	18	...	10	3	3
45	78	3	3	...	2	5	3
50	5	3	...	...	3	1	4
55	...	7	...	2	4	7	3
60	...	5	4	...	5	2	2
65	...	2	...	...	2	3	3
70	...	...	4	2	2	1	4
75	...	...	7	...	1	5	3
80	...	...	7	...	2	5	4
85	...	...	...	...	2	6	3
90	...	...	...	4	1	2	2
95	...	...	...	...	3	3	5
100	...	...	15	...	2	1	4
105	...	4	7	2	1	1	3
110	...	7	3	4	3	1	3
115	...	2	11	4	2	2	3
120	...	3	3	12	2	2	3
125	...	...	4	11	2	4	3
130	...	...	4	9	1	3	4
135	...	...	3	7	1	1	2
140	...	...	2	9	2	1	2
145	...	...	1	2	2	1	3
150	...	...	3	4	3	1	2
155	...	...	1	4	2	3	2
160	...	...	...	4	2	3	1
165	...	...	...	...	4	3	2
170	...	...	...	2	...	...	1
175	...	...	...	...	2	1	1
180	...	...	...	2	2	...	1
185	...	...	...	2	2	1	1
190	...	...	...	3	2	1	10
195	...	...	...	...	...	1	1
200	...	...	...	...	...	1	1
205	...	...	...	...	...	1	10
210	...	...	...	...	2	1	0·5
215	...	...	...	...	2	1	0·5
220	...	...	...	...	1	1	1·0
225	...	...	...	...	...	...	...
230	...	...	...	...	...	...	1

TABLE IV—*Showing the length frequencies of Tilapia grown in irrigation well.*

Length in mm.	Number of days of growth						
	Start	60	120	180	240	300	360
10	...	25	18	...	11	9	4
15	...	12	5	...	7	6	7
20	...	1	13	...	9	12	3
25	...	...	11	...	2	3	6
30	8	...	...	2	4	6	9
35	58	...	4	2	7	3	7
40	35	...	3	7	4	3	5
45	...	...	2	...	9	3	3
50	...	...	3	2	11	3	1
55	...	...	4	5	2	...	2
60	...	...	2	13	2	6	3
65	...	...	3	20	...	3	2
70	...	2	...	12	2	...	1
75	...	4	...	16	2	6	3
80	...	2	...	13	5	6	1
85	...	11	4	2	7	...	2
90	...	13	3	...	2	3	1
95	...	15	2	...	...	...	4
100	...	7	3	...	...	...	5
105	...	4	6	...	...	...	2
110	...	1	2	...	...	...	1
115	...	1	3	...	3	...	1
120	...	1	2	...	2	3	1
125	...	1	1	...	2	...	1
130	...	...	2	2	...	3	3
135	...	...	1	...	...	3	2
140	...	...	1	...	...	...	1
145	...	...	1	...	...	3	1
150	...	...	...	...	1	3	3
155	...	...	...	...	...	...	1
160	...	...	...	...	...	...	...
165	...	...	...	...	...	...	2
170	...	...	...	2	...	...	3
175	...	...	...	...	2	3	1
180	...	...	...	...	...	...	1
185	...	...	...	...	...	...	1
190	...	...	...	...	...	3	...
195	...	...	...	...	...	3	...
200	...	...	...	...	...	...	...
205	...	...	...	...	...	...	...
210	...	...	...	...	...	...	...
215	...	...	...	...	...	...	2
220	...	...	...	...	..	...	
225	...	...					
230	...						

GROWTH OF THE ORIGINAL STOCK

In following the growth of the original stock, we have taken that the outer most mode of the frequency curve is representative of the sample of the original stock. The mean size of this group that contributes to the outermost peak has been taken as the average size of the original stock. For comparing the growths in the three different pieces of waters we have calculated the mean sizes of all the specimens of this group that came into the collection irrespective of sex.

The mean sizes reached by Tilapia in the three different pieces of waters are furnished in Table V and Fig. IV.

TABLE V. *Showing the mean sizes reached by the original stock in the 3 pieces of waters.*

Stocking size	Tank fed by rains & springs mm.	Tank fed by river mm.	Irrigation well mm.
60 days ...	39.2	39.4	41.25
120 days ...	101.9	94.0	98.60
180 days ...	120.0	137.1	140.0
240 days ...	155.0	172.2	180.0
300 days ...	169.3	202.0	190.0
360 days ...	195.0	210.0	207.0
...	211.2	216.2	230.0

The growth curves are fairly identical and similar except that the final size reached in the irrigation well is slightly higher. This may be in all probability due to the availability of large quantities of the Blue-green algae like *Oscillatoria* and *Microcystis* and filamentous green algae like *Spirogyra* in the irrigation well. These organisms have been found to be the normal natural food of adolescent and adult Tilapia. Tilapia grows fairly rapidly in the first seven or eight weeks and then the growth falls off. This falling off in the growth rate coincides with the first breeding of the fish. Tilapia is found to breed when it attains a lenth of 95 to 100 mm. and 80 to 90 days old. Vaas and Hofstede (1952) also noticed that Tilapia "is a quick grower during its juvenile stage of development. It starts to propagate at the age of about 2 months, then measuring about 9-10 centimetres, after that time growth becomes imperceptible."

Tilapia also shows a differential rate of growth for the sexes. The mean sizes attained by both sexes of the original stock of Tilapia introduced into the tank fed by rains and springs are given in Table VI and Fig. V. These mean sizes have been calculated in the same way as described earlier.

TABLE VI—*Showing the mean sizes reached by male and female Tilapia of the original stock.*

Stocking size	Male mm.	Female mm.
60 days ...	39·3	39·2
120 „ ...	100·8	103·5
180 „ ...	121·8	117·1
240 „ ...	155·0	137·3
300 „ ...	170·0	151·7
360 „ ...	191·9	165·8
	211·2	183·0

The rates of growth of the two sexes appear to be same till the first breeding. After that the growth rate of the female is very much lessened almost "becoming imperceptible in time." Vaas and Hofstede (1952) also noted that males grow to a larger size than the females, and that the spawning and mouth breeding interfere with growth. They also noticed that in a series of experiments of seggregated culture where females are unable to spawn, their growth rate practically equals that of the males.

Panikkar and Tampi (1954) also noticed that in a population of Tilapia the larger specimens were almost always males. We have in our investigations noticed that the ratio of males to females increases with increasing lengths of fish as can be seen from the Fig. IV. In this figure we have plotted a graph of the ratio of males to females examined by us in the rainfed tank over the period of one year and compared it with those given by Vaas and Hofstede (1952) for three samples from Bandung, Tjiarnis and Tjisaat. The samples of Bandung and Tjiarnis are very small and contain in them only a few specimens of small length frequency scale. The samples from Tjisaat is larger and is hence fairly comparable with our results. It can be seen from the figure that till the first breeding and for some time later, i.e, till about 125 — 135 am length, the ratio of males to females remains fairly constant and similar to the average of the ratio in the total sample. After this stage and at bigger sizes the number of males increases in relation to the number of females in the sample. This difference appears to be due to two reasons (1) the quicker pace of growth of males and (2) the possible greater percentage of natural mortality in the females after spawning. The latter question will be examined in detail in the III Part of our investigations. Hofsted, (1941) writing on the experiment of Djaeni noted "shortly after the first introduction of mudjair in fresh water ponds it has been noted that the initial rapid growth alowed down as soon as the fish reached a length of about 10 cms". These authors have pinned the reason for such slowing of growth to the act of breeding which after the first

instance becomes a monthly and periodical affair. It will be worthwhile to follow the growth of any subsequent generations in the population to see whether this rate of such slowing of growth happens at such regular or fixed stages. As stated earlier it is possible to follow the growth of two or three subsequent stocks of generations. Calculating the mean sizes of these three groups by selecting them from the length frequency curves the following average sizes are reached by the respective generations.

TABLE VII.—*Showing the rates of growth of three generations of Tilapia in Pond fed by rains and springs.*

Start	A1 mm.	A2 mm.	A3 mm.
60 days later ...	65·5	48·1	33·0
120 days later ...	136·1	107·8	82·2
180 days later ...	146·0	124·6	104·1
240 days later ...	170·5	141·9	122·6
	194·2	166·4	144·0

TABLE VIII—*Showing the rates of growth of three generations of Tilapia in Irrigation well.*

Start	A1 mm.	A2 mm.	A3 mm.
60 days later ...	12·3		
120 days later ...	60·9	17·0	
180 days later ...	80·7	68·0	40·0
240 days later ...	131·0	87·8	71·3
300 days later ...	162·5	141·7	92·5
...	188·0	162·0	141·8

TABLE IX.—*Showing the rates of growth of three generations of Tilapia in tank fed by river water*

Start	A1 mm.	A2 mm.	A3 mm.
60 days later ...	51·5	10·0	30·7
120 days later ...	102·3	63·0	80·0
180 days later ...	143·6	116·0	106·8
240 days later ...	172·1	142·8	132·5
300 days later ...	185·0	154·3	148·8
...	196·0	171·1	··

Since the initial mean sizes of each generations at the start of their appearance in length frequency curve varies and as such not comparable with the figures of the original stock, the method followed to compare these figures was by superimposing the figures of subsequent generations on the growth curve of the original stock. For all purposes if the rate of growth between the succeeding generations does not vary, then the mean sizes attained by the generations A^1, A^2 and A^3 should all lie on the same curve as that of the original stock. In growing Tilapia from the egg stage to fingerling size it was noticed that when the fish reached a size of 39.2 mm. it was 28 days old. The experiments on the growth in the rain fed tank started with specimens of 28 to 29 days old. After 69 days or when the fish was 88 to 89 days old they were 101.9 mm. in size. The curves for the original stock in Figures VII to IX are taken as the normal growth of the fish. On this the initial mean sizes of the succeeding generations are noted. A vertical line is drawn to the abcissa of the graph. The point at which the vertical line cuts the abscissa is taken as the "calculated" age of that fish. The subsequent mean sizes of each generation are noted at intervals of 60 days from this calculated age and then the points are connected as a curve. Curves drawn by this procedure are comparable with the curve of the original stock, as all curves then become those of fish of the same age at every point on curves. If the now attention is drawn to figures VII to IX, it will be seen that growth falls off at a fast pace with every succeeding generation. The falling off in growth rate is more marked in the case of the succeeding generations of the well where there is a diurnal variation in the depth of the water. It is also interesting to note as can be seen from the graphs on the length frequency that Tilapia has bred earlier in the irrigation well than in the other two pieces of waters. We have observed in several series of our experiments connected with Tilapia, that breeding takes place earlier in waters of shallower depths and at smaller sizes. The relationship of water depth to breeding of Tilapia will be discussed in greater detail in the III Part of our investigations of Tilapia. But the observation is mentioned here to explain, necessarily, the earlier appearance of the very small groups in the length frequency curves of Tilapia in the irrigation well.

The investigations have shown thus that if Tilapia is left uncropped or uncontrolled a certain amount of population pressure sets in creating conditions of such alarming nature as smaller and still smaller generations succeeding one another. Pierre Chimits (1955) observes this point in his notes on "Destroying a myth." "Since Tilapia begins to reproduce at an early age, and then breeds prolifically, there is a possibility that in the absence of careful control, a pond may become overstocked with young fish which will too vigorously compete for available foods for any of them to reach marketable size". George

S. Myers (1955) also is of the same opinion. "*Tilapia mossambica* produces huge populations which rapidly become stunted through overcrowding unless thinned by scientific methods. Are such methods known and would they be used by the rural people?" Chimits (1955) noted that where predatory fish are present, the *Tilapia mossambica* are the most vulnerable for feeding by them, whether Tilapia be swimming on their own or sheltering in their mother's mouths". A sort of predator introduction to control the ubiquitous breeding of Tilapia is suggestive in this opinion. In South India for the past few years, the Madras Fisheries have been popularising the introduction of fish culture in small back yard wells and irrigation wells by introducing murrels (*Ophicephalus marulius* or *striatus*) and *Etroplus suratensis*. *Etroplus suratensis* is a Cichlid just like *Tilapia mossambica*. Its feeding niche also is more or less similar to that of *Tilapia mossambica*, feeding mainly on filamentous algae and aquatic vegetation like *Hydrilla verticellata* during its adolescent and adult stages. Though the breeding takes place only when the fish is about 180 mm., i.e., about 8 to 9 months after the first breeding, it breeds periodically throughout the year. At each breeding as many as 2,000 eggs are laid. There is very great amount of parental care till the young ones are capable of feeding for themselves. The parents show very great pugnacity and sagacity in getting atleast a small percentage of survival of the young ones. The murrel is a high predator. A combination of *Etroplus suratensis* and murrel have always yielded good results because the depredation by murrels on the various generations of *Etroplus suratensis* is not a total affair due to the fair ly stiff dorsal spines of Etroplus. Only in the very young stages *Etroplus suratensis* is vulnerable to murrel predations and at that time the pugnacity and sagacity of the parents save at least a small percentage of the young ones. It was necessarily thought that a combination of *Tilapia mossambica* and *Ophicephalus marulius* was worth investigating. Four fairly identical irrigation wells were selected at a place called Satyamangalam, thirteen miles from Bhavanisagar. All the irrigation wells were of the type described earlier. The enthusiasm of the owners (who are very respectable ryots of the locality with unimpeachable record of public service and interest) was exploited by the authors to see that no fishing was done in these wells by any one other than the authors and that very accurate data were kept. The physical features of these four wells are furnished in Table X.

TABLE X.—*Showing the physical features of the 4 irrigation wells.*

	A	B	C	D
	ft.	ft.	ft.	ft.
Length and bredth	50 × 50	46 × 46	48 × 48	50 × 50
Minimum depth	2½	3	2¼	2½
Maximum depth normally	6	2½	6	6¼
Maximum depth during rains	30	32	34	27

All are spring fed. The bottom is rocky for the major part with fair stretches of sand in between. The bottom contained large clumps of green and Blue-green filamentous algae. The phytoplankton and zoo-plankton content of the waters were fairly uniform as can be seen from the appendix. The hydrological factors also did not vary very much as to warrant any possibility of these variations affecting the growth of the fish or the plankton and incidentally the observations. All these irrigation wells are sunk deep in the land, such sinking varying in these cases as follows:—

A.	B.	C.	D.
ft.	ft.	ft.	ft.
65½	69½	70	63

The water is used for irrigation by pumping the water with motors. The take off pipes are covered with very fine meshed wire net and reinforced with a wire jacketting. All the irrigation wells are pumped daily in the morning. A minimum water level of 2½ ft. is maintained. When the water reaches this minimum level the pumping is stopped. Due to springs the maximum water level is again regained by afternoon. So in all the cases there is a daily rise and fall of the water level because of which there is a thorough mixing up of all the layers of waters and consequently there has been fairly uniform sets of conditions of existence remaining in all the wells. The rainy season also is a very short one, lasting for a maximum period of 20 to 25 days in the year and that too distributed sporadically over the year. Thus most of the factors had more or less in this case a uniformity of structure and fluctuations creating a fairly comparable condition for the data collected from the four different wells. The wells were all stocked with the varieties of fishes in the combinations and sizes noted in Table XI.

TABLE XI.—*Showing the mean size and number of fishes introduced in the 4 irrigation wells.*

	A.		B.		C.		D.	
	No.	Mean size.	No.	Mean size.	No.	Mean size.	No.	Mean size.
Tilapia ..	24	41.25	8	42.5	12	44.83	12	40. 33
Etroplus ..			8	56.75	12	47.67	12	52.67
Murrel ..			8	44.25				

All the wells were netted once a month as per the procedure mentioned in the earlier section. In the assessment of the data for growth, the bi-monthly figures alone have been taken, since for the elucidation of the growth and effect of the predators, these are found to be quite sufficient. All the specimens of each species were measured to the

nearest millimeter and the mean average of size of each species was worked out. In the case of the wells where Tilapia alone, and Tilapia and *Etroplus suratensis* together were introduced, it was found that Tilapia had bred repeatedly several times. In these cases the working out of the mean average sizes of all the specimens measured would give a very low figure of growth since the majority of specimens measured would be the newer and later generations. As such in these two cases the length frequency curves were drawn and the mean average of the size groups that form the outer most mode of the curve was taken as the mean size of the original generation introduced at the start of the experiments.

All these mean sizes of the various species examined are furnished in the Table XII and expressed as positions in the growth curves (Fig. X).

TABLE XII.—*Showing the mean sizes of Tilapia grown in combination with Etroplus suratensis and Ophicephelus striatus in irrigation wells.*

Size at :	*A.* Alone	*B.* In combination with a predator and a fish belonging to same feeding niche	*C.* In combination with a predator	*D.* In combination with a fish belonging to same feeding niche
Start	41·25	42·50	44·83	40·33
60 days	98·60	147·66	143·50	99·25
120 days	140·00	191·50	210·00	126·50
180 days	180·00	224·60	235·00	138·67
240 days	190·00	245·33	250·50	192·30
300 days	207·00	266·66	254·00	197·50
360 days	203·00	283·40	260·10	198·80

From these it can be seen that while Tilapia grew to size of 283·4 mm. and 260·1 mm. when grown together with a predator like *Ophicephalus marulius*, it has grown only to a size of 230·0 mm. in a pure culture and 198·8 mm. in combination with a non-predator fish belonging to the same feeding niche as itself. In these experiments it was found that in both the wells where the predator had been introduced with Tilapia, no fresh generations have come into the population. In both the cases on more than 3 different occasion, Tilapia were found harbouring developing eggs inside the mouths, but on no occasion have we noticed a single young one in the population. Whereas in the case of the other two wells where Tilapia was introduced alone and in combination with *Etroplus suratensis*, Tilapia

had bred several times bringing into the population a continuous or rather a repeated recruitment of new generations. Such repeated recruitment of newer generations into the population seems to have brought in a population pressure, resulting in an apparent reduction or slowing of growth, of the individuals. In the case of the well where the predator had been introduced, no population pressure has entered the picture and necessarily Tilapia has grown very fast and to a very good size of 260·10 mm. One would expect that the growth will be less in a contingency where added to the predator—Tilapia culture, a fish of the same normal feeding niche like *Etroplus suratensis*, is also introduced. But in the observations of the present series Tilapia has grown to a bigger size, viz., 283·4 mm. in such a case. The explanation for this variation from our earlier observations may possibly be in the difference of the numerical relationship of the predator in the total population of the piece of water. The influence of predators in varying proportions to total population of Tilapia is under investigation now and the results of these investigations will throw further light on this question. These observations of an efficient predator like *Ophicephalus marulius* controlling the population pressure of Tilapia and indirectly contributing to the increased pace in the growth of Tilapia was further confirmed in a series of laboratory scale experiments in cement cisterns. Three cement cisterns each of 4' x 3' x 2' were taken for the experiments. A bottom of sand and mud mixture in the proportion of 1 : 1 was provided for each tank for a depth of eight inches. Each of the cistern was manured with Fifty gms. of cow dung and the same water was let into each. The number of fish that was introduced into these cisterns was purely guided by the factor that in the course of the experiments even if a few died, there would be at least one or two of the individuals to provide some working details. The distribution of fish in these cisterns were as given in Table XIII.

TABLE XIII.—*Showing the mean size and distribution of fish's in the experimental cisterns.*

	I.		II.		III.	
	No.	Size in mm.	No.	Size in mm.	No.	Size in mm.
Tilapia	8	59·8	4	55·5	4	58·8
Ophicephalus marúlius	...	...	4	63·5	...	...
Glassogobius giuris	...	...	...	...	4	62·8

After 261 days the experiments were stopped due to an unfortunate incident of the death of the predators in the *III* cistern. It was found in the course of the experiments that there was a set back in the plan due to the upsetting of the predator—predated fish ratio as a result of the mortality of these fishes. Because of this factor the data has not

been indicative of the numerical relationship of the predators to the total population. As such these data are useful only from the point of view of the question of the influence of a predator on the population pressure of Tilapia On the day the last of the *Glassogobius giuris* died, i.e., exactly on the 261st day after the start of the experiments all the three cisterns were drained and the fish removed. They were all measured and weighed and the lengths are furnished in Table XIV.

TABLE XIV.—*Showing the mean average sizes of Tilapia at the beginning and end of the experiments in the cisterns.*

	I. Tilapia alone mm.	II. Tilapia with Ophicephalus mm.	III. Tilapia with Glassogobius mm.
Mean size at the start ...	59·9	55·4	58·8
Mean size at the end of experiments (261 days) ...	121·3	151·5	137 5

The measurements are shown as growth points in Fig. XI.

It can be seen that in the cistern containing only Tilapia, the fish has bred well and in the length frequency curve of the final measurements, at least five stocks of generations are seen besides the original stock of Tilapia denoting the intensive breeding of the original stock. In the length frequency curve of the final measurements of the fish of this cistern, it is seen that besides the original stock there is at least one more stock, if not two, of fresh generations. The females of the original stock have not come into the final position of the population probably due to natural mortality during the period prior to the 261st day and after the 240th day (when the penultimate measurements were taken), for at the time of the penultimate measurements the last of the females of the original stock measuring 112 mm. had been present in the collections. In the I cistern no fresh stocks of generation have come into the population at all. Taking the mean size of the outer most mode of the length frequency curve of Tilapia population as the mean size of the original stock of Tilapia, the average lengths attained by the fish after 261 days are furnished in Table XIV.

Though the growth of Tilapia in these cases is not comparable with the growth in the natural waters, these experiments have more or less confirmed our observations that in the presence of a predator like *Ophicephalus marulius*, the population pressure as a result of repeated breeding of Tilapia is very much reduced, if not completely prevented. Such reduction in population seems to have a cumulative effect in increasing the pace of growth of Tilapia. One could expect that in the presence of *Glassogobius giuris* which is a predator of a calibre higher than *Ophicephalus marulius* (Menon and Chacko, 1959) there would be

a total prevention of population pressure. But actually in these series of experiments it was noticed that at least one fresh stock of generation has come into the Tilapia population of the cistern indicating that the population pressure has not been controlled totally by *Glassogobius giuris*. This may be due to various reasons but one that is very plausible is the ecological niche of *Glassogobius giuris*. Glassogobius lies for the most part at the bottom of the piece of water making occasional darts at the shoals of the predated fishes. The murrel, *Ophicephalus marulius* is a more active fish moving very often in all the layers of water and actually hunting out its prey. It is possible that because of this variation, there is some element of chance for at least a few of the fresh stocks of generation of Tilapia escaping the predations of *Glassogobius giuris* whereas such chances are almost completely nil in the presence of an active predator like *Ophicephalus marulius*. One of the authors (B. K. Murthi) has made some rough observations in the actual field during his recent surveys of the Rural Fishery Demonstration Tanks. He has noted that in all the tanks (where Tilapia culture has been introduced), containing bottom inhabiting predators like *Notopterus notopterus*, *Saccobranchus fossilis* and *Glassogobius giuris*, the population pressure from the periodic recruitment of generations of Tilapia has been controlled to a fair extent as seen in the Webster moat, Tanjore and in such tanks Tilapia has been found to grow to very good sizes of 250 and 260 mm. in 12 months and very good catches of Tilapia are made continuously. Concurrently he has noticed that in all the tanks where there are large numbers of such active predators like *Ophicephalus marulius* or *O. striatus Wallagonia attu* or which contain a combination of bottom inhabiting predators and active predators, Tilapia culture has not yielded any good results or very often no results as in the case of the Gangadheeswarar Koil tank in Madras. Naturally the investigations have to be taken to the next stage of determining the type of predator and the numerical ratio of the predators and Tilapia combination. We have also to investigate the results of starting fish culture of Tilapia and predators of disproportionate sizes, for as has been expressed by B. K. Murthi in his manuscript notes the "explanation for the utter and total failure of Tilapia culture in Gangadhareswarar Koil Tank can be seen positively in the existence in the tank of fairly large numbers of large sized predators like *Saccobranchus fossilis*, *Notopterus notopterus* and *Ophicepahlus marulius* that must have made a complete meal of the original stock of Tilapia of 40 to 60 mm. stocked in the tank". These investigations have been taken up and they are under study and the results of these studies will be conveyed in the next part of our contributions.

Growth in Combination with Indigenous Carps.

More than anything else, the greatest fears expressed in certain quarters were that the enormous fecundity and high survival issues of *Tilapia mossambica* will soon make it choke itself in any piece of water and literally squeeze out any indigenous varieties of fish by the dual actions of population pressure and competition for food. We have to once again point out here that our investigations on the food of Tilapia have shown beyond doubt that in the face of any competition in food, Tilapia clears itself off from the field to a niche where there is no competition. It was necessarily thought that a series of experiments on culturing some of the indigenous carps with Tilapia and without Tilapia were necessary. Two long ponds fairly identical in size and shape and fed by the same waters were utilised in the Chetput Fish Farm for the experiments. The two commonest of the indigenous carps used for fish cultural operations in this State and that are most frequent in the riverine and lacustrine milieu are *Cirrhina cirrhosa* and *Labeo fimbriatus*. And so these two species were selected for the experiments. The size of the ponds used were 80′ x 25′ x 4′ For clarity's sake these ponds may be called as A and B. The hydrological conditions were more or less identical. Into each pond 15 *Cirrhina cirrhosa* and 15 *Labeo fimbriatus* were introduced. Besides these, 12 Tilapia (4 males and 8 females) were introduced in Pond B.

The ponds were netted every 30th day and the measurements of all the fish that came in 3 hauls of the same drag net were taken. The mean sizes at which the various species were introduced and the mean sizes attained at intervals of 30 days are furnished in Table XV. In the case of Tilapia several generations had come into the picture in the course of the experiments. But, for the examination of the growth particulars only the mean size of the outermost mode in the length frequency curve was taken as in the case of the experiments detailed earlier.

Table XV.—*Showing the mean sizes of the fishes introduced into the 2 ponds in Chetput Fish Farm.*

	Pond A.		Pond B.		
	Cirrhina cirrhosa	Labeo fimbriatus	Cirrhina cirrhosa	Labeo fimbriatus	Tilapia
Number introduced	15	15	15	15	12
Size at introduction	mm.	mm.	mm.	mm.	mm.
On 30th day	85·0	72·1	87·0	69·7	74·0
On 60th day	113·1	93·5	117·3	99·1	103·0
On 90th day	132·2	129·1	147·0	107·0	127 5
On 120th day	145·0	137·3	162·5	118·5	121·6
On 150th day	157·7	141·5	167·5	122·7	140·0
On 180th day	187·5	149·0	173·1	156·0	163·3
On 210th day	193·0	179·0	186·1	163·3	180·0
On 240th day	211·0	187·5	199·0	169·5	191·0
On 270th day	221·3	192·0	191·0	181·0	196·0
On 300th day	239·0	219·0	210·5	197·5	208·0
On 330th day	231·0	257·0	267·0	203·0	200 0
On 360th day	316·2	244·5	293·0	246·0	217·0
On 385th day	342·0	287·6	257·1	263·7	221·0
	362·0	290·0	379·0	276·8	231·0

From this table it can be seen that there has been virtually not much of difference in the growth of the carps in the two ponds. In fact in the final analysis the mean size of *Cirrhinna cirrhosa* grown together with Tilapia is slightly higher than its mean size when grown without Tilapia. In the case of *Labeo fimbriatus*, the mean size of the fish when grown with Tilapia has been uniformly lower than mean sizes when grown without Tilapia. But the variation in size has been only about 20 mm. which is not much and cannot be deemed as very significant over a period of 385 days. In the case of *Cirrhina cirrhosa* it is on the other hand noticed that the mean size of the fish when grown with Tilapia is actually about 20 mm. greater than when grown without Tilapia. Actually the biggest specimen of *Labeo fimbriatus* measuring 288·0 mm. was caught from the pond containing Tilapia out of the 2 ponds. These studies though not very conclusive, show that there is not much significant and deleterious effect by Tilapia on the growth of carps.

In the course of our studies on the Rural Fisheries Demonstration tanks we had occasion to compare the rates of growth of various species in some of the tanks prior to introduction of Tilapia and after introduction of Tilapia. A perusal of two of these will be worth while

to throw some more light on this erstwhile question of deleterious effect of Tilapia on the indigenous fishes. The two tanks taken for example are the Mariamman Teppakulam in Madurai and the Webster moat at Tanjore. The average mean sizes of the various fishes stocked in the ponds for years prior to introduction of Tilapia and after introduction are furnished in Table XVI.

TABLE XVI.—*Showing the mean sizes reached annually by the stocked fishes in the Mariamman Teppakulam and Webster moat before and after introduction of Tilapia (Tilapia introduced in 1955).*

(*a*) *Mariamman Teppakulam.*

Name of fishes	Average size reached in : 1952.	1956.
	mm.	mm.
Chanos chanos	300	295
Labeo fimbriatus	210	230
Catla catla	275	290
Cirrhina cirrhosa	195	216
Cyprinus carpio	325	216

(*b*) *Webster moat, Tanjore.*

	(Tilapia introduced in 1953).	
	mm.	mm.
Labeo fimbriatus	290	285
Catla catla	375	410

From this table it can be seen that in both these tanks the growth of the indigenous fishes have not been affected in the least. In fact the production in these two tanks has always shown only an upward trend as can be seen from the total quantity of fish landed, which would not have been the case had only the fears expressed about the population pressure from Tilapia choking out the indigenous carps were to prove infalliable.

The investigations so far conducted on Tilapia have not shown any definite deleterious effect on the indigenous carps. These studies are yet inconclusive and fresh series of experiments are under way which will yield further elucidation on the point at issue.

SUMMARY.

1. Details of studies on the rates of growth of *Tilapia* mossambica in three different types of water (Pond fed by river water, pond fed by rains and springs and irrigation well) are given. The utility of predators like *Ophicephalus marulius* and *Glassogobius giuris* in keeping down the population pressure of successive generations of Tilapia is discussed. The effects of *Tilapia mossambica* on fishes like *Etroplus*

suratensis, *Labeo fimbriatus* and *Cirrhina cirrhosa* when grown together are furnished.

2. The growth rate of Tilapia in the three different types of waters are fairly identical. Of the three waters, the growth in irrigation well is the maximum.

3. Growth is fairly rapid in the first seven or eight weeks. Then with the first breeding, the growth begins to fall off.

4. The rates of growth of the two sexes are the same till the first breeding after which the growth is very much lessened in the female.

5. It is seen that if Tilapia is left uncropped or uncontrolled that the growth is lessened in every succeeding generations and that population pressure plays the vital part in the reduction in growth of every succeeding generations.

6. When grown with predators like *Ophicephalus marulius* and *Glassogobius*, it was found that the pressure from population of successive generations was very much reduced and Tilapia of the original stock grew rapidly and to better sizes.

7. No significant or deleterious effect was noticed in the growth of *Etroplus suratensis*, *Labeo fimbriatus* and *Cirrhina cirrhosa* when grown with Tilapia confirming our observations in our studies on food of Tilapia, that Tilapia can be grown with the indegenous carps with no fear of adverse effects on the carps.

ACKNOWLEDGMENTS.

To Sri D. D. Peter Devadoss and S. Varadarajan we express our gratitude for the kind interest they took in these investigations.

Our thanks are in no small measure to one and all of the field staff of the Freshwater Research Station for the unstinted help they gave us in the collection of data. We thank Messrs. Gaffoor Saheb, Kempiah Gownder and Rakkiah Gownder, the ryots of Satyamangalam for placing at our disposal their irrigation wells for our investigations and later on for permitting us to destroy all the fish in keeping with the orders of the Madras Government.

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ANNEXTURES

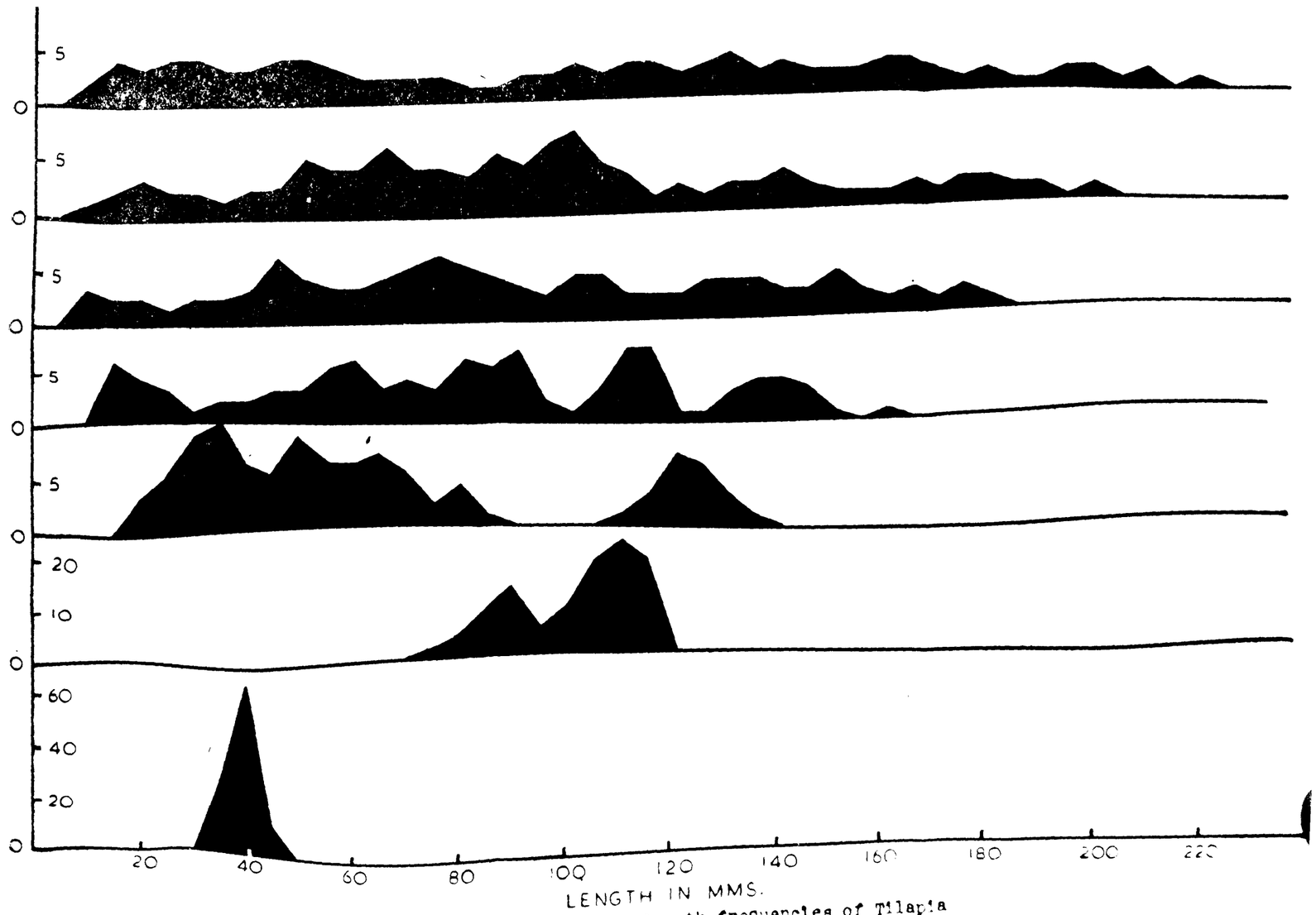


Fig. I showing the length frequencies of Tilapia in the pond fed by rains and springs.

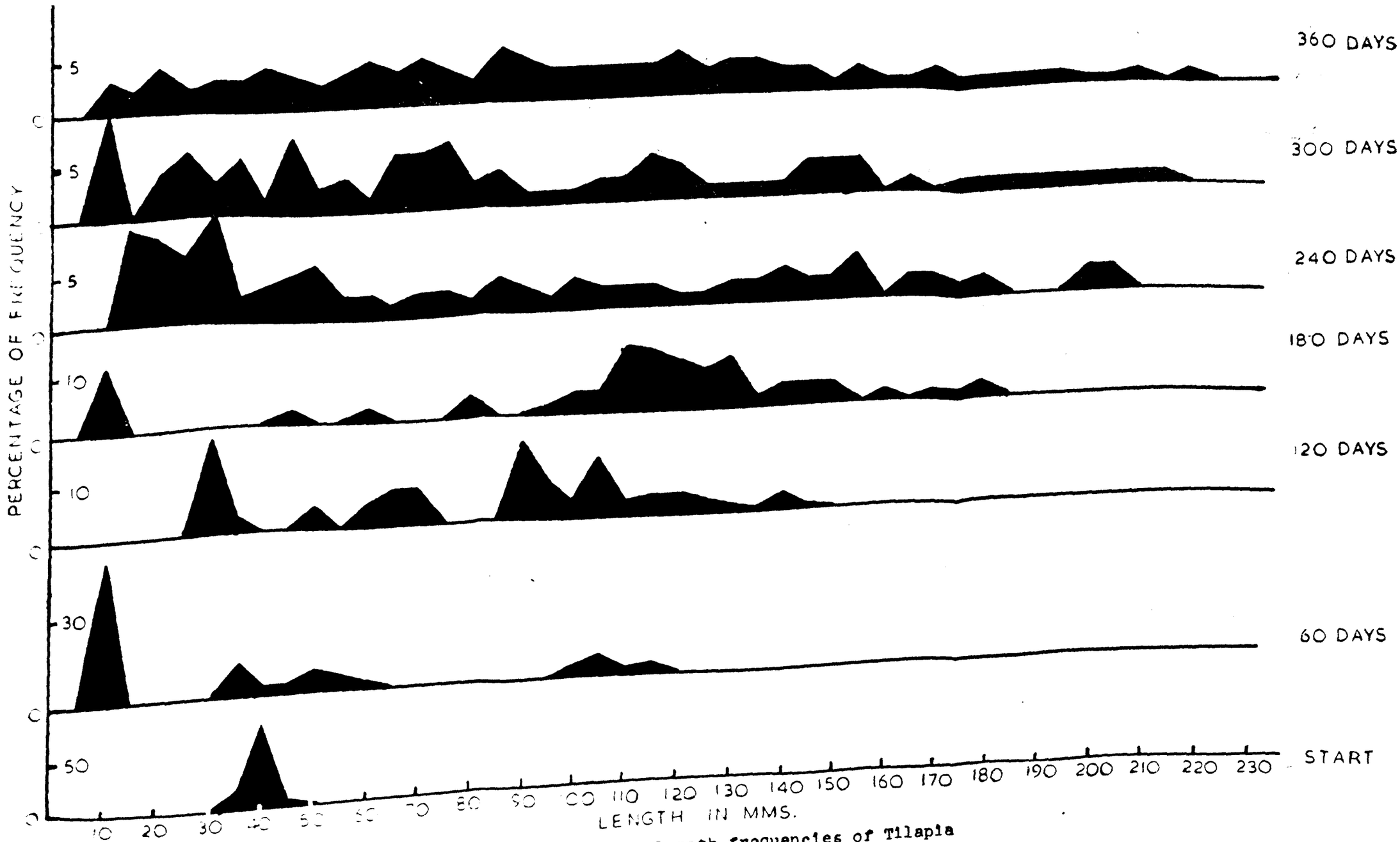


Fig. II showing the length frequencies of Tilapia in the pond fed by river.

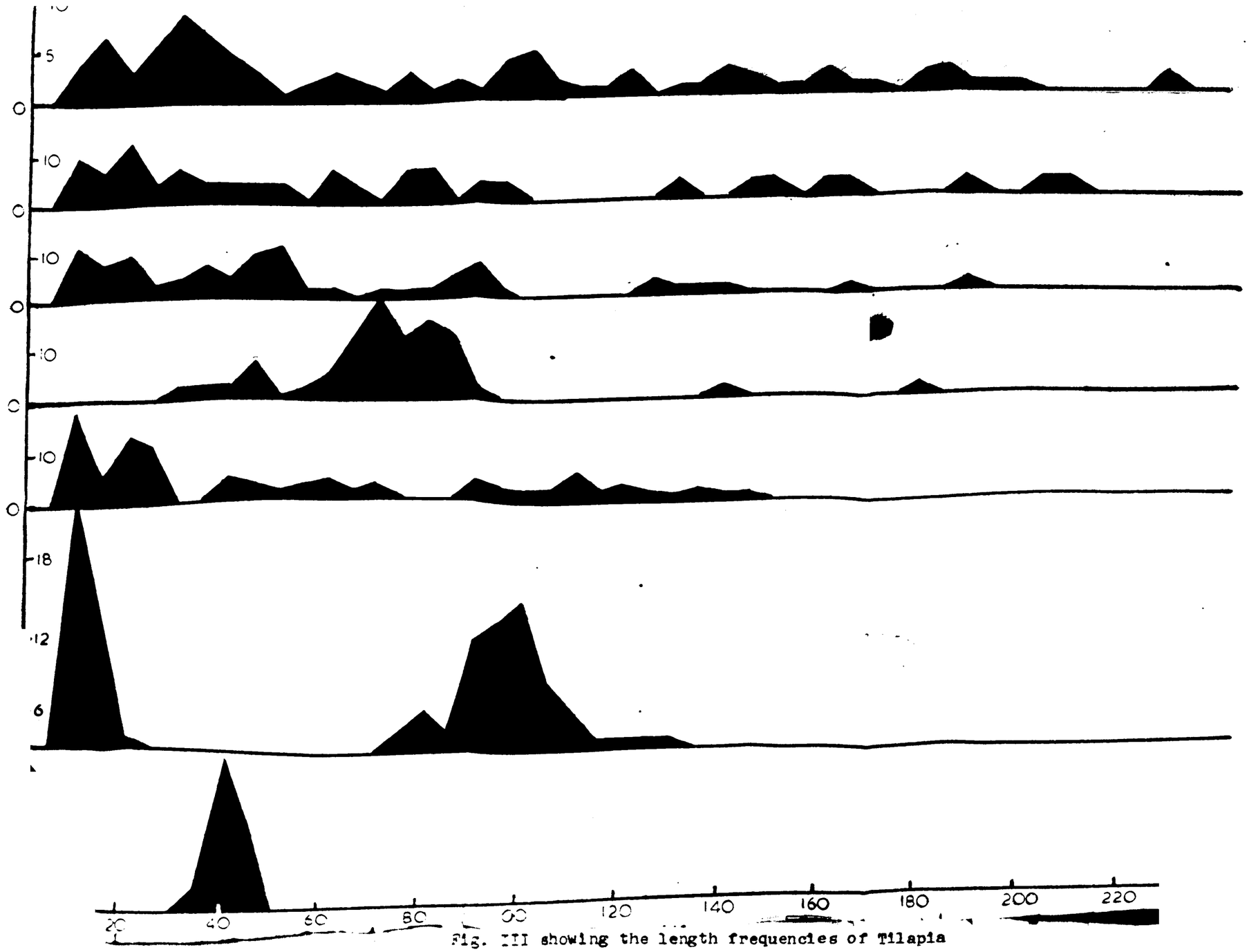


Fig. III showing the length frequencies of Tilapia in the pond fed by irrigation well.

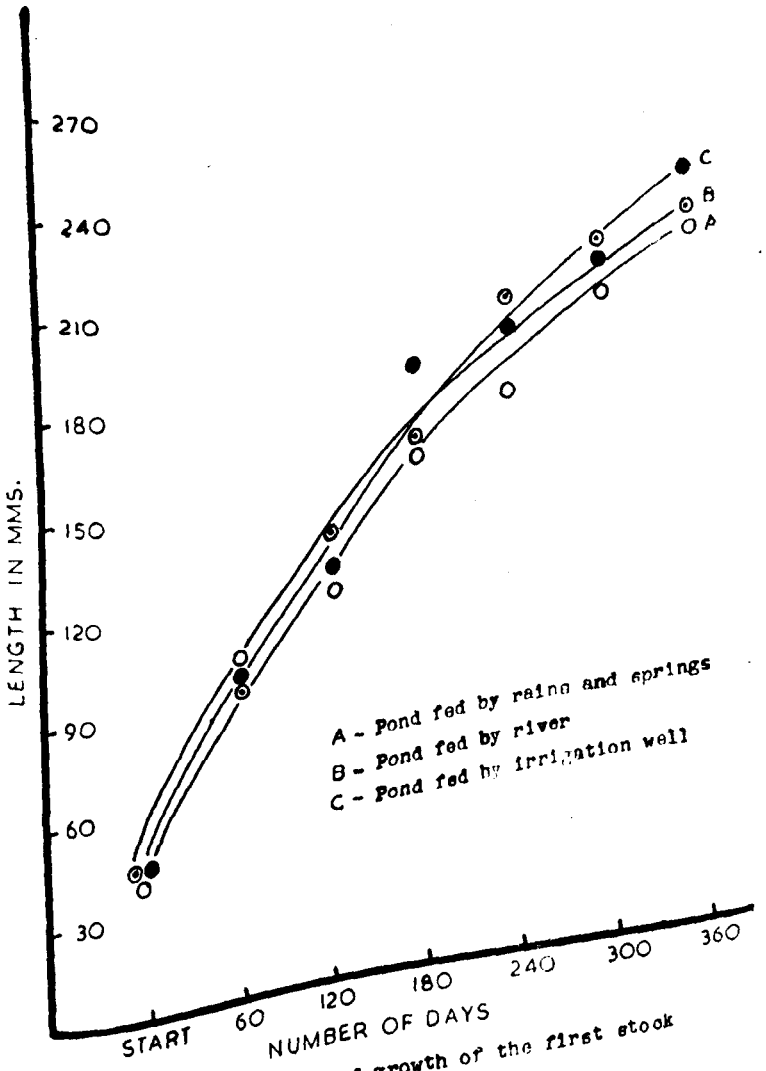


Fig. IV showing the rate of growth of the first stock of Tilapia in the three pieces of waters.

fed by rains and springs.

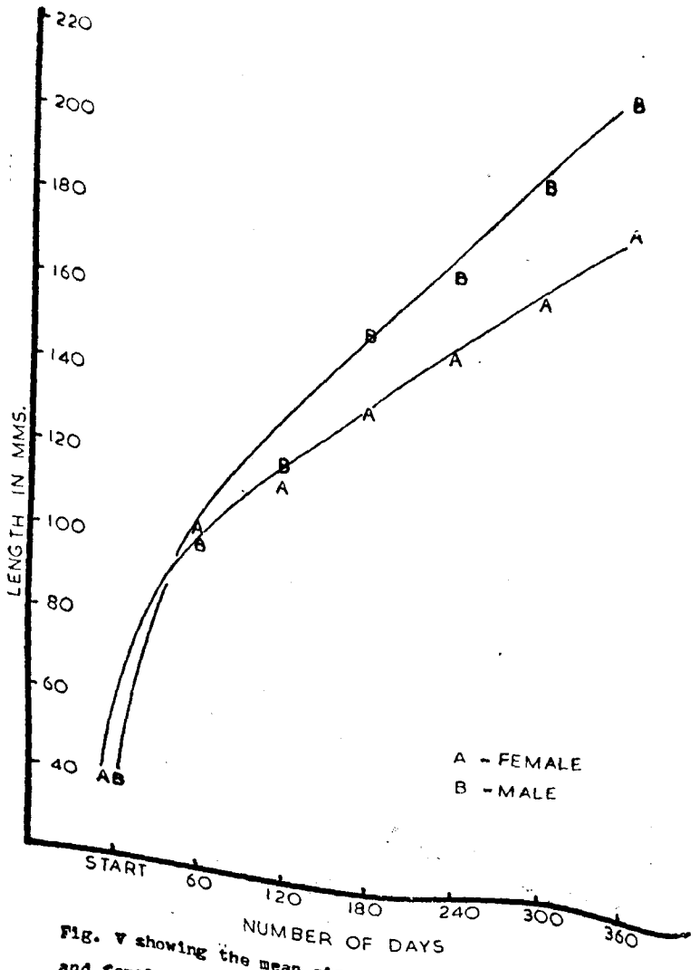


Fig. V showing the mean sizes attained by the males and females of the original stock of Tilapia in the pond fed by rains and springs.

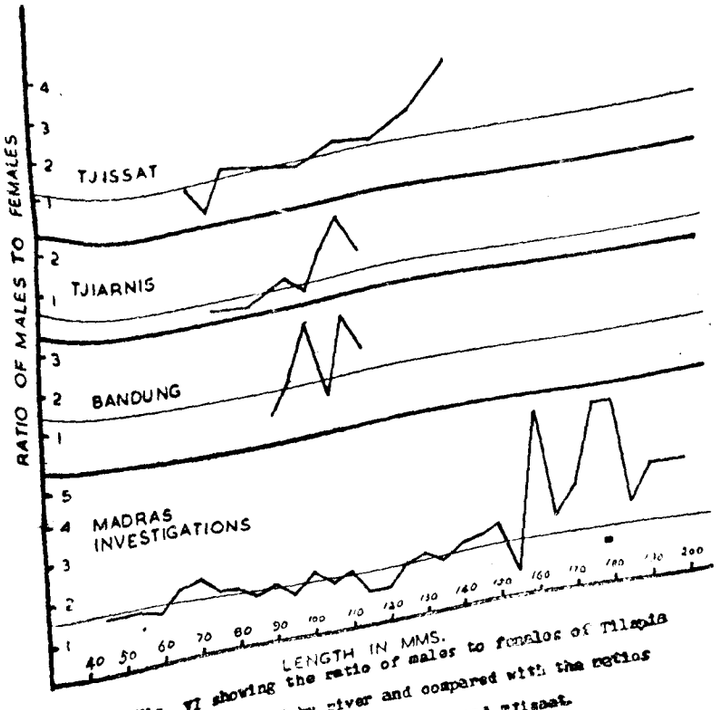


Fig. VI showing the ratio of males to females of Tilapia in the pond fed by river and compared with the ratios from Bandung, Tjiarnis and Tjisaat.

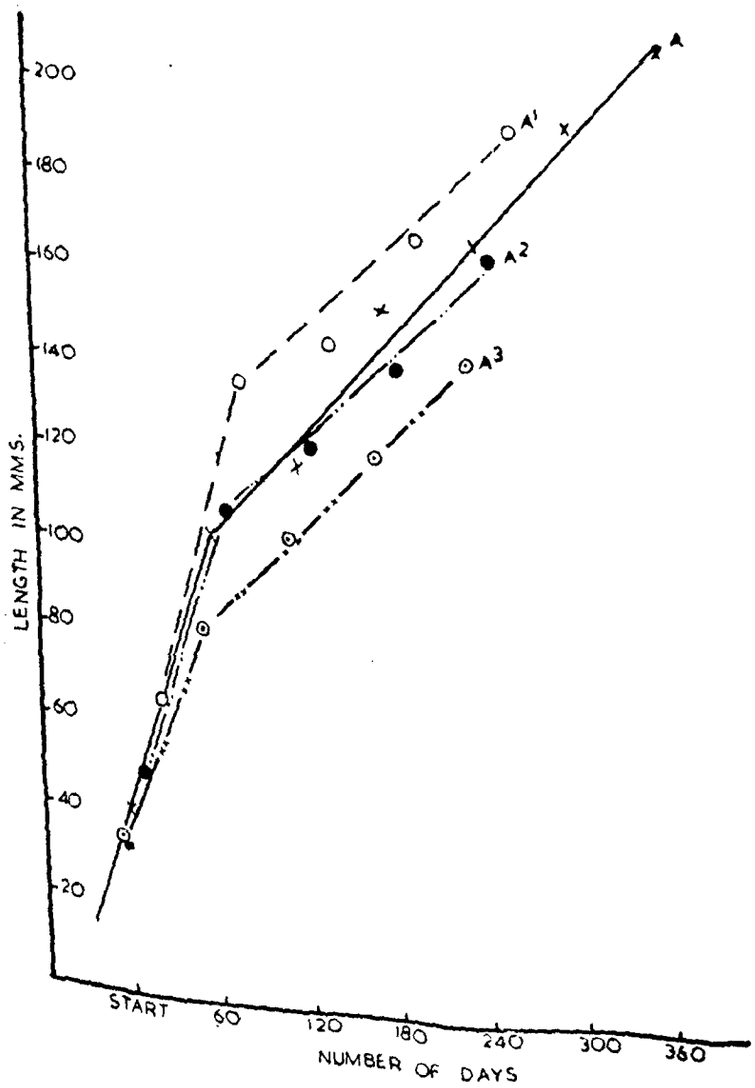


Fig. VII showing rates of growth of three generations of Tilapia compared with the original stock in pond fed by rains and springs.

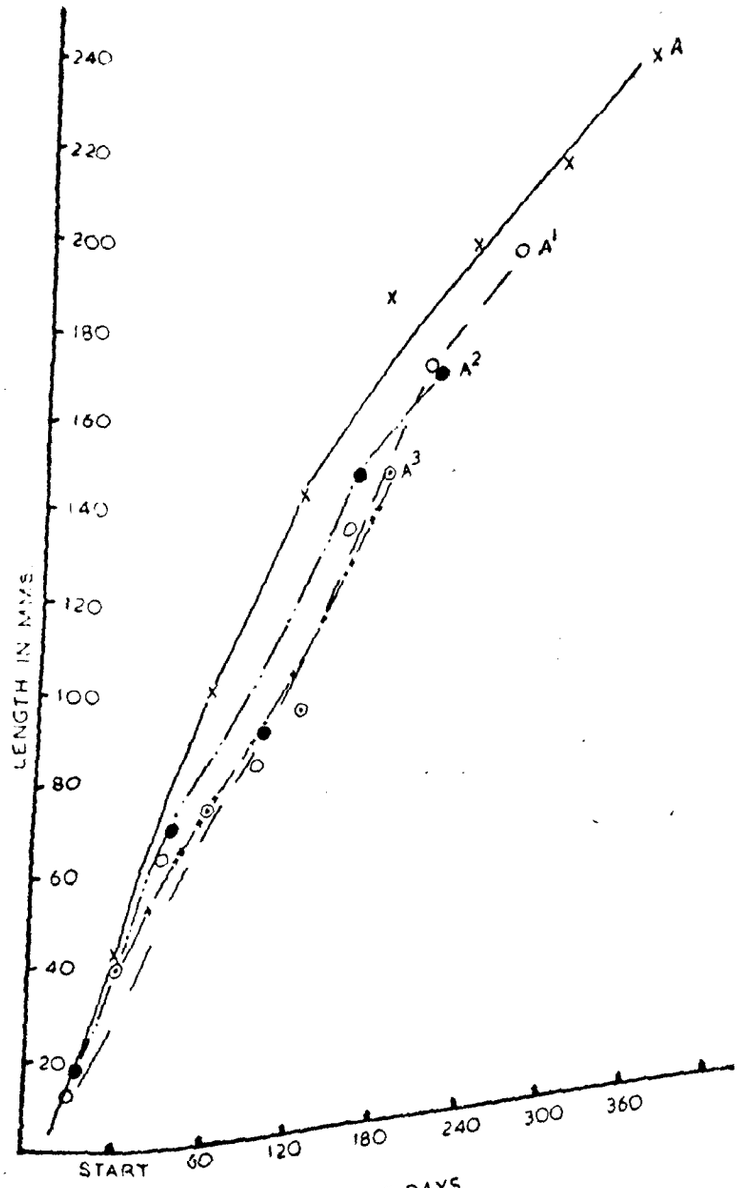


Fig. VIII showing rates of growth of three generations of Tilapia compared with the original stock in pond fed by irrigation well.

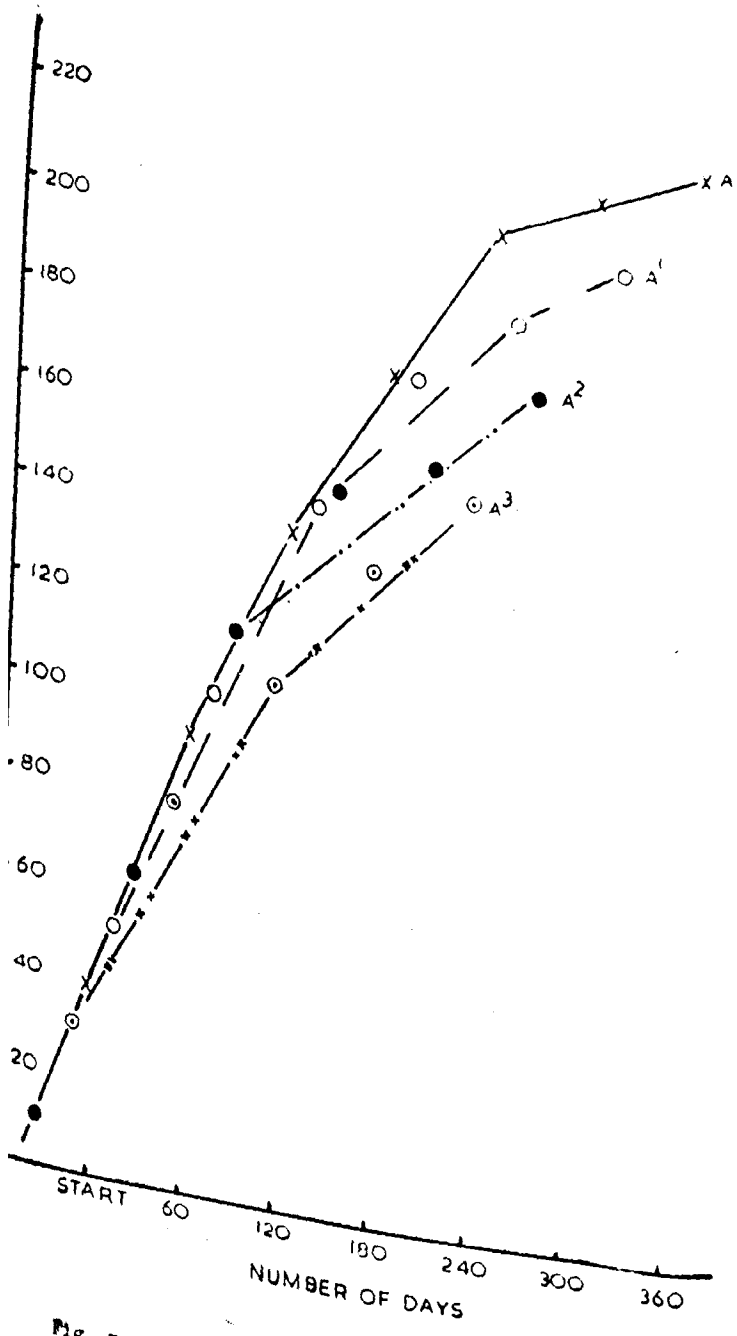


Fig. IX showing rates of growth of three generations of Tilapia compared with the original stock in pond fed by river.

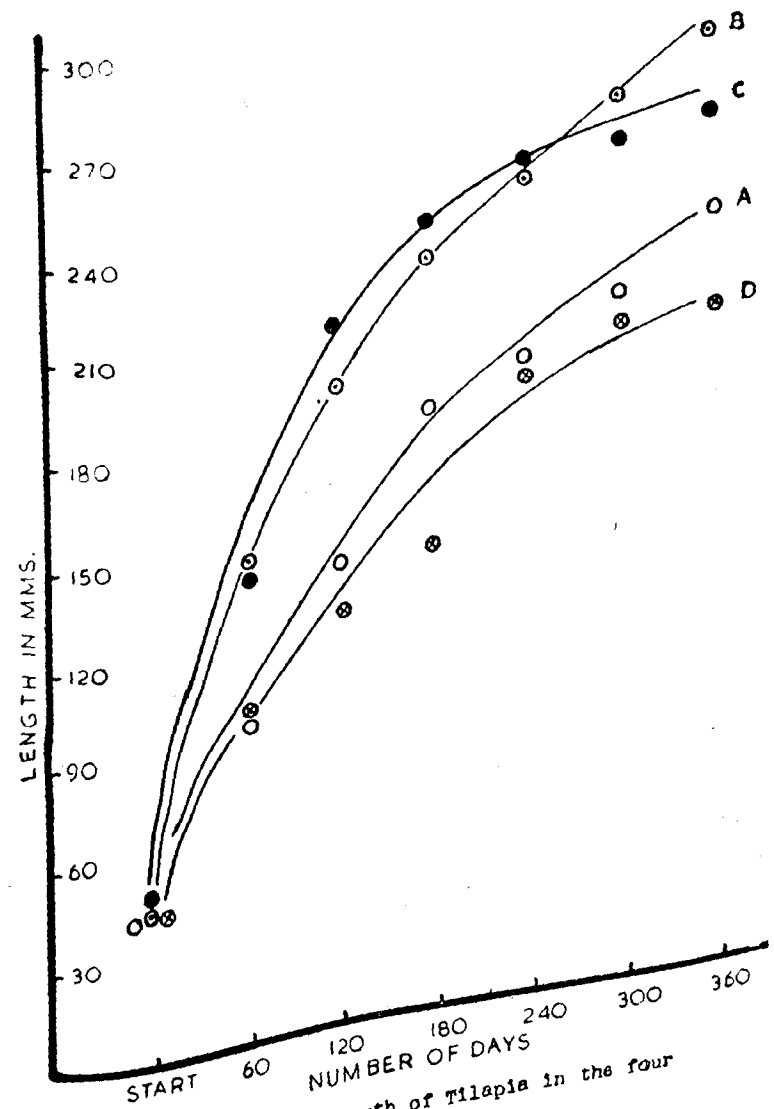
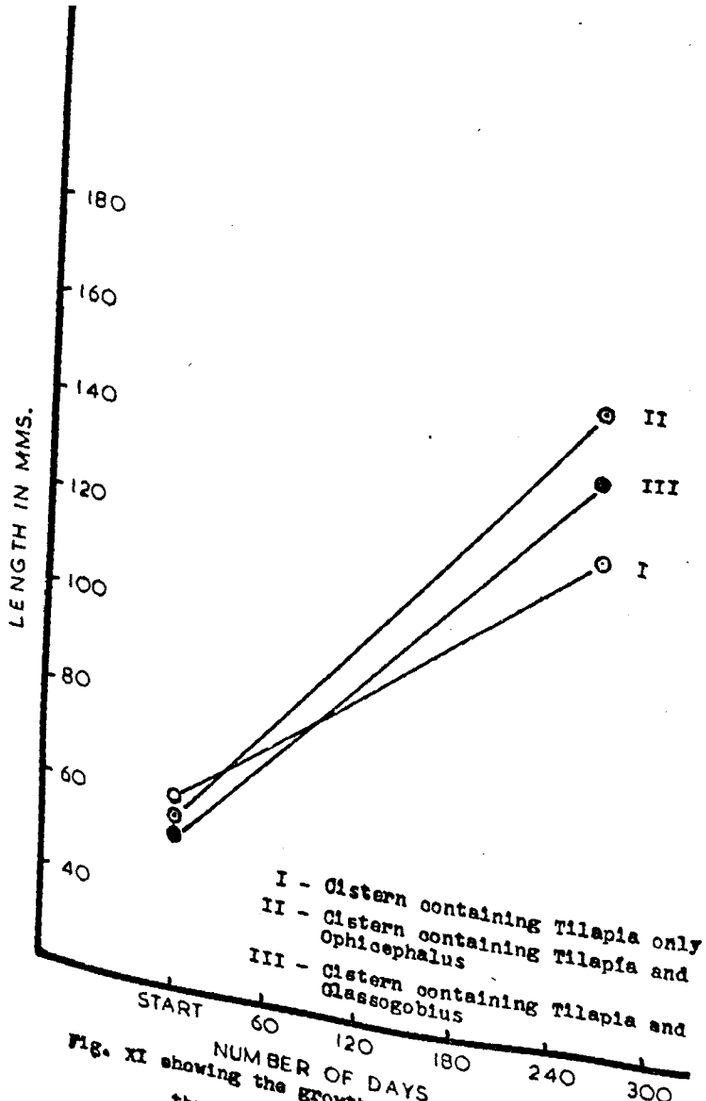
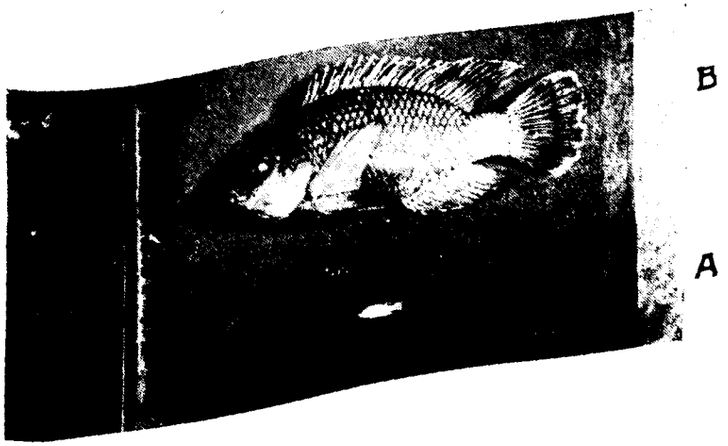


Fig. X showing the growth of Tilapia in the four irrigation wells under different cond



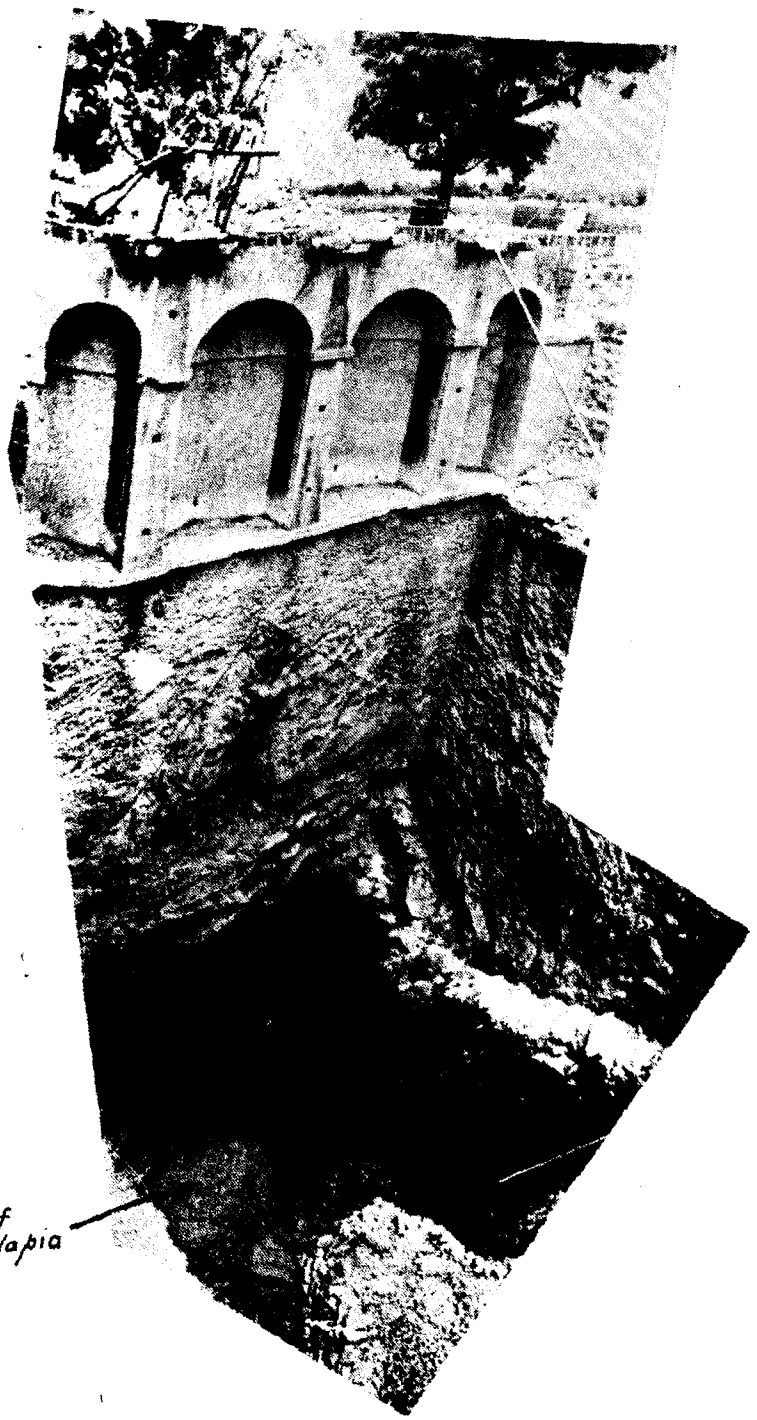
I - Cistern containing Tilapia only
II - Cistern containing Tilapia and Ophicephalus
III - Cistern containing Tilapia and Glassogobius

Fig. XI showing the growth of Tilapia in the three experimental cisterns.



A - One individual of the original stock at the time of stocking.

B - Its growth in 360 days in the well containing Tilapia and Ophicephalus



Well A where Tilapia alone was grown.

XXIII. OBSERVATIONS ON THE SEXUAL DIMORPHISM IN BARBUS DUBIUS (Day)—BY N. V. CHOODAMANI AND S. THYAGARAJAN.

Secondary sexual characters in various species of Indian freshwater fish have been observed by several authors. [Chaudhuri (1912), Hora (1922), Hora and Mukerjee (1931), Hora and Misra (1936), Mookerjee (1938), Raj (1939), Hamid Khan and Amjud Hussain (1944) and Chacko (1950)].

The study of sexual dimorphism in fishes is of great importance in Fish culture as it helps in the selection and sorting of breeders. Hamid Khan and Amjud Hussain (1944) have observed a relation of pectorals to Anal in *Labeo rohita* and *Cirrhina mrigala*. Hora and Misra (1936) observed that the "Pearl Organs" on the snout of the males of *Labeo dero* were greatly enlarged.

This communication discusses certain morphological and biometric peculiarities and differences that distinguish the two sexes in *Barbus dubius* (Day), a carp of considerable economic importance in the Moyar, the Bhavani and the Cauvery rivers of the Madras State. The fish attains a maximum size of 77 cms. and a weight of 20 lb. Its food consists mainly of *planktonic organisms* and occasionally of small aquatic insects. The spawning season is during the months from September to November. During the spawning season the males are very highly coloured. The body is reddish with silvery and yellow sheens along the sides, dull white in the abdominal region and dark steel blue along the dorsal side. Fins are reddish with grey margins. The spawning colouration of the female is the same except that it is relatively much less pronounced. The head in the male is dark bluish grey and has enlarged pores or tubercles profusely distributed on the snout and cheeks. In the female the dull grey shade of the head fades in the isthumus region and mandibular symphysis. The number of pores is less and they are not enlarged as in the male.

Besides the above variations there are some biometric differences which distinguish the sexes easily. The lengths of anal, ventral and pectoral fins of the fish of various sizes examined are given in Table I for both the sexes. It is quite clear from the table that there is very great sexual variation in the length of the anal in relation to the size of the fish. It is found that the length of the anal fin is the primary factor to indicate sexual dimorphism in the fish. Taking this factor, the following biometric variations are seen in *Barbus dubius* (Day). The

anal is larger than the ventrals and pectorals in the female. In the male it is smaller than the pectorals and smaller than or equal to the ventrals. The anal spine is very well developed in the female and is provided with pronounced lateral grooves, which serve as the channels for conducting the ova at the time of spawning. The spine is not so well developed in the male. The pectorals are larger than the ventrals or anal in the male. In the female they are larger than the ventrals but smaller than the anal. The differential growth of the fin in relation to size of the fish was also studied. Few fishes were analysed for the development of gonads also.

Our observations on *Barbus dubius* also indicate that the males have larger number of tubercles or pores (Pearl organs) than the females and that these are bigger in size with pointed ends. These tubercles, though more pronounced and dominant during the spawning season, are observed on the snout in both sexes throughout the year.

From a study, Graphs 1 to 3 show that the differential growth of the respective fins in relation to the size of the fish takes place when the fish reaches a size of 210 to 220 mm. In the analysis of the gonads it was found that *Barbus dubius* attains its maturity at the size of about 200 mm. This is noteworthy in that the physiological stress of maturation and spawning has a significant effect on certain morphological factors. This phenomenon of the influence of physiological metabolism on the morphology of the fish has been noticed in the case of the differential growth between males and females of several fishes (Hickling 1933, Hart 1946 and Menon 1950). In the analysis of length measurements of *Barbus dubius* it was also noticed that the females attain a bigger size than the males. Desbrosses (1949) has pointed out that "chez la plupart des teleosteens, la femelle grandit plus rapidement que le male, aussi a langevite egale, les males atteignment—ils des tailles bien infericures a celles des females." He further regards this variation in the size of the fish as a family is a good factor in the identification of either sex.

The growth of fins is directly proportional to the growth in length of the fish, variations in length not being marked. The average length of the anal fin of the male is less than that of the female at corresponding body lengths, at least from the time they are beginning to mature.

Summary.

Barbus dubius exhibits sexual dimorphism in the following factors :—

	Male.	*Female.*
Pearl organs.	Larger number, greatly enlarged.	Few and small.
Anal fin.	Smaller than pectorals and equal to or smaller than ventrals	Larger than both pectorals and ventrals.
Pectoral.	Larger than both anal and ventrals	Larger than ventrals but smaller than anal.
Ventral.	Smaller than pectorals and equal to or slightly larger than anal.	Smaller than both anal and pectorals.

MALE

TABLE I - A

Serial Number	Length of fish in mm.	Length of		
		Pectoral.	Ventral.	Anal.
1	218	36		
2	227	36	32	32
3	255	39	36	37
4	280	47	35	28
5	292	48	41	41
6	292	58	43	46
7	301	54	45	56
8	302	51	48	48
9	305	50	48	46
10	310	51	43	42
11	324	50	48	46
12	325	56	43	42
13	327	56	49	54
14	336	55	49	51
15	337	54	52	52
16	344	54	47	45
17	358	62	52	49
18	362	59	56	56
19	363	60	67	56
20	365	62	55	55·5
21	373	60	57	58
22	375	63	56	57·5
23	377	62·5	57	58
24	388	66	56·5	54·5
25	390	62	59	57
26	400	66	56	59
27	402	68	61	61
28	403	69	58	60
29	405	73	68	61
30	410	68	65	65
31	412	78	61	61
32	420	71	59	55
33	421	69	66	64
34	433	67	61	61
35	435	70	59	58
36	437	73	64	62
37	443	69	65	64·5
38	445	73	69	68
39	446	76	69	66
40	452	73	71	68
41	454	78	72	68
42		79	70	70
			70	70

FEMALE

TABLE I - B

Serial Number	Length of fish in mm.	Length of		
		Pectoral.	Ventral.	Anal.
1	240	39	33	38
2	252	39	36	39
3	271	49	49	49
4	275	44	40	48
5	283	50	45	53
6	289	47	43	50
7	293	49	42	49
8	312	52	47	57
9	315	52	48	56
10	317	56	45	53
11	319	57	47	54
12	321	51	50	48
13	330	53	49	54
14	335	45	46	47
15	336	55	50	61
16	337	54·5	47·5	60·5
17	345	56	52	58
18	352	57	50	65
19	355	59	50	60
20	361	61	56	68
21	365	59	53	61
22	368	60	54	66
23	370	67	59	70
24	383	65	74	53
25	384	64	57	72
26	388	68	59	76
27	390	69	62	79
28	395	65·5	60	72·5
29	406	69	63	84
30	411	68	58	69
31	415	70	64	72
32	418	71·5	65·5	74
33	426	78	66	86·5
34	429	74	62	83
35	430	73	66	82
36	431	68	64·5	82
37	433	73·5	63·5	80
38	435	74	66	82
39	438	71	67	83·5
40	442	77	67	81
41	451	71	68	87
42	452	81	70	86
43	456	82	68	91
44	466	79		93
45	484			95

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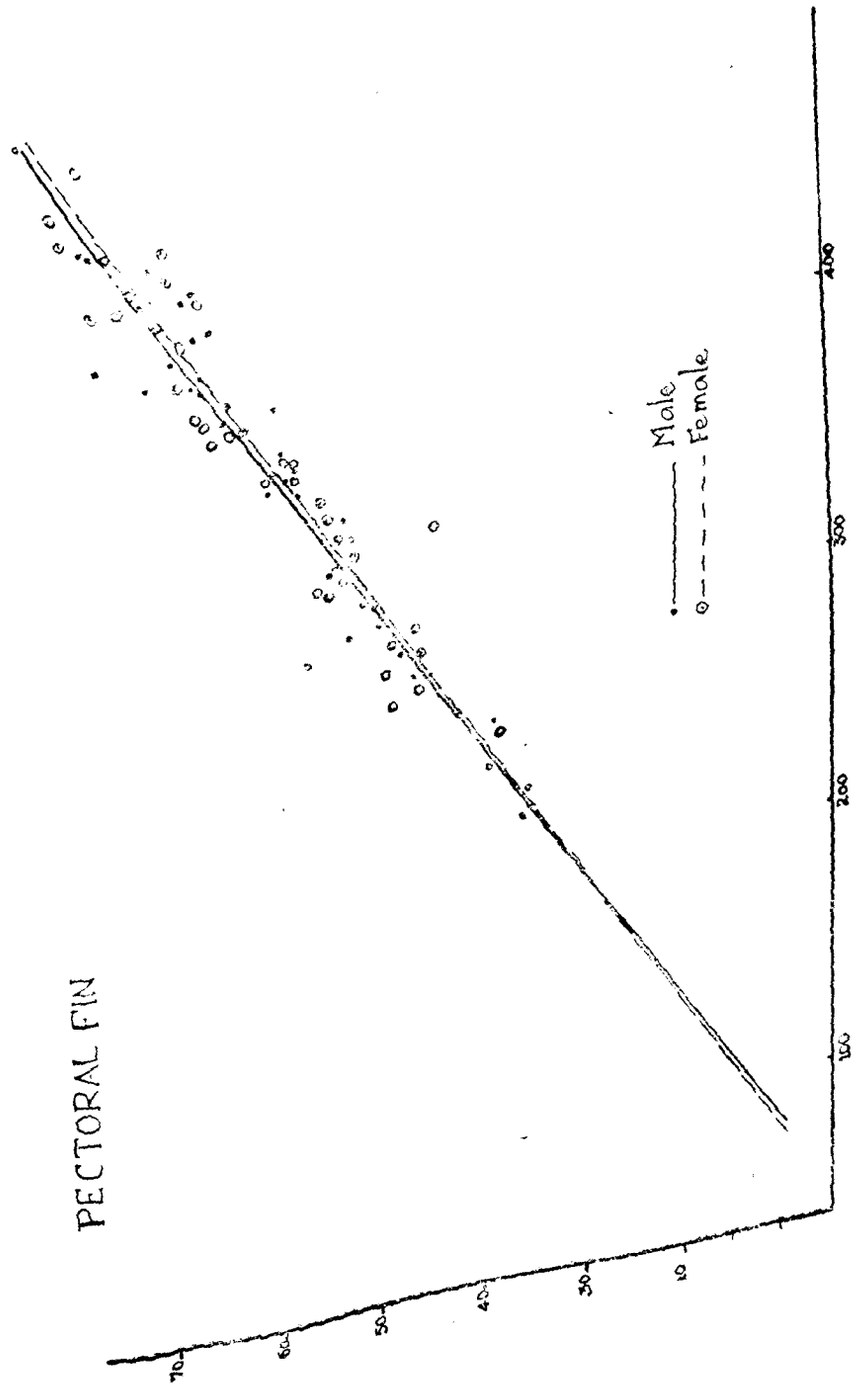

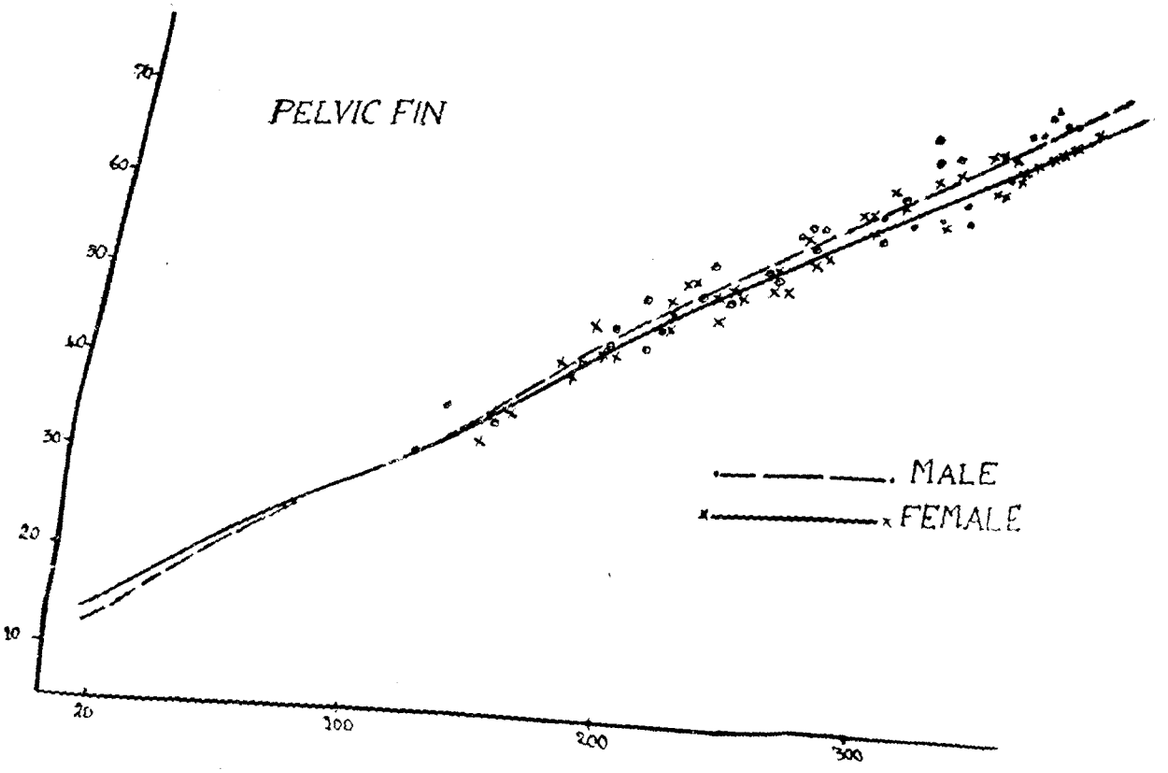
PELVIC FIN
70
60
50
40
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100
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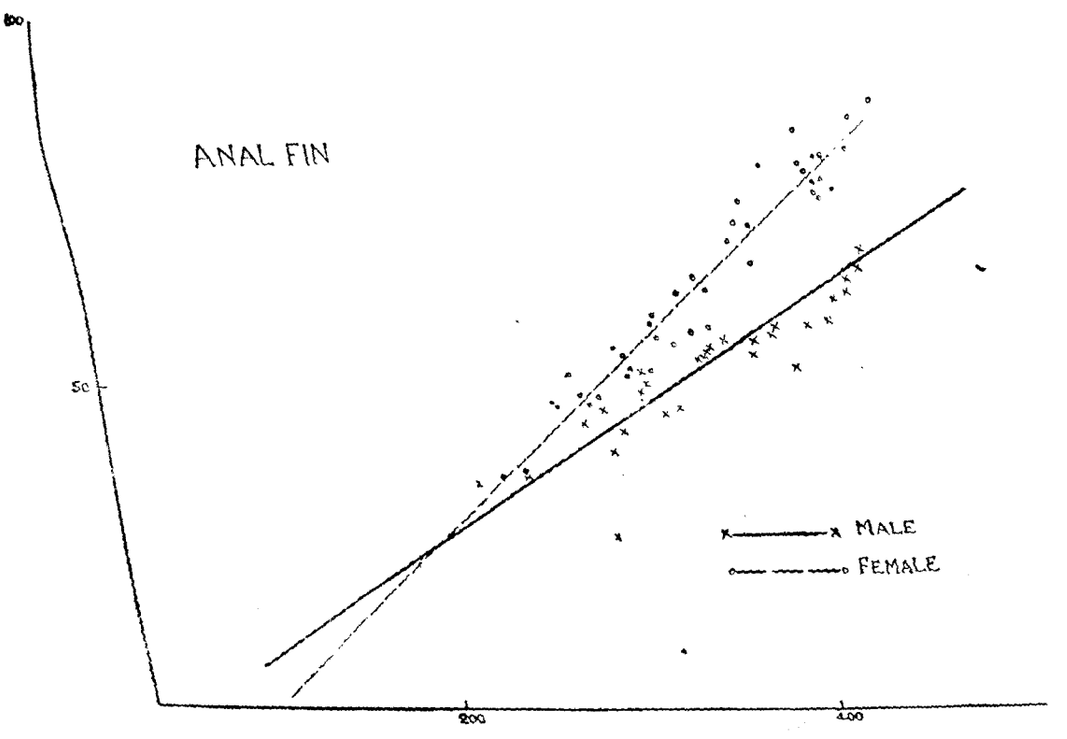
300
MALE
FEMALE


ANAL FIN
100
50
200
400
MALE
FEMALE

XXIV. THE FISHERY OF A MINOR IRRIGATION TANK

BY K. A. DORAIRAJAH, AND A. D. VENKATASWAMI.

Introduction

In the Madras State 900,000 acres of Inland waters have been surveyed by the State Fisheries Department for pisciculural programme. Amongst them there are a number of large minor irrigation tanks of which the Odathurai tank in the Bhavani taluk, is maintained as a demonstration tank. A detailed study of this piece of water was conducted to base estimations of fish production in such minor irrigation tanks.

Description of the Odathurai Tank

The Odathurai tank (fig. 1) is a minor irrigation tank of about 180·3 acres situated near Odathurai village in Bhavani taluk of Coimbatore District. The tank has a high mud embankment on its eastern side. Water for irrigation is drawn through three sluices in the mud embankment. The tank has a surplus sluice on its north-east corner. Prior to the construction of the Lower Bhavani dam and the connected irrigation canals, the Odathurai tank was only a seasonal tank retaining water for a maximum of 6 months. After the completion of the Lower Bhavani Project, the tank gets filled up through seepage water and the drainage water from the surrounding paddy fields, that are fed by irrigation canals of the Lower Bhavani Project. Drainage water from the fields and the rain waters from a catchment area of about 10 miles alround, enter the tank through a drainage channel called Pallipalayampallam on the western side of the tank. The water spread in the tank goes down to about 60 acres during the summer months of March-May. The soundings taken in the tank are shown as depth contours in figure 1. The maximum depth during F.T.L. is 25 feet and in summer it comes down to 10 feet.

The bed of the tank is not uniform owing to the removal of the silt and mud indiscriminately from different places. Every year about 60,000 cubic feet of the mud and silt from its bed are removed by the local people for manuring their fields.

Vegetation

Aquatic vegetation consisted of Potomogeton found sparcely scattered at the fringes. Other than this there was no vegetation.

Plankton

The tank was characterised by an abundance of phytoplankton (Table I). *Cylindrosphaerium* and *Merismopedia* were dominant and diatoms were next in abundance. Chlorophyceae were present only in moderate numbers. Zoo-plankton were very poorly represented.

Fishery Management

The tank was under the control of the Coimbatore District Board till July 1955 and the State Revenue Department used to annually auction out the fishery of the tank to the highest bidder. The details of the rentals realised were as follows :—

		Rs.
	...	1,159/-.
1945–46	...	390/-.
1946–47	...	Nil
1947–48	...	25/-.
1948–49	...	50/-.
1949–50	...	Nil
1950–51	...	9/-.
1951–52	...	Nil
1952–53	...	33/-.
1953–54		

In view of the poor returns, the tank was taken over by the State Fisheries Department in 1955.

Fish fauna

The fish fauna prior to the construction of the Lower Bhavani Dam consisted mainly of small sized cat fishes, *Mastacembalus armatus*, and Murrels. The department stocked the tank with fingerlings of *Barbus carnaticus, B. hexagonolepis, B. dubius, B. chrysopoma, Labeo kontius, L. fimbriatus* and *Cirrhina cirrhosa*. Three-hundred *Etroplus suratensis*, the backwater perch were also stocked in the tank in June 1953. In addition to the above the following were observed in the catches : *B. dorsalis, B. mahecola, B. ticto, Cirrhina reba, Macrones vittatus, Ophicephalus striatus, O. marulius, Glassogobius giuris, Mastacembalus armatus, Notopterus notopterus, Chela spp., Danio spp., Rasbora daniconius, Etroplus maculatus* and *Amblypharyngodon spp.*

Exploitation and marketing

The tank fishery was exploited by the Department with departmental fishermen and with local fishermen paid at one-third of their daily catches. The two-third share of the department were sold locally and in the surrounding towns and villages or auctioned at the fishing site. Fishing was conducted from the middle of August to the end of September 1955 and a total quantity of 17,500 lbs. of fish were caught and sold for Rs. 1900. Fishing could not be continued further as the water level in the tank rose up.

The fishing was conducted for most part with cast nets (both large and small meshed) and Rangoon nets. Uduvalai from a coracle and drag nets were also used occasionally. A novel method was adopted to catch the spiny eels (*Mastacembalus spp.*). The method is more or less like the "bush" method in vogue in Madras to capture *E. suratensis* seed. A bundle of assorted twigs was made, weighted with stones and sunk into the water at a depth of 8–10 feet so as to remain at the bottom. About 15–20 bundles were placed in a row and their positions were marked by planting opposite to them small sticks on the shore line. After the lapse of a few hours the operator dived in and slowly rolled the bundles into a large sized cloth bag. The mouth of the bag was closed and brought to the shore. The spiny eels taking shelter amongst the twigs were then shaken out. Only one person was engaged on this method of fishing and almost the entire catches of *Mastacembalus spp.* were caught by that person. One person normally operated about 15 bundles in a day. The maximum catch brought in was 200 to 225 spiny eels per day weighing about 75 lb. and worth about Rs. 35.

PRODUCTIVITY OF THE TANK

The total landings during the fishing period was 17,500 lbs. More than this could have been taken out if the water level had not risen up and the catch per effort became very low. Though the extent of the tank is about 180 acres, for most part of the year water is retained only to an extent of about 140 acres and in the summer months it goes down to 60 acres. Taking the area as 140 acres the production of fish is 125 lb. per acre.

The tank had been stocked, with about 77,000 carp fry in 1954, out of which nearly 50 percent were of major carps. Allowing for a mortality of 12 persent during transport and 22 percent after stocking, (Ganapati and Chacko, 1950) the survival is about 50,000 in which only 25,000 would be major carps. Basing on the annual rate of increase of 0·56 lb. in weight given by Ganapati and Chacko (1950) the estimated production would work out to 14,000 lb. per annum. The tank has given 3,500 lb. more than the estimated yield. This was due to the Mirror carp stocked and the other fishes in the tank not taken into account.

CONCLUSION

The Odathurai tank was not fetching profitable returns until the management was taken over by the Fisheries Department. It has been clearly shown that such large pieces of waters could be used for successful pisciculture through a scientific stocking and management programme. The productivity per acre of the tank compares favourably with such minor irrigation tanks like the Kannigiri Reservoir (Chacko and Krishnamurthi, 1952) and the Kadamba tank (Chacko and George, 1952). As part of improvement programme, the department have stocked the Odathurai tank in 1955 with Mirror carp. In view of the similarity of hydrobiological conditions between the Odathurai tank and Polupally tank in which the first breeding of Mirror carp in the plains was observed, it is hoped that the fish might breed in Odathurai tank also and enrich the fishery of the Bhavani river system.

ACKNOWLEDGEMENT

We wish to express our sincere thankfulness to Sri M. Devidas Menon and Sri B. Krishnamurthi for the valuable help and guidance in preparing this report. Our thanks are also due to Sri T. Kanakasabapathy and Sri V. Madhavan Nair for help rendered in the collection of field data.

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TABLE No. I—*Showing the Planktonic Organisms in Odathurai Tank on 21st March, 1956.*

Name of Organisms.	Surface (No. per c.c.)	Bottom (No per c.c.)
Cyanophyceae.	22650	2200
1. Cylindriosphorium ...	1150	650
2. Merismopedia ...		—
Chlorophyaceae.	100	—
1. Scenedesmus ...	50	
2. Pediastrum ...		700
Bacillariaceae.	1260	2300
1. Pinnularia ...	3550	—
2. Navicula ...	350	450
3. Nitzschia ...	100	300
4. Amphora ...	150	50
5. Cymbella ...	150	
6. Synedra ...		

XXV. THE EFFECT OF THE EFFLUENTS OF THE BLEACHING FACTORY ON THE FISHERY OF KALINGAROYAN CHANNEL BY K. A. DORAIRAJAH AND A. D. VENKATASWAMY

In his note to the Indian Council of Agricultural Research Hora (1942) was the first to draw the attention to the problem of Pollution of streams and rivers in our Union. Following this Malden (1943), Hora and Nair (1944), Bimachar and David (1946), Ganapati *et al* (1950 and 1952), and Chacko and Srinivasan (1954) have studied in detail the effects of Industrial Pollution on the Streams and Rivers in this country. The Indo-Pacific Fisheries Council in its fifth meeting at Bangkok, drew the attention of the Member Governments to the problem of water Pollutions by Industrial wastes and its consequence on the stream and river fisheries that is assuming serious proportions. The present communication is about the effects of the effluents of a small Bleaching Factory at Pallipalayam in Erode Taluk (South India) discharging its effluents into an irrigation channel called the "Kalingarayan channel."

Description of the Channel

The Kalingarayan channel about 50 feet in width is an irrigation channel taking off from Bhavani river and running a course of 25 miles on the southern side of the River Cauvery and joining Noyyal River in Erode taluk. The fishery of the stream is auctioned annually by the Revenue Department. The rentals for the years 1950-56 is appended below :—

1950-51.	1951-52.	1952-53.	1953-54.	1954-55.	1955-56.
Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1615/-	1702/-	1100/-	545/-	465/-	470/-

The channel goes dry every year from the month of May to the middle of June. The rate of flow in the channel during the period of water retention is given in Appendix I. The maximum average flow is seen to be 518 cusecs. in 1951-52 and the minimum of 330 cusecs. in 1950-51. There are six bleaching factories near the Kalingaroyan channel within Erode municipal limits, bleaching handloom cloths. The effluents and other waste waters of these are thrown in the vicinity of the channel. But, one factory belonging to one Nachimuthu Gounder, actually lets the effluents into the Kalingarayan channel.

The Factory

The bleaching factory is situated in the cultivable gardens of the owner Sri T. Natchimuthu Gounder, and lies about 50 yards from the southern bank of Kalingaroyan channel in the village of Karungalpalayam in Erode Municipal area. The factory is in existence for the past 2½ years.

The factory has nine cement cisterns of 10 x 15 feet in which the entire process of bleaching is done. Fresh water supply for the factory is pumped from a deep well nearby.

Approximately 1,500–2,000 yards of handloom cloths are bleached in the factory with the help of about 16 men. No elaborate machinery is used by the firm. The entire process of boiling, souring, bleaching, and finishing is done by manual labour only. The effluents and waste waters are led from the premises through a small dug out drain of 12-18 inches width and 6 inches depth. The drain passes through a "tope" of cocoanuts and plantains in the garden and finally empties into the Kalingarayan channel. About 60-100 gallons of effluents are discharged during a 12 hour shift (6 a.m. to 6 p.m.) daily into the channel.

Methods

Detailed observations were conducted on 14th October, 1955 and 15th December, 1955 when samples of the effluents, water, plankton and fish were collected. The collections were made at a spot 100 yards above the place of confluence of the effluents, at the confluence of the effluents with the Kalingarayan channel and 100 yards below the confluence.

Observations

1. *Hydrological conditions*

The details of analysis of these samples collected are given in Tables I and II. The strong effluents collected direct from the cement cisterns was white in colour, nearly neutral in reaction with a pH. of 7·0 to 7·5. The total solids figure was 17,600 ppm. and the conductivity ranged from 1825 to 1975 Meg. Ohms. The CO_2 content ranged from 4·95 to 6·6 ppm. The bi-carbonate value fluctuated between 30·5 and 573·4 ppm. Dissolved oxygen was totally absent. The partly spent and fully spent up effluents had also similar pH values with total absence of dissolved oxygen. The other factors were in comparatively less proportions than that of the strong bleach liquor.

The water samples from the Kalingaroyan channel exhibited a dissolved oxygen figure of over 5·0 mg/litre. The effluents did not appear to have lowered the dissolved oxygen content of the channel to any appreciable degree.

There was a general increase in the other chemical factors of the water samples collected at the place of confluence and 100 yards below it than at 100 yards above the confluence.

2. *Plankton*

The details of the plankton analysis from the places of collection are given in Table III. The total number of phytoplanktonic organisms increased in general at the confluence of the effluents and about 100 yards below it. The chlorophyceae particularly which were absent at 100 yards above the confluence were present in considerable numbers at the confluence and at 100 yards below it. The number of zoo-plankton was very low. Such conditions have also been noted by Srinivasan and Ganesan (1955) in the case of the pollution of River Cauvery by the Erode-Cauvery Textiles.

3. *Fish Fauna*

Minnows like Rasbora daniconius. Danio malabaricus, Chela clupeoides, Barbus spp. were observed in the channel at the time of the investigations. They were found to be moving about even at the place of confluence of the effluents, without any distress. No case of fish mortality was noticed any where in the channel.

Discussion

Redeke (1927) in his classification of industrial wastes observes that the waste liquors discharged from bottom bleaching processes are chiefly diluted alkaline and acidic fluids and solutions of chlorides of lime, which when not diluted properly may cause harm for fish life. In the case of the Nachimuthu Gounder's Factory dealt with in this paper the discharge of effluents during the 12 hours shift from 6 A.M. to 6 P.M. is 1,200 gallous on an average. This is discharged into the Kalingarayan channel in which the minimum rate of flow is 80 cusecs. and 4,31,20,000 gallons of water per day flows through. A quantity of 1,200 gallons of raw effluents thus get mixed in 4,31,20,000 gallons of water, the dilution rate working out to approximately 1 : 36,000. Actually there is scope for greater dilution as the rate of flow in the channel exceeded 100 cusecs during most of the months.

The effluents did not appear to be causing any harm to the indigenous fishes of the channel, as a number of minows were seen moving about at the place of the confluence. But Shelford (1917) has shown that this may be due to the " habit " forming nature in fishes which makes them to prefer toxic or poisonous solutions once they get into it by accident, even though it may cause their deaths. That this was not the case was checked up by conducting laboratory experiments on the effect of the effluents on the fish life. The effluents were diluted with distilled water at 1 : 100, 1 : 50, 1 : 20 and 1 : 10 and *Danio malabaricus* of 2 to 2½" in size were placed in them. The fish were not affected even in a dilution of 1 : 10 in 48 hours. Further no mortality of fish in the channel has been reported so far.

CONCLUSION

The results of laboratory experiments on the safe limits of dilution of the effluents of the bleaching factory was found to be 1 : 10. Actually there is a dilution of over 3600 times in the Kalingarayan channel throughout the year. No further treatment of the effluents of the bleaching factory prior to the discharge into the channel therefore, is necessary to make the effluents harmless to fish life or planktonic production.

The reduction in the fishery rentals of the Kalingarayan channel does not seem to be due to any pollutional causes from the bleaching factory. It may be due to other causes like lack of healthy competition in the public auctions, etc.

ACKNOWLEDGMENTS

We wish to thank Sri M. Devidas Menon, and Sri B. Krishnamurthi for their guidance and help in the preparation of this communication. To Sri T. Kanakasabathy our thanks are due for the help rendered in the collection of field data.

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APPENDIX I

Showing the Average rate of flow (in cusecs) of water in Kalingarayan channel during 1950-56.

Month	1950–51	1951–52	1952–53	1953–54	1954–55	1955–56
April	153·5	403·56	291·46	398·93	281·56	217·29
May	Nil	Nil	Nil	Nil	Nil	Nil
June	297	633·63	328·39	549·40	131·90	260·20
July	478·7	611·93	569·19	654·22	473·35	471·12
August	586·2	625·80	611·20	347·87	591·77	605·90
September	528·0	568·2	388·70	515·66	608·33	603·22
October	383	581·83	615·90	592·00	513·70	606·58
November	537·33	509·33	337·06	606·13	549·60	593·34
December	389·30	627·96	410·17	538·09	603·83	...
January	179·83	371·48	469·83	620·50	478·12	...
February	100·12	349·52	320·74	520·07	302·33	...
March	86·45	408·0	187·98	265·68	337·22	...
	329·26	517·38	412·8	509·86	442·9	483·520

TABLE 1—*Showing the hydrological condition in the Kalingarayan channel on 14th October 1955.*

	100 yards above the confluence.	At the outfall of the effluent.	100 yards below the confluence of effluent.
Time	11 a.m.	11-15 a.m.	11-30 a.m.
Dissolved oxygen (Mg/litre)	6·1	6·0	6·4
Temp. °C	30·1	30·2	30·2
Free CO_2 (ppm.)	4·4	8·25	7·15
Carbonates	Nil.	Nil.	Nil.
Bi-carbonates (ppm.)	18·3	30·5	24·4
pH	7·6	7·4	7·6
Total Hardness (ppm.)	108	146	106
Elec. conductivity	200	280	200
B.O.D. (ppm.) (3 days)	20	40	20
Total solids (ppm.)	480	1000	490
Organic matter (ppm.) ignitable	90	200	100
Chlorides (ppm.)	17	28	18
Free chloride	Nil.	Nil.	Nil.
Free Ammonia	Nil.	Nil.	Nil.

TABLE 2—*Showing the hydrological conditions in the Kalingarayan channel on 15th December 1955.*

	100 yards above confluence.	At confluence of effluents.	100 yards below confluence.
Time	2-30 p.m.	2-45 p.m.	3-00 p.m.
Temperature °C	27·1	27·2	27·1
Dissolved 0_2 Mg/Litre	6·6	5·4	6·6
Free CO_2 (ppm.)	6·6	8·8	6·6
Carbonates (ppm.)	Nil.	Nil.	Nil.
Bi-carbonates (ppm.)	201·30	213·5	200·74
pH	8·2	8·4	8·1
Elec. conductivity	265	300	265
B.O.D. (3 days)	25	50	26
Chlorides (ppm.)	18	27	18
Free chlorine	Nil.	Nil.	Nil.
Free Ammonia	Nil.	Nil.	Nil.

TABLE 3—*Showing the Phytoplankton organisms per c.c. in Kalingarayan channel on 15th November 1955.*

	Kalingaroyan channel 200 yards above fall of the effluents.	At the junction of the confluents in the channel.	100 yards below the confluence joining the channel
Cyanophyaceae			
Oscillatoria	350	100	...
Chlorophyaceae			
Scenedesmus	...	250	250
Microspora	...	100	...
Pediastrum	...	...	50
Bacillariaceae			
Navicula	150	550	300
Synedra	300	...	200
Nitzschia	50	300	200
	850	1300	1000

XXVI. INVESTIGATION ON THE QUALITY OF SALTED FISH SOLD IN THE MARKET BY R. VENKATARAMAN AND A. G. VASAVAN

INTRODUCTION

As a result of a number of experiments conducted at the Fisheries Technological Station, Kozhikode, for improving the quality of salted fish we were able to arrive at certain standards for judging the quality of salted fish. The moisture content of the fish should be 35 - 40% and the sodium chloride content 20 - 25% on dry basis, the figures varying considerably according to the species and size of the fish (R. Venkataraman and A. G. Vasavan)[1]. The T.V.B. (Total Volatile Bases) is taken as a standard of judging the quality of salted fish. Samples in the initial stages of spoilage had a T.V.B. value of 200 mgms. per 100 gms. Properly salted fish remained in good condition for not less than ninety days. After fixing up the quality standards for the salted fish, investigation on the market samples were taken up to see to what extent they conform to the standards arrived at.

MATERIAL AND METHODS

Representative samples of the following fishes were collected from Kozhikode and Nadakav markets in different seasons :—

A. Kozhikode market.—(1) Silver bellies, (2) Oil Sardines, (3) White bait beach dried (without salting), (4) White bait dried after salting, (5) Mackerels, (6) Sole fish, (7) Shark and (8) Miscellaneous fish.

B. Nadakkav market.—(1) Mackerel, (2) Miscellaneous fish, (3) Chooda (Clupea lile), (4) Sole and (5) Silver bellies.

The samples were observed for appearance including the presence of 'red', odour and texture. Representative samples were taken and after wiping carefully the free salt present on the surface, the flesh was minced in a meat mincer thrice and the moisture and NaCl determined as per A. O. A. C., Method[2] 10 gms. of the mineed fish was treated in a 10% solution of trichloracetic acid and the T.V.B. was determined according to the method of Conway[3]. Periodical observation and chemical tests were carried out on preserved samples of each lot.

RESULTS AND DISCUSSION

The analysis of the samples collected from Kozhikode market are given in Table I and the analysis of samples from Nadakkavu market are given in Table II. The first sample of silver bellie from Kozhikode market contained a high moisture of 54·5%. Free water was oozing

from it after a few days. Even within a month, a sample began to emanate foul odour and were attacked by red halophiles. In two months, they became putrid and completely covered with 'red'. The second samples had a low moisture level (36·6%) and as such remained good even at the end of second month of observation. The third sample had a value in between the first and second (46%) and it deteriorated after one month. At the end of second month it was completely spoiled.

The samples of oil sardine had only a very low moisture content of 30·5% and they remained good for three months.

White bait being a lean fish and also very small, it is usually dried on the beach without any application of salt. Drying without salt however does not give a long storage life. Within two months, it became dark in colour and crumbled to pieces. On the other hand samples of salted white bait remained in good condition for two months without any attack of 'red' or moulds. This proves that beach drying (without application of salt) is not a very efficient method of processing them. In addition to poor keeping quality, the process is unhygienic due to the admixture of sand and other extraneous matters.

The samples of mackerel had a high moisture content (47·56%) and spoiled rapidly. The samples turned putrid and were attacked by 'red'.

The samples of sole fish had a low initial moisture content of 16·39, but they picked up moisture very rapidly and in two months it increased to 25·83 an increase of 50%. In two months they were attacked by insects. The samples of shark had a high moisture content of 49·86. The surface was moist and emanated the smell of urea. Though there was no attack of red or moulds for two months the odour was repulsive. The miscellaneous fish samples had a slightly high moisture content of 44·58 and they were spoiled in two months.

Out of the samples collected from Nadakkav Market mackerel contained only a moisture of 42% initially, but the samples picked up moisture in storage. The sample remained good for two months and were attacked by 'red' afterwards. The odour became pungent and after a lapse of three months the sample turned completely putrid and was inedible.

In the case of miscellaneous fish the moisture content was 45% and the sample darkened in colour within two months. At the end of three months they were completely spoiled. The sample of Choda (*clupea lile*) had a high moisture content of 48% and they turned brown within a few days. In two months they were completely spoiled. The

sample of a sole fish had only 38·5% moisture, but turned brown and were attacked by moulds within a few days. In two months they were spoiled. The samples of silver bellies had a high initial moisture 50% but they dried up in storage and remained good for two months but for slight attack of 'red' and moulds.

To sum up it is evident that a high percentage of moisture is in general the cause of early spoilage of salted fish sold in the markets. Lafont[4] has remarked that curers have a tendency to dry the fish just sufficiently to preserve the fish for the few days required for its transport and sale, disregarding the period of subsequent storage. Evidently this is the condition prevailing in our markets also. The curers are reluctant to dry the fish sufficiently since the drying involves loss of weight and a reduction in their profits. So unless strict measures are taken at Governmental level to enforce the proper drying of fish, the state of things will not improve. The moisture content of the samples, excepting in a few instances were fonnd to increase in storage and this factor also contributed towards spoilage. Periodic drying of salted fish stored in godowns, if convenient is suggested to remedy this situation.

Conclusions

Most of the samples of salted fish collected from the two markets of Kozhikode municipality were found to contain a high percentage of moisture and because of this single factor they spoiled rapidly. Steps to enforce regulations on the maximun of moisture and minimum of salt must be taken, if the salted product is to improve keeping in quality. Periodic drying of salted fish samples kept in storage, as a means to check the rise in moisture during storage is also suggested. The present system of beach drying small fishes like white bait, without application of salt must be discouraged, as the quality of the processed product is poor and its keeping quality very short. Instead if it is treated with salt and properly dried, it keeps very well over periods.

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TABLE I—*Storage Studies of Salted Fish Samples Collected from Kozhikode Market.*

Particulars	Month		Initial	After one month	After two months
1. Silver bellies	June	Moisture percent	54·49	50·41	52·64
		NaCl on dry basis percent	35·25	28·92	34·81
		T. V. B. mgm. percent	140·0	70·0	224·0
					Red attack.
2. Silver bellies (ii)	February	Moisture percent	36·59	36·83	37·40
		NaCl on dry basis percent	27·52	27·56	27·54
		T V. B. mgm percent	84·0	140·0	182·0
3. Silver bellies (iii)	June	Moisture percent	46·02	48·31	50·46
		NaCl on dry basis percent	36·39	32·78	36·19
		T. V. B. mgm. per cent	210·0	320 0	476·0
4. Oil Sardine	February	Moisture percent	30·50	31·52	32·52
		NaCl on dry basis percent	16·59	16·84	18·73
		T. V. B. mgm. percent	84·0	140·0	182·0
5. White Bait Beach dried	June	Moisture percent	15·18	14·8	14·14
		NaCl on dry basis percent	0·1712	...	0·170
		T. V. B. mgm. percent	112·0	140·0	140·0
					Crumbled to pieces.
6. White bait Salted	June	Moisture percent	44·02	45·38	45·46
		NaCl on dry basis percent	33·77	31·72	32·76
		T. V. B. mgm. percent	154·0	476·0	560·0
7. Mackerel	June	Moisture percent	47·56	47·50	47·80
		NaCl on dry basis percent	32·32	36·81	30·21
		T. V. B. mgm. percent	112·0	312·0	564·0
				Red attack	
8. Sole fish	June	Moisture percent	16·39	22·61	25·83
		NaCl on dry basis percent	21·80	23·54	24·11
		T. V. B. mgm. percent	266·0	470·0	476·0
					Insect eaten.
9. Shark	June	Moisture percent	49·86	51·10	48·45
		NaCl on dry basis percent	35·77	33·66	33·40
		T. V. B. mgm. percent	305·0	476·0	308·0
10. Miscellaneous fish	June	Moisture percent	44·58	50·30	46·61
		NaCl on dry basis percent	31·59	25·87	53·13
		T. V. B. mgm. percent	182·0	216·0	336·0

TABLE II—*Storage Studies on Salted Fish Samples Collected from Naddakav Market.*

Particulars	Month		Initial	After one month	After two months	After three months
1. Mackerel	September	Moisture percent	42·22	46·07	46·81	47·75
		NaCl on dry basis percent	29·02	33·09	29·69	29·86
		T. V. B. mgm. percent	42 0	112·0	350·0	420·0
					Red attack	
2. Miscellaneous	September	Moisture percent	44·92	46·19	46·59	49·17
		NaCl on dry basis percent	24·05	25·30	25·1	25·06
		T. V. B. mgm. percent	84·0	195·0	350·0	420·0
					Mangled	
3. Chooda (Clupea lile)	September	Moisture percent	47·99	44·68	45·98	48·44
		NaCl on dry basis percent	31·32	30·60	31·62	31·86
		T. V. B. mgm. percent	84·0	195·0	420·0	756·0
					Mangled	
4. Sole	September	Moisture percent	38·54	37·30	36·89	44·92
		NaCl on dry basis percent	28·41	25·16	26·15	29·28
		T. V. B. mgm. percent	35·0	56·0	420·0	672·0
					Mould attack	
5. Silver bellies	September	Moisture percent	49·94	39·85	40·67	46·67
		NaCl on dry basis percent	35·45	28·67	29·95	34·85
		T. V. B. mgm. percent	56·0	98·0	210·0	280·0

XXVII. BIOLOGICAL STABILITY OF " COLOMBO CURED " FISH BY R. VENKATARAMAN AND A. SREENIVASAN

Large shoals of mackerels are caught in the West Coast off South Kanara, not all of which is either consumed fresh or dry salted in the usual fashion. They are preserved by what is popularly known as " Colombo curing " or " Jade curing ", which is a special method of pickling not different from " marinading ". The extent of these operations will be evident from the fact that in four months October 1955 to January 1956 alone, 13,125 maunds of mackerel were pickled in the Government Curing Yard alone. There are many private yards besides this. Since this trade is more or less a very important one, it was thought desirable to study the methods of commercial curing and to investigate the biological stability of the product. Nicholsons (1909) account of colombo curing is not exhaustive.

Curing Practice

Mackerel are the fish mainly used but seer and large non-fatty sardines are also pickled in this manner. The name " *Colombo* " curing is derived from the fact that this stuff is intended only for the Ceylonese market, though the curing is done in South Kanara. Absolutely fresh fish are used for this. The fish are gutted, gills removed and washed in sea water. They are then intimately rubbed with salt in large cement tanks, the ration of salt to fish being 1 : 3. Along with salt a variety of tamarind known as " Gorikapuli ", or. " Kodapuli " in Malayalam (*Garcinia camboges*, family *Guttiferae*) is also mixed. The dried fleshy pod of this is almost like tamarind and is acid to taste. The curers do not exactly know the significance of the addition of this except that it is required for the Ceylon market. 1½ cwt. is used for curing one lakh mackerels, i.e., approximately ten tons. Of course some curers use less of this since it costs about annas eight per pound. It is imported from Ceylon, the Cochin product being of poor quality. Due to the action of salt, part of the water in fish is abstracted and " self brine " is formed, that the fish float on it (this is " blood pickle " in foreign parlance) and are weighted down by mats and stones. The fish remain in brine for two to four months or more till they are required to be exported. When needed, they are packed in wooden barrels, pressed down by stamping by human feet, more mackerels from the same cure are added, and finally filled up by self brine, and the bunghole closed. In this condition the fish is reported to keep well for one year or more. Each barrel may contain 5,000 large mackerels or 7 to 8,000 small ones and the entire cask will weigh ½ a ton. The barrel is generally made out of mango wood. The price of mackerels thus packed will be about Rs. 350 to 400 per ton or less while seer fetch a higher price namely Rs. 750 to 1,000 per ton.

Bacteriological Studies

" Total " counts were made on nutrient sea water agar. For halophillic types 12.5% NaCl agar was used. Chapmanstone Staphylococcus agar was used to detect coagulase positive stephylococci. Thioglycollate agar deeps, and cooked meat medium were used to enumerate anaerobes. The pH of the brines was also tested. The results are presented in Table I.

Discussion

The Colombo cured product is reputed to keep well for one year or more. We could detect no spoilage in the mackerels examined. In fact a sort of peculiar fruity odour which was pleasant was noted. The flesh was flaky and firm. The bacteriological examination shows the very small numbers of normal mesophilic bacteria. Staphylococci were completely absent. However a number of colonies developed on thioglycollate agar ' deeps ' and produced gas. In ' spray ' dish with thioglycollate agar also a good number of these developed. They produced gas in cooked meat medium but did not digest or darken it and no adverse odour was produced. Two types of organisms were found in this - thin motile rods and chains of coccoid rods. It is believed that these anaerobes play an important role in the ' maturing ' of mackerels in pickle imparting the sweet odour.

The normal flora consisted mainly of *Bacillus*. Very few cocci were noted in contrast to the usual findings of foreign workers but this is well in accord with our earlier work (Venkataraman and Sreenivasan 1954).

It was seen that the addition of " Gorikapuli " brought down the pH to 5·4. Quite naturally under the mild acidic conditions coupled with the high salt concentrations the spoilage flora is suppressed. Chromatographic investigations (unpublished) have shown that citric and tartaric acids were present in the " Gorikapuli ". It is also possible that the polyphenol(s) present also had some effect on the flora.

Though the product is good there is room for improvement. For instance salt used must be of purer variety. The scum floating on the brine should be removed. In some cases it was seen that guts and gills were not properly removed. These may lead to biological instability. Insects and their maggots were also frequently encountered. Since these indicate adverse sanitation, steps to prevent access to these must be taken.

A surprising feature of these studies was that the mackerels in brine taken out after 4–5 months, dried and stored, developed ' red ' halophilic attack in 15 days. It is very interesting that the red halophile has survived an acid medium (pH 5.4) and anaerobic conditions

in the brine. The organism isolated in pure culture appeared to be different from the ones already known. In the brining tanks themselves, a surface film and encrustation of salt is formed which floats on the brine and turns red.

From the nutritional point of view the 'Colombo' cured product does not allow of any wastage. The brine in which a considerable amount of albuminoid material would be present (removed from fish) is not wasted as in kench curing but is also added to the barrel of fish. This is mixed with rice as sauce and is much relished. With better observation of sanitary conditions this method of curing will be very efficient and will preserve fish much longer than in the normal method of dry salting which is biologically unstable.

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TABLE I.—*Bacterial Counts in Pickled Fish and Brine*

Media	Mackerel			Brine		
	A	B	C	A	B	C
Sea water agar	5,200	9,300	10,800	540	6,000	160,800
12.5% salt agar	5,500	1,120	2,840	930	1,130	3,300
Staphylococcus	Nil	Nil	Nil	..	Nil	Nil
Anaerobes	3,200 (gas)	..	1,800	3 (gas)	300 (gas)	12,800
pH	..	..	..	6.0	5.4	..

XXVIII. STUDIES ON THE MANUFACTURE OF SEMIDRIED PRAWNS, WITH REFERENCE TO THE LEVELS OF MOISTURE AND SODIUM CHLORIDE IN THE FINISHED PRODUCT AND THE PERCENTAGE YIELD

BY R. VENKATARAMAN AND A.G. VASAVAN

Introduction

The manufacture of semidried prawns patented at this research Station has established itself as an efficient method of processing and preserving prawns. The method of manufacture was described in earlier papers published from this Station 1, 2 & 3. The prawns are first blanched in 6% brine for 2 - 3 minutes. After peeling the pulp is immersed in cold saturated brine (25°Be) for 15 - 20 minutes, depending upon the size of the prawns. They are then removed, spread on perforated thattis and excess brine drained, and dried in direct sun for 6 hours when the moisture content is reduced to 40 - 45%. The final product is lozenge pink in colour and has a rubber like consistency. The product contains 40 - 45% moisture and 12 - 15% sodium chloride (wet basis).

The percentage yield varies with the size and species of raw prawns used for the manufacture. The prawns generally used in the West Coast for the process are Penaeopsis dobsoni (Malayam - Vala chemmin), Parapenaeopsis stylifera (Malayalam Karikadi) and Penaeus indicus (Malayalam - Vella chemmin). Peneopsis dobsoni, the black prawns caught abundantly in West Coast during the monsoon give the best yield and the product is pink in colour. Parapeneopsis stylifera give only a poor yield though the product has a very attractive pink colour. Penaeus indicus give a fairly good yield but the colour of the product is pale and dull. In the commercial processing of prawns an accurate knowledge of the anticipated yield is essential to have an effective control over the quality. Attempt is also made to arrive at the optimum moisture content of the finished product based on the keeping quality and percentage yield.

Material and Methods

In the first four experiments Peneopsis dobsoni was used. They were sorted out on the basis of their length into four lots 1. less than 100 mm. 2. 100 - 105 mm. 3. 105 - 110 mm. 4. 110 mm. and above. Each lot was processed separately. The weights of raw prawns in each lot and the respective weights in the different stages of manufacture were determined accurately using an accurate balance. The representative samples of raw prawns and the prawns immediately after blanching were taken out, shelled and analysed for moisture and sodium chloride. Similarly the samples of the pulp obtained after shelling were take and the moisture content was determined. Finally the repressentative samples of dried pulp were analysed for moisture and NaCl. The experiment was repeated using the other two species of prawns. In ail the experiments the A.O.A.C. methods of analysis was followed for the determination of moisture and NaCl.

A sample of semidried prawns made from penaeopsis dobsoni was dried to four different moisture levels (1) 37.5% (2) 40% (3) 42.5% (4) 45% and kept for observations in airtight bottles. Observations on the quality were made by organoleptic tests noting the appearance, odour, texture and the attack of moulds.

Results and Discussions

The values of moisture and NaCl in the different stages of processing are given in Table 1. The percentage yield in each lot is calculated based on the final moisture content. Since the yield is likely to vary according to the final moisture, which is not constant, it is necessary to know the variations in the yield according to the moisture content. The estimated yields at moisture levels of 37.5%, 40%, 42.5%, 45%, 47.5% and 50% were calculated using the formula $X = \frac{Y Z}{100 Z}$ 100 where X is the weight lost per 100 weight units, while drying from an initial moisture content of Y% to a final moisture content of Z% This is given in Table II. A look at the table will indicate the percentage yield that could be expected while processing the semidried prawns. Though in practice the actual yield may be slightly less due to the wastage and loss the difference should not be above 1%.

For all the species, the initial moisture content was 77 - 79% and in final dried product pulp was 72 - 73%, in brined pulp 64 - 66% the finished product 40 - 45%. The sodium chloride content in appreciable change in weight was 20 - 25%. During blanching there was no 30 - 40% of the weight of raw prawns. The yield of wet pulp varied from pulp very slightly. The weight of dried pulp was 55 - 65% of the wet weight of the pulp, according to the moisture content.

The keeping quality of semidried prawns dried to different moisture levels are given in Table III. The Table indicates that the proper of 3 months. A higher moisture gives a yield of 20% and shelf life short time due to rapid attack of moulds. The drying of semidried prawns to any lower moisture content results in spoilage in a very too hard and this will affect the taste of the cooked product adversely.

Conclusions

The percentage yield varies according to size, species and final moisture. The prawns penaeopsis dobsoni give the maximum yield of about 20% if the moisture content of the final product is 42.5%. In the case of Parapenaeopsis stylifera the yield is minimum, i.e., only 17% for the moisture content of 42.5%. The moisture content of keeping quality and the texture of the product is the optimum considering the about 42.5% in the content of 42.5%. In remain good for 3 months.

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TABLE I— *Data Showing the Progress of* Processing.

No.	Species of Prawns	Size	Colour	Raw wt.	Blanched Weight	Raw Pulp	Moisture	Yield of Raw Pulp	Moisture of Raw Pulp	Raw wt. of Shell	Wt. of Brine Pulp	Moisture in Brined Pulp	Dried Weight	Moisture in Dried Pulp	N.A.C.L. on M.F.B.	Colour of the Product	Percentage Yield
		ms.		Lb.	Lbs. oz.	Lbs oz.	Percent	Percent	Percent	Lbs. oz.	Lbs. oz.	Percent	Lbs. oz.	Percent	Percent		Percent
1	Penaeopsio Delesoin	< 100	Black	10	5 15	4	0 728·23	40· 0	72· 4	5 15	3 15½	65·69	2 8½	49·07	29·29	Pink	25·33
2	-do-	100 - 105	-do-	12	11 14	5	0 78·16	41·67	72·39	6 14	4 15	65·70	3 3¼	46·93	20·11	-do-	26·69
3	-do-	105 - 110	-do-	15	14 14	5	4 78·20	35·01	72·50	9 10	7	64·72	3 4¾	45·75	20·86	-do-	21·98
4	-do-	> 110	-do-	3¼	3 4	1	1 78·30	32·69	72·78	2 3	1 1	62·85	0 10½	45·36	23·26	-do-	20·98
5	Parapenaeopsis Stylipera	85 - 110	Red	387	348	0 115	0 77·11	29·70	72·11	195	0 114	0 65·30	60 0	37·48	20·82	Reddish Pink	15·54
6	Penaeus Indicus	65 - 100	White	346	320	0 128	0 77· 5	36·99	72·35	175	0 125	0 65·32	71 0	40·61	26·53	Whitish Pink	20·52

TABLE II—*Estimated percentage yield of semidried prawn at various moisture levels.*

Number	Species	Size mms.	Percentage yield of semidried prawns at different moisture contents.					
			37·5 percent	40 percent	42·5 percent	45 percent	47·5 percent	50 percent
1	Penaeopsis dobsoni (Mal. vala chemmin)	100	20·64	21·50	22·44	23·45	24·57	28·80
2	Do	100-105	22·67	23·62	24·74	25·95	27·36	28·83
3	Do	100-110	19·05	19·85	20·71	21·65	22·68	24·81
4	Do	110	18·35	19·11	19·94	20·84	21·84	22·93
5	Parapeneopsis stylifera (Mal. Karikadi)	85-110	15·54	16·19	16·89	17·66	18·50	19·43
6	Penaesus indicus (Mal. Vella chemmin)	65-100	19·50	20·31	21·20	22·16	23·21	24·37