GOVERNMENT OF INDIA

CENTRAL INLAND FISHERIES RESEARCH STATION
BARRACKPORE

ANNUAL REPORT OF THE CENTRAL INLAND FISHERIES RESEARCH STATION, BARRACKPORE, FOR THE YEAR 1959-60

BANGALORE CITY
PRINTED AT THE BANGALORE PRESS, MYSORE ROAD
1961

Reprinted from "Indian Journal of Fisheries", Vol. VII, No. 2, 1960

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General

The headquarters of the Central Inland Fisheries Research Station was shifted from Calcutta to its newly constructed permanent buildings at Barrackpore with effect from 1st June 1959. The buildings were formally declared open by Dr. B. C. Roy, Chief Minister of West Bengal, on 17th June 1959. Shri M. V. Krishnappa, Union Deputy Minister for Agriculture, presided on the occasion. The Research Station has been built on an area of about 13 acres of land and the main laboratory building has a floor area of 15,000 sq.ft., excluding corridors and verandahs. The trainees' hostel has a usable floor area of 7,000 sq.ft., and has 25 rooms, a common room, drawing room, etc. 51 residential quarters have been built so far, and a few more are under construction. The new buildings have been constructed at a total cost of about Rs. 13 lakhs.

Substantial progress was achieved during the year in all investigations undertaken by the Research Station. In addition, there was also an all-round expansion of activities of the various sections and units, under both normal and Second Five-Year Plan programmes.

The undermentioned Assistant Research Officers were appointed during the year:

Shri K. L. Sehgal
Dr. (Miss) Eva Mitra
Shri L. N. Mandal
Dr. K. C. Jayaramakrishnan
Shri K. K. Ghosh
Shri S. N. Sengupta
Shri A. N. Ghosh
Shri M. A. Vijayalakshmanan

Shri Hiralal Chaudhuri, Assistant Research Officer (Estuarine Fishery Biology), was relieved of his duties to take up the post of Fisheries Extension

Officer under the Ministry of Food and Agriculture. Shri A. Datta took over as Fisheries Training Superintendent with effect from 14th March 1960.

Shri J. M. David, Administrative Officer, was relieved of his duties to enable him to join the Oil and Natural Gas Commission.

Training

The 12th Session of the Inland Fisheries Training Course conducted during the year under report was attended by 36 candidates, consisting of 2 Colombo Plan Trainees—one each from Thailand and Philippines; 19 Government deputees from the States of Uttar Pradesh, Assam, West Bengal, North East Frontier Agency, Rajasthan, Madhya Pradesh, Orissa, Andhra, Delhi and Bombay; 5 Government stipendiaries from the States of Assam and Manipur and 10 private candidates from the States of Bombay, Uttar Pradesh, West Bengal, Andhra Pradesh, Madhya Pradesh, Punjab and Mysore. In the final examination conducted in January 1960, 2 candidates were placed in the First Class, 18 in the Second Class and 14 in the Third Class.

A short training-*cum*-demonstration course in induced spawning of Major Carps by hormone injection was conducted at the Cuttack Substation from 6th to 16th July 1959.

Deputation

Shri K. H. Alikunhi, deputed for training in Japan under the Colombo Plan, left Calcutta on 28th May 1959 and after a period of successful training, returned to India and resumed duty at Cuttack on 8th September 1959.

Meetings

The Chief Research Officer attended the State Fisheries Directors' Meeting convened by the Ministry of Food and Agriculture on the 16th and 17th April at New Delhi, the inaugural meeting of the Central Board of Fisheries and the meeting of the Standing Fisheries Research Committee at New Delhi in December 1959, and the West Bengal State Advisory Board Meeting at Digha from 10th to 13th January 1960.

Shri K. H. Alikunhi and Shri Hiralal Chaudhuri attended the Sixth Meeting of the Standing Fisheries Research Committee held at Trivandrum from 2nd to 6th April 1959.

F.A.O. Fellows

Mrs. Agnes Cooper Dennis, Lecturer in Biology, University of Liberia and UNESCO Scholar, visited this Research Station during 14th February

1960 to 17th February 1960 and arrangements were made for her training in freshwater biology.

Mr. M. E. Faltas, F.A.O. Fellow from Egypt, whose visit to this Research Station was arranged by the Institute of Agricultural Research Statistics, New Delhi, was afforded necessary facilities and was shown the fishing activities around Calcutta with a view to provide a first-hand knowledge of the fisheries management and methods of collection of official statistics.

F.A.O. Expert

Mr. S. B. Gulbadamov, F.A.O. Gear Technologist, along with the Russian Interpretor Mr. G. A. Semin, was assigned to this Research Station. A programme of work has been arranged for the Expert, and he is now conducting preliminary experiments in deep-water fishing in the Mettur Reservoir. Dr. Y. R. Tripathi, Research Officer (Lacustrine), has been posted as understudy to Mr. Gulbadamov.

Reports

The final report of the Committee on standardisation of names of fishes and fishing subjects was submitted to Government.

Visitors

Shri Krishan Chand, I.C.S., Joint Secretary, Dr. N. K. Panikkar, Fisheries Development Adviser, Shri K. Chidambaram, Assistant Fisheries Development Adviser, Shri V. V. Kalyani, Director of Fisheries, Mysore, Dr. Monmohan Das, Deputy Minister, Ministry of Scientific Research and Cultural Affairs, Shri S. Miskeith, Superintending Engineer of Deep-Sea Fishing Station, Dr. B. N. Chopra, former Fisheries Development Adviser and Consultant, National Council of Applied Economic Research, Dr. L. R. Donaldson, Professor of Fisheries, University of Washington, and Dr. J. K. Thompson, Director, Colombo Plan Bureau, visited this Research Station during the year.

Miscellaneous

350 Silver Carp (*Hypophthalmychthys molitrix*) fingerlings received as gift from Japan are being used for experimental studies. 400 Grass Carp (*Ctenopharyngodon idellus*) fry were also imported from Hong Kong for similar investigations. The Research Station took active part in the World Agriculture Fair held at New Delhi. Facilities were rendered to the representatives of Cine Co-operative Ltd., for preparing a documentary film on Pond Culture.

Pond Culture Division

Induced Breeding of Indian Carps

During the 1959 fish breeding season (May to August), work on induced breeding by injection of hormones was taken up at Cuttack and Joysagar. Breeding was successfully induced in all the four major carps Catla, Rohu, Mrigal and Calbasu and commercial production of large number of spawn and fry was achieved for the first time by this method.

The common carp (*Cyprinus carpio*) was found to be a very satisfactory species for year-round collection of pituitary glands, because sexually mature specimens of the species were available throughout the year in the farm ponds. Collection of pituitary glands, was therefore made a routine before mature specimens were sold from the farm. Over 200 glands were collected by this method and the bulk of these was utilised for experiments at Joysagar, Assam. With the kind courtesy of the Fisheries Development Officer, Madhya Pradesh, 510 pituitary glands, mostly from small but mature Mrigals, were collected during May–June 1959 at Gwalior. 264 glands (Rohu 140, Mrigal 117 and Catla 7) were collected at Calcutta and majority of these were utilised in Assam.

The absolute alcohol method was followed for preserving the glands. Part of the material collected was preserved in a refrigerator at low temperature, while the rest was kept at room temperature in order to ascertain whether the hormone potency of the glands will remain unaffected under such conditions.

Fish breeding in Assam commenced from the last week of May. Catla, Rohu and Calbasu were successfully induced to breed. Two female specimens (29 lb. and 12 lb.) bred, each as a result of single injection. The percentage of fertilization of eggs ranged from 32 to 89. A total of 8,70,000 spawn was raised. Besides supplying 2 lakhs of spawn to the Nowgong Centre, 294,000 advanced fry were reared out of the above spawn indicating a survival of 44%. That Catla also can be successfully induced to breed like the other Indian carps is now fully demonstrated. Total production of spawn and advanced fry at the Joysagar Centre during the year was 9,18,000 and 3,02,500 respectively, representing an overall survival of 42%. At Cuttack, routine procedure of keeping selected breeders in smaller ponds, preparation of nurseries for successful rearing of fry, etc., were carried out during May to June. Of the major Indian carps, Mrigal was found to attain maturity earlier in the season than Catla or Rohu and the fish successfully spawned during the second week of June. All the major carps, *viz.*,

Catla, Rohu, Mrigal and Calbasu and the minor carps Bata and Reba spawned during the season as a result of pituitary injections.

Breeding experiments were carried out in tap-water kept in cement cisterns, in stagnant pond-water and also in flowing river-water. Though positive results were obtained under all these conditions, the results in tap-water were comparatively poor. The best results were obtained in flowing river-water. It is proposed to make arrangements for supply of flowing river-water in cisterns in the Killa for further experiments. The breeding experiments were most successful with Rohu, where spawning was induced in 51% of the breeders injected.

The details of spawn and fry produced during the period under report are given below:

Rohu.—21,15,000 hatchlings, which yielded just over 10,00,000 advanced fry and fingerlings valued at approximately Rs. 10,000. Over 90% of these fingerlings were supplied to the Orissa Fisheries Department for stocking purposes. Average survival works out to over 47%.

Mrigal.—Nearly 6,00,000 hatchlings, which yielded about 2,00,000 advanced fry and fingerlings valued at approximately Rs. 2,000. About 60% of these were supplied to the Orissa State Fisheries Department for stocking. The survival works out to 33%.

Catla.—Though 3 specimens of Catla spawned, the percentage of fertilization was very low and only less than 1,000 advanced fry and fingerlings could be obtained.

Non-specificity of the glands to induce spawning was clearly demonstrated this year also. Pituitary glands of *Cyprinus carpio* induced successful spawning in Rohu and Mrigal, those of Rohu induced spawning in Catla, Rohu and Mrigal and the glands of Mrigal induced spawning in Mrigal and Rohu. Pituitary glands stored at room temperature for a period of $2\frac{1}{2}$ to 3 months induce successful spawning at similar doses, as glands stored under low temperature do. Results obtained from experiments carried out with the minor carp *Cirrhina reba*, using pituitary glands from fishes of various stages of maturity, have shown that comparable doses of glands from fishes of earlier stages of maturity do not induce spawning as the glands from mature fishes.

While weather does not appear to be a very important factor in inducing spawning of fish, hot sultry conditions are not conducive to the satisfactory handling of the fertilized eggs and their proper hatching. It appears from observations on fishes injected and kept in cisterns that when female

starts laying eggs and the male is not active enough to fertilise them, stripping could be resorted to for successful fertilization.

Observations have also indicated that fry produced from induced breeding mature normally. Experiments for inducing maturity earlier than the normal season are in progress.

Breeding and Propagation of the Common Carp Cyprinus carpio

On the basis of detailed information furnished by this Research Station on the biology and growth of this species, the Fisheries Research Committee of the Government of India recommended in April 1959 that the fish be introduced throughout the country and also desired the States' Departments of Fisheries to take up breeding and cultivation of the species. The following supplies were made during the year under report to different agencies:

Statistical Institute, Calcutta		25000 (Spawn)
Department of Fisheries, West Bengal (through the Director of Fisheries, Orissa)	..	500 ($2\frac{1}{2}$ to 3 ″)
Fisheries Officer, Tripura	..	25,000 (1 to $1\frac{1}{2}$″)
Assistant Director of Fisheries, Nellore, Andhra Pradesh	..	4,300 (1 to $1\frac{1}{4}$″)
Fisheries Officer, Raipur, Madhya Pradesh	..	7,000 (1 to $1\frac{1}{2}$″)
Shri A. Bari, Barang, through Director of Fisheries, Orissa	..	5,000 (1 to $1\frac{1}{2}$″)
Assistant Fisheries Extension Officer, Mandapam Camp	..	800 ($1\frac{1}{2}$ to 2 ″)
St. Joseph's Convent, Vishakhapatnam	..	200 (1 to $1\frac{1}{2}$″)
Orissa Fisheries Department	..	46,100 ($\frac{3}{4}$ to $1\frac{1}{4}$″)

Besides supplying a few breeders of common carp to the Barang Fish Farm, Orissa, the breeding technique was successfully demonstrated at the Barang and Sambalpur fish farms. Intensive breeding of the species was taken up at Cuttack and during January to March 1960, a little over 10 million fry (about 200 batis), 2 to 3 days old after hatching, valued at about Rs. 4,020, were supplied to the State Department.

Breeding of the common carp was carried out in the cement cisterns containing tap and well-water. Soon after spawning, weeds with attached eggs were transferred to ponds, where they were distributed in hapas. To ensure high percentage of fertilization of the eggs, 3 to 4 males were often

introduced along with a single female. Percentage of hatching depended on the hatching space provided. Breeding generally took place within 12 to 36 hours after the introduction of the fishes in the cisterns. Breeding was successfully carried out in hapas fixed in ponds. With proper thinning of weeds, the rate of hatching was found to be better than in cisterns. Natural spawning of fish in stocking ponds is generally rare. However, if the fish are kept in hapas and necessary weeds are introduced, they readily spawn.

Natural spawning was observed in the Killa channel, two of the rearing ponds and in a prepared nursery pond. Weeds with attached eggs were collected from the channel and rearing ponds and by hatching of the eggs in cisterns and ponds nearly a lakh of fry could be obtained. However, though the bulk of the eggs laid in the channel and rearing ponds hatched, hardly any fry could be seen presumably due to their having been preyed upon by predators. In the prepared nursery pond some of the fry survived, yielding a little over 1,000 early fingerlings. These observations are in conformity with findings already reported and indicate that for proper propagation of common carp, provision of breeding facilities is essential.

In the Bangkok strain (Eastern Strain) of common carp, colour varieties are common. Preliminary work on selective breeding of some of the colour variations of common carp has been taken up recently.

Certain preliminary observations on the size of eggs and hatchlings in relation to the size of the breeding female and the relative growth and survival of fry from fishes of different sizes have been made.

In a field experiment lasting for 4½ months, Mrigal and common carp of comparable size were stocked in equal numbers and it was found that the average survival of common carp was 83·4%, while that of Rohu and Mrigal was only 67% and 54·5% respectively. The production of common carp was more than the combined production of Rohu and Mrigal. Further experiments in this line have been taken up.

Observations on the mirror carp (Cyprinus carpio *var.* specularis)

The mirror carp was introduced into India in 1939 and since then it has been thriving in the relatively cold upland waters. Though the fish has been brought down to the plains and found to grow rapidly in the tropical habitat, it was not breeding in the lower elevations. To ascertain whether the fish could be induced to breed at sea-level by adopting the breeding techniques followed in South-East Asia for the scale carp, consignments of mirror carp fingerlings were brought from Shillong to Cuttack

and Joysagar. When these fishes became mature, they were induced to breed in cisterns and hapas by adopting the same technique as used for the scale carps. During the period under report the fish bred twice at Cuttack, producing 1,40,000 fry at Cuttack and twice at Joysagar, yielding 38,000 fry. Seven months' old males of the species were observed to have become generally mature at the Cuttack farm. 1,000 fingerlings were supplied to the Orissa Fisheries Department for stocking in Koraput at an elevation of about 4,000 ft. The successful breeding of mirror carp at Cuttack and Joysagar clearly demonstrates that when proper breeding facilities are provided, the fish breeds in the plains also.

Observations on Chinese Carps

Consignments of 400 fingerlings each of the grass carp (*Ctenopharyngodon idellus*) and the silver carp (*Hypophthalmychthys molitrix*) were brought from Hong Kong and Tokyo respectively and are being studied at Cuttack. The survival of Silver carp during September 1959 to March 1960 has been 64% and that of Grass carp during a 3·5 months' period 30%. The growth of the former has been very satisfactory, the maximum size attained so far being 47·2 cm. (weight 1·4 kg.). 114 specimens, weighing 0·4 kg. each, have been stocked in the Killa channel for rapid growth. The maximum size attained by Silver carps has been only 19·4 cm. (average weight being 37 gm.).

The Chinese carps do not breed in ponds. As importing fry every year is not practicable, the fish are being provided with optimal conditions for rapid growth and early attainment of maturity, so that it could be ascertained whether they could be induced to breed in ponds. Stocked at the rate of 1,000 per acre, the Silver carps showed higher rate of survival than Catla. The weight increased by 234%, whereas the corresponding increase in weight of Catla was only 139%. Investigations are being continued in this direction.

Tilapia Investigations

A field experiment in 20 ponds at Puri, designed to ascertain the role of Tilapia when stocked with various combinations of carps, was completed during the period under report. The final results are in agreement with the earlier findings that presence of Tilapia markedly affects the growth and survival of Mrigal. Because of intensive breeding Tilapia multiplies rapidly in ponds which soon get overpopulated, resulting in an abundance of very small fish in ponds. Such fish have no market value. To find out whether by frequent harvesting of the large fish, the smaller ones could be made to

grow and yield marketable fish, observations were continued in a one-acre stocking pond in Killa. It was found that the size and yield considerably improved with weekly harvesting of large fish. The market value of Tilapia is however only about half that of carps.

Some observations on mono-sex culture of male Tilapia were also made. Though fish exceeding 30 cm. in length and weighing upto 0·68 kg. could be produced, the quantity of fish produced appeared to be low. The rate of stocking was 3,000/ha. The larger fish have a better market value than the smaller ones and attempts are being made to find out whether mono-sex culture of Tilapia could be taken up as a supplementary crop in carp ponds.

Fresh experiments on the possible use of Tilapia as a forage fish for murrel were also taken up. Test samplings indicate that while in the control ponds different size-groups of Tilapia occur and that they multiply rapidly, there is a definite check on the production of the young in ponds where murrels have also been introduced.

Fish Culture in Paddy Fields

Only one experiment could be taken up during the year at the Central Rice Research Institute plots. Fingerlings of Common carp and Rohu were stocked in 6 plots at the rate of 2,500 per hectare, but heavy rains and consequent overflooding of the plots soon after stocking, as also draught conditions towards the end of the year have necessitated fresh observations to be made.

A survey of the soil, water and fish-food conditions in selected deep water paddy fields in the districts of Cuttack, Puri, Ganjam, Sambalpur, Sundergarh and Bhawanipatna was taken up. The fields at Puri and Bhubaneswar appear to be poorer than those at Sambalpur, Kujang and Berhampur. Plankton in fields at all the places is poor. These data seem to corroborate earlier findings that the paddy fields cannot be classified as a good environment for fish production.

Soil Composition and Fish Production

In order to study the soil conditions and water qualities of fish ponds in various parts of India, a random survey has been initiated. Samples from demonstration fish ponds in Howrah and 24 Parganas showed the soil reaction to be slightly acidic or slightly alkaline, pH ranging from 6·6 to 7·8; available nitrogen quite fair (21·0 to 52·0 mg./100 gm.) and available phosphorus to be varying from a low (2·0 mg./100 gm.) to a fairly high concentration (14·0 mg./100 gm.). Data on fish production

furnished by fish farmers indicate that generally available phosphorus has a direct relation with yield of fish.

The relation between available nutrient status of piscicultural soils and production of fish was also studied by conducting a series of experiments in selected tanks with different soil conditions. Results of analyses showed that soil reaction continued to be slightly acidic or slightly alkaline, nitrogen content was quite fair, while available phosphorus varied from 'very poor' to 'fairly high'. The data obtained confirmed last year's observations that in slightly acidic or slightly alkaline soils with a fair concentration of available nitrogen, available soil phosphorus is likely to play an important role in determining the production of the tanks.

Investigations have been taken up in Choudwar fish farm in six selected tanks to study the effect of trace elements when applied with inorganic fertilizers. The tanks have been divided into three sets of two each. Keeping one set as control, one set has been treated with superphosphate alone and the other set with superphosphate and salts of trace elements Manganese, Copper and Iron. Chemical quality of them, inclusive of the concentrations of the trace elements added, were determined regularly and organic productivity was assessed by gravimetric estimation of total plankton. The fluctuation in concentration of trace elements in aquatic phase was rather irregular. However it was observed that for Manganese the decrease in concentration was rather slow in treated ponds. It was also noticed that just after treatment there was an abrupt increase of plankton and that plankton concentration was generally maximum in ponds treated with trace elements.

With a view to determine whether low-nutrient acid soils could be corrected by application of organic and inorganic fertilisers with lime, an experiment has been taken up in 24 ponds at Lingipur. The ponds have been divided into eight sets of three each and keeping one set as control, they have been treated with different combinations of lime and fertiliser. The tanks were stocked with carp fingerlings at a uniform rate and the response of different types of treatment was assessed by the production of fish. Chemical examination of water and soil showed that liming did not improve the alkalinity of water permanently. There was no marked increase in soil pH by lime treatment. This showed that the reserve soil acidity was rather high in these ponds. It was observed that excepting treatment with low lime, all others showed an increase in production, maximum being with low lime + high phosphate and high lime + high phosphate.

Weed Control Investigations

Field applications of urea indicated that *Hydrilla* and unwanted fish in the water were completely eliminated at concentrations of 250 and 330 p.p.m., and that roughly a third of the urea was converted into ammoniacal nitrogen by the third or fourth day after treatment, which lead to the conclusion that probably ammonia was the active principle involved in the eradication of the weed and weed fish. Hence experiments were carried out using liquor ammonia as well as a mixture of ammonium sulphate and quicklime. Complete kill of *Hydrilla* and *Naias* were obtained with 20 p.p.m. or more of ammonia (N). 10 p.p.m. also gave a fairly good kill. Field trials were carried out with anhydrous ammonia available in steel cylinders in the liquefied condition. A plot of about 0·24 hectares and 1·52 metres deep was effectively cleared of the weeds with 34 kgm. of ammonia gas, about 36 man-hours being required for a supplementary clearance of remnants of weeds. Larger fish in the treated plot were saved by sectional treatment of the choked area. Unlike poisonous chemicals such as sodium arsenite, urea and ammonia have the additional advantages of being combined fertilisers, fish poisons and weedicides, which renders them much cheaper to use. The action of ammonia on aquatic weeds appears to be one of direct toxicity, as indicated by the stoppage of photosynthetic activity.

Further experiments were carried out in the laboratory with various soil sterilising chemicals at high rates of application to see whether any of them could be effective. The extent of sterilisation obtained was determined by the capacity of the chemicals to suppress the germination of the winter buds of *Hydrilla*. None of the chemicals except sodium arsenite gave complete suppression.

It has been found that a mixture of equal quantities of sodium metabisulphite and sulphuric acid kills *Hydrilla* completely at a dosage of 75 p.p.m., the lethal action being due to the release of about 50 p.p.m. of sulphur dioxide. At a dosage of 50 p.p.m. of acid and 34 p.p.m. of salt serious damage to the plant was achieved. Fish are not killed at both these concentrations.

It is generally known that high doses of trace elements often prove toxic to plants. To see whether this is true of aquatic plants as well, some laboratory experiments were carried out with manganese and iron. Manganese was applied at the rate of 20 p.p.m. on healthy *Hydrilla* kept in glass jars containing water, but the plants were not affected. Iron was applied in the form of ferrous sulphate alone, as well as mixed with the activators

ammonium sulphate or sodium nitrate or with acids, the rates of application being 50–100 p.p.m. In both cases there was only partial effect on *Hydrilla* grown on a soil-water medium.

Laboratory, yard and field experiments with the hormone weedicides "Fernoxone" and "Dicotox" showed that *Wolffia* and *Ottelia* are killed by fernoxone at 25 kgm. per hectare, *Nelumbium* requires a second treatment before it is completely killed, *Ipomœa* treated with 5–10 kgm. per hectare and *Pistia* with 15 to 25 kgm. per hectare of these weedicides showed only defoliation of the leaves, the unaffected stems giving rise to fresh leaves at the end of the four weeks. *Hydrilla* is not killed by fernoxone at 20, 30, 50, 75 and 100 kgm. per hectare even when the water level is lowered to expose the trips of shoots.

Field plots of *Pistia* treated with diesel oil and power kerosene at 600 litres per hectare killed about 80% of the leaves initially, but the plant regenerated vigorously from unaffected stems and plants at the end of 3 to 4 weeks. Monochlorobenzene emulsified in soap killed *Hydrilla* completely at 350 p.p.m. At lower concentrations the kill was not complete. 100 p.p.m. of 'atlacide' with 25 p.p.m. of sulphuric acid gave encouraging results on *Hydrilla.*

Autecological studies on *Ottelia* were made throughout the year in four ponds at Cuttack. Data obtained indicate that *Ottelia* grows best under the following conditions:

Average yield of tomatoes per plant

	Depth of water (metres)	Temperature °C.	Turbidity p.p.m.	pH	T. alk. p.p.m.	Cl. p.p.m.	NO_3 p.p.m.	PO_4 p.p.m.
Range ..	0·45–1·82	25·3–34·7	20–110	6·8–8·9	54–180	9–171	9·05–0·70	0·01–2·80

A single *Ottelia* plant produces on the average about 20,000 seeds. Studies carried out in the laboratory and yard indicate that there is 50% germination under crowded and anaerobic conditions, 5% germination under aerobic conditions and 60 to 100% in containers with soil from 0·75% to 1 metre deep in cement cisterns.

Laboratory studies on the period of viability of *Hydrilla* turions indicated that they remain viable in pond-water and wet pond mud at the end of six months, whereas they die in dry pond mud, dry sand and dry cotton wool.

Observations were continued on five sections of the Killa moat and a deep tank to study the effect of algal blooms in the suppression of submerged weeds.

An experiment was carried out to assess the comparative value of composts from various weeds and the results obtained are given below:

	gm.
Water hyacinth	6015
Hydrilla ..	2353
Hydrilla + *Pistia* ..	2265
Pistia ..	1931
Control ..	2290

In order to obtain information on the nature of weeds and the extent and causes of weed infestation in cultivable waters of Orissa, a sample survey of the inland waters was carried out during the year. Preliminary findings from the survey are as follows:

Type of water	Number surveyed	Total area covered (hectares)	Area infested with weeds (hectares)	% infestation in area
Farm ponds ..	53	39·25	15·75	40·0
Public tanks ..	56	34·41	20·53	60·0
Reservoirs and lakes	6	350·40	259·32	74·0
Swamps and derelict tanks ..	10	127·00	119·56	94·5
Total ..	125	551·06	413·15	75·0

Riverine and Lacustrine Division

Catch Statistics and Disposition of Fisheries in the Ganga River System

Data on monthly production and average catch per day obtained from the Ganga and Jumna are summarised and tabulated on the next page.

	Ganga		Jumna	
	Monthly (kgm.)	Daily (kgm.)	Monthly (kgm.)	Daily (kgm.)
1959—				
April ..	91035·55	3034·52	94977·63	3166·25
May ..	81104·38	2617·43	46284·06	1493·03
June ..	98232·30	3274·40	108967·27	3632·24
July ..	94453·88	3046·90	98427·33	3175·08
August ..	33193·79	1070·77	13946·95	449·90
September ..	54518·80	1817·29	21209·61	706·99
October ..	79611·13	2568·10	18118·81	584·48
November ..	69363·07	2312·10	25118·81	837·29
December ..	86897·57	2803·15	28424·75	916·93
1960—				
January ..	62249·60	2008·05	21275·61	686·31
February ..	77632·09	2676·97	47791·64	1647·99
March ..	71155·26	2295·33	20783·95	670·45

The composition of the catches is as under:

	Ganga (kgm.)	Jumna (kgm.)
Major carps		
(*Catla catla, Cirrhina mrigala, Labeo rohita* and *L. calbasu*) ..	224795·67	282834·06
Major cat-fishes		
(*Mystus aor, M. seenghala, Wallago attu, Silonia silondia, Pangasius pangasius, Rita rita* and *Bagarius bagarius*) ..	263116·45	18311·80
Minor cat-fishes		
(*Clupisoma garua, Eutropiichthys vacha, Ailla coila,* etc.)	55866·72	12552·84

	Ganga (kgm.)	Jumna (kgm.)
Hilsa	154750·33	14343·70
Murrel ..	1257·05	2373·42
Featherbacks (*Notopterus chitala* and *N. notopterus*) ..	18732·72	10790·08
F. W. Rays (*Dasyatis fluviatilis*) ..	9718·58	314·45
Prawns (*Palæmon, Leander* and *Caridina* spp.) ..	21907·74	362·48
Tortoise ..	9261·09	..
Miscellaneous ..	146154·40	19988·33

Catch Statistics of Narbada River at Hoshangabad

A 30-mile stretch of the Narbada river has been selected for intensive study. 40,000 kgm. of fish valued at about Rs. 50,000 were estimated to have been landed in this stretch during the year under report. Mahaseer (*Tor* spp.), *Labeo fimbriatus* and *Rita pavimentata* formed the major part of landings (26·7, 19·7 and 14·3%). Mahaseer dominated in the catches followed by *Labeo fimbriatus* and *Wallago attu*, *Rita pavimentata* and *M. seenghala*.

Cast nets and long lines were the most common gear operated and the catch-per-hour of these gears was 0·45 and 0·19 kgm. respectively.

Catch Statistics of Godavary River at Rajahmundry

A stretch of 60 miles of the Godavary was studied and the fish catch (from March 1959 to February 1960) was estimated and tabulated on next page.

Biological Investigations

A total of 23481·43 kgm. of *M. aor* and 14040·02 kgm. of *M. seenghala* were estimated to have been landed during 1959–60 at Allahabad from Sadiapur and Daraganj Centres. 100 specimens of *M. aor* (T.L. 53–989 mm.) and 79 of *M. seenghala* (T.L. 59–1067 mm.) were studied in detail. Sexual maturity (season-wise) has been recorded. Between February and June various mature and just-spent specimens were recorded, indicating that the spawning

	Total (kgm.)	Per day (kgm.)
1959—		
March ..	21022·79	678·15
April ..	17338·13	577·93
May ..	15614·52	503·69
June ..	9759·06	325·30
July ..	6584·84	212·41
August ..	4885·85	157·60
September ..	13299·59	443·31
October ..	26283·19	847·84
Nobember ..	23286·36	776·21
December ..	17470·58	563·56
1960—		
January ..	10587·67	341·53
February ..	16725·40	576·73

season of both species could be placed between these months. The following gonadial characters were determined for *M. aor:*

Immature stage	.. 0·01–0·19 mm.	ova diameter
Intermediate stage	.. 0·02–0·42 mm.	do.
Maturing stage	.. 0·43–0·81 mm.	do.
Ripe	.. 0·81–1·20 mm.	do.

Spent ovary-flaccid with degenerate ova.

By studying seven pairs of gonads in *M. aor* and one pair in *M. seenghala*, fecundity noted was between 772 and 1,002 ova per gm. weight of ovary in the former and 975 in the latter. The following regressions have been calculated by the method of least squares:

(i) No. of ova spawned : T. L. of fish:

$$\text{Log } Y = -0{\cdot}95138 + 1{\cdot}99552 \text{ Log T.L.}$$

(ii) No. of ova spawned: Weight of fish.

$$\text{Log } Y = -1{\cdot}70610 + 0{\cdot}86492 \text{ Log weight.}$$

Gonado-somatic indices in *M. aor* for four years, from 1955 to 1959, show that the index value was the highest in April 1956, 1957 and 1958 and in March 1959. Values were the lowest between July and August, with a progressive development culminating in the highest values in March to April. Large number of early developmental stages of both the species (6 to 9 mm. and 13 to 18 mm. T.L.) have been procured in February and March from breeding pits (known as Thalas or 'kunda') at various shallow portions of the main river stream of both the Jumna and the Ganga. From the length-frequency studies and means calculated from examination of vertebral (centrum) rings, the following age-groups could be determined for *M. aor:*

Age	Length frequency mm. (T.L.)	Mean lengths calculated from vertebral rings mm. (T.L.)
1st Year ..	460	440
2nd Year ..	660	620
3rd Year ..	820	904
4th Year ..	900	910

Morphometric studies for analysis of co-variance between males and females were made on seven characters. The regression equations were calculated and appropriate 'F' tests revealed that except in dorsal and pectoral spines none of the characters were statistically significant between sexes.

Examinations of guts revealed that adults of both species subsist mainly on teleosts (33·81 and 60·63% respectively). Insects were found only in 7·24% of *M. aor* and were completely absent in *M. seenghala.* Crustaceans comprised 6·42% and 6·27% respectively. Juveniles of *M. aor* feed mainly on insects (54·55%), whereas those of *M. seenghala* consume mainly teleosts (61·74%).

Total landings of *Catla catla* in the Ganga and Jumna were 53780·03 and 95867·62 kgm. respectively. The fish was found to feed on 50·3% by volume of Crustacea, 7·4% algæ, 6·1% insects, 3·8% plants, 2·5% rotifers, 1·5% diatoms, 0·2% protozoa and 15·6% sand or mud. Gastro-somotic index was the lowest in June and highest in March. Gonads of IV, V and VI stages were noted in April, May, June and July, the species spawning by the commencement of monsoon. Number of mature ova per

unit gram weight is 210. Scale readings of growth checks (in rings) were made and the following tentative conclusions have been arrived at:

Age	Size range (mm.)	Mean length (mm.)
End of 1st Year ..	175–245	210
End of 2nd Year ..	422–492	457
End of 3rd Year ..	598–669	633
End of 4th Year ..	774–845	809
End of 5th Year ..	951–···	951

24846·48 and 155561·32 kgm. of *Silonia silondia* were landed from the Ganga and Jumna respectively, forming 2·76% and 2·85% of the total yield. Gut content analyses showed that fish formed 32·33%, insects 29·08%, prawns 3·72%, plant matter 5·6%, digested organic matter 15·87%, snails 0·12%, conchostracans 1·45% and fungi 0·26%.

Gonads of VI stage were noted in August and May with spent specimens occurring in May, October, November and December. Number of mature eggs per unit gram weight is 28.

3,570 kgm. (valued at Rs. 3,590) of *Rita pavimentata* were estimated to have been landed at Hoshangabad (Sahagunj) centre from the Narbada river. Size-group 125 to 205 mm. was the most dominant (60·8%) in the year. Catch-per-unit-effort of 500 hooks per hour was 0·12 kgm. (range 0·05 (in July) to 0·19 kgm. (in August). Baits used were dragon-fly nymphs, prawns, earthworms, fish flour, bivalves and gastropod flesh. Sex ratio was 36·4 (M): 63·6 (F).

Data obtained from analyses of stomach contents are given below:

	Average food (c.c.)	Gastro-somatic index	Condition of stomach %	Condition of factor
April–May ..	0·36	1·05	19·1	1·335
June–July ..	1·16	2·19	39·2	1·435
August–September ..	0·60	1·75	7·3	1·425
October–November ..	0·30	1·19	5·9	1·424
December–January ..	0·20	1:10	5·9	1·395
February–March ..	0·11	1·00	0·0	1·355

Main food items were molluscs 38·0%, prawns 6·6%, macrovegetation 5·5%, insects 4·5%, teleosts 3·4%, earthworm 0·7%, centipedes 0·3% and microvegetation 0·2%.

2,704 specimens were measured for length-frequency studies and the following modal characters were noticed:

Age (year)	Mean length (mm.)
I	153
II	213
III	258
IV	288
V	301

Cleithrum bones from 357 specimens were studied and results indicate that the markings are probably annular.

Gross examination of gonads, ova diameters and gonado-somatic index has clearly shown that the fish spawns from July to September, maturity being attained between 213 and 268 mm. Fecundity ranged between 3,000 and 25,000 ova, among 240 to 250 mm. sized fishes.

Exploitation of Fish-Seed Resources

Spawning grounds of *Hilsa ilisha* in the Narbada river were located between Poicha and Indravarna (18 miles) but spawn was available only at Poicha. Collections of Mahseer fry in the same river during five months (November to March) were successful. Spawning of this fish occurs twice, first during monsoon and later in winter. The species is already being stocked on a large scale by the M.P. Fisheries Department from fry obtained at various places.

Systematic operation of shooting nets in the Godavari at Rajahmundry and experimental rearing of spawn from July to end of September gave the following results regarding density of carp spawn resources in Godavari river:

Species	% in total	% among major carps
Labeo fimbriatus ..	23·8	59·9
Catla catla ..	6·3	19·4
Cirrhina mrigala ..	5·2	19·1
Labeo calbasu ..	0·3	0·9
L. rohita ..	0·2	0·7

In order to ascertain whether the Tilaiya and the Konar reservoirs of the Damodar Valley Corporation could be self-sufficient in their fish-seed resources, investigations were undertaken during August 1959. Major carps already introduced do actually spawn in the connecting rivers above at the first and to a small extent during subsequent flooding, but the eggs and hatchlings seem to perish and fail to attain even fry sizes.

Physico-chemical and Biological Factors Affecting the Distribution of the Ganga Fisheries

Analysis of regular collections made from seven centres (*viz.*, Kanpur, Allahabad, Varanasi, Ballia, Patna, Bhagalpur and Rajmahal) on a 700-mile stretch of the Ganga river showed that during the last quarter free CO_2 registered a gradual decline, while dissolved oxygen attained a maximum of 11·4 p.p.m. in January and pH remained steady (8·2). Inorganic nutrients (nitrates, phosphates and silicates) are fairly well represented. Lower reaches seem to have less nutrients than the upper. There has been a rise in plankton with temperature. *Mougeotia*, *Spirogyra* and *Synedra* spp. amongst phytoplankters and *Keratella*, *Brachionus* amongst zooplankters were the more important organisms. Since the middle of February, *Actinastrum*, *Anabæna*, *Eudorina*, etc., have tended to increase in number. Bottom biota also showed an increasing trend with rise in temperature. Chironomids (105 per sq. foot), insects, molluscs and vermes dominated. Varanasi indicated the richest biota. Stomachs of about 400 fish from the above centres were examined. Generally insect debris were found to be the dominant items, followed by fish remains.

Stream Pollution Studies

None of the chemical conditions observed in Ganga was sufficient to cause mortality of fish, as both dissolved oxygen and B.O.D. (except close

to the Jajmau outfall), even though low, were unable to cause destruction of fish. No planktonic organisms except amæboid protozoa, fungal spores and hyphæ and *Oscillatoria* and sewage matter are added to the already organically-rich Ganga water. No anaerobic or toxic conditions are allowed to develop in the sewage because of its lead into the river from domestic or factory sources.

Blooms of *Mougeotia* and *Fragillaria* and at one station swarms of *Cladocera* were noted in April and May. These had no relation to pollution. Colonies of Tubificid worms and Chironomids were the major bottom organisms, indicating pollution of the surface water below Jajmau outfall for about a mile. The polluted water on the right bank was still inhabited by fishes like *Labeo dero*, *L. bata*, *Rohtee* spp. and other medium-sized carps, indicating that no adverse effects were being felt by them. *Mystus* spp., *Eutropiichthys vacha* and *Clupisoma garua* were present within the polluted portion.

Lethal limits of tolerance shown by *Mystus vittatus* and *Puntius sophore* were studied with reference to textile (three phases) and tannery wastes (three kinds). Results obtained are as follows:

Nature of liquor	Toxic range	Test fish	Average size	Average weight
Chrome tan ..	6·03– 8·14	*P. sophore*	71·53	5·73
Sulphide tan ..	9·45–10·98	do.	66·16	4·78
Vegetable tan ..	6·03– 8·14	do.	72·51	4·66
Chrome tan ..	10·98–12·76	*M. vittatus*	73·64	4·04
Sulphide tan ..	do.	do.	73·83	3·98
Vegetable tan ..	6·03– 8·14	do.	74·90	4·62
Kier liquor ..	4·47– 6·03	*P. sophore*	69·96	5·00
Dye liquor ..	10·98–14·82	do.	68·80	5·31
Bleach liquor ..	0·5– 0·10	do.	74·10	6·21
Do. ..	0·1 – 0·15	*M. vittatus*	75·80	4·91

No significant changes in tolerance are exhibited by the fishes from season to season. Chromium as hexavalent indicated a dilution tolerance

range of 150 to 220 and 340 to 410 p.p.m. by *M. vittatus* and *P. sophore* respectively.

All three tannery liquors, three phases of textile wastes and raw sewage were analysed for 19 to 20 characters. Tannery liquors contain readily and highly oxidisable organic suspensions than textile liquors with 510 to 1,460 p.p.m. (3 mts. permanganate) values as against a maximum of 590 p.p.m. in textile wastes. Dye and vegetable tan liquors have a very high B.O.D. of 7,272 and 4,800 p.p.m. respectively, which at once reduce oxygen to nil, if sufficient dilution is not available. Sulphide values are high. Bleach liquor showed a value of 141 p.p.m. of free chlorine. No chromium was found in resultant final liquors as a result of its precipitation. Raw sewage at the outfall has a pH of 6·8 with a B.O.D. of 310 and a chloride content of 100. Nitrates and phosphates were 6·67 and 3·3 p.p.m. respectively.

From September 1959 ecological studies on the small stream Daha in the Savan Subdivision of Saran district (N. Bihar) were undertaken. A stretch of 20 miles of the river was studied each month from six stations.

It was possible to observe fish mortality twice in the river during September and November, when except for air breathing Murrels and cat-fishes, all other fish died, rendering the entire river barren for 15 miles. Fish supply to the stream is renewed regularly from the Goghra below. Fingerlings of *Cirrhina mrigala* and *Labeo rohita* were prominent amongst the major carps. Plankton life is very rich except close to the outfalls where the complex "sewage fungi" colonise along with blankets of Chironomids and Tubificidæ. Molluscs are scarce and are generally found dead after each mixing of distillation wastes. Mortality of fish in the Daha are entirely due to deoxygenation by changes brought by breaking up of sulphates to H_2S, which under low pH condition prove lethal. Ferric salts in the process of conversion into ferrous and *vice versa*, seem further to contribute to thorough deoxygenation.

Bioassay experiments using *Puntius sophore* indicated that distillary effluents have toxic range between 6·03 and 8·14% when fish are 78·8 mm. (average T.L.) and 9·23 gm. (average weight). Raw undiluted sugar wastes did not show any toxicity even after 24 hrs. Complications arise only when these sugar wastes are subjected to bacterial activity. Distillery wastes contain highly oxidisable substances and showed a B.O.D. of 8,750 p.p.m. and O.C. value of 1,754 p.p.m. (3 mts. KM No. 4). Sugar wastes showed a B.O.D. of 820 p.p.m. and O.C. value of 65 p.p.m. Sulphur-reducing bacteria favoured in these two effluents produce H_2S (as much as 12 p.p.m.) and prove lethal to fish.

Lacustrine Investigations

Investigations at Tungabhadra Dam

Data collected from the Hospet Fish market indicate that 20·108 m. tons of fish were brought to the market during the year. Carps formed over 50% of the catches during April and August to January. Since the nets used are very selective, significant variations in sizes are not obtained. The total weight, size range and mean size of the twelve predominant species were calculated as shown below:

	Weight (kgm.)	Size range (mm.)	Mean size (mm.)
Barbus kolus ..	5694·0	200–460	315·8
B. pinnauratus ..	300·4	180–340	253·6
B. tor ..	309·16	200– 680	436·8
B. dobsoni ..	655·77	221– 720	358·6
Labeo fimbriatus ..	2798·7	201– 820	473·4
L. potail ..	177·1	220- 580	306·8
L. calbasu ..	370·1	220– 640	388·5
Mystus aor ..	4330·2	220– 880	531·0
M. seenghala ..	5254·0	200–1100	702·0
Silonia silondia ..	387·0	180–560	362·3
Wallago attu ..	505·0	280–1020	662·0
Bagarius bagarius ..	488·1	301– 840	572·3

Departmental fishing was undertaken in the reservoir on 147 days by using Uduvalai and Rangoon nets. The average catch per day was 4·52 kgm. *Barbus kolus* predominated in the catches this year also, followed by *Mystus seenghala*. *B. kolus* (34·6%), *M. seenghala* (25·1%), *L. calbasu* (10·4%), *L. fimbriatus* (6·5%), *M. aor* (6·5%) and *S. silondia* (3·2%) were the important fishes represented in the catches. The catch-per-day in kgm. for Uduvalai and Rangoon nets worked out to as in next page.

Mesh ..	0·5″	1·0″	1·5″	2″	3″
Uduvalai—					
Catch per day	0·48	0·167	1·6	1·8	0·35
Mesh ..	0·5″	1·0″	2·5″	3·5″	..
Rangoon nets—					
Catch per day	0·225	0·2	0·34	0·30	..

It was observed that Uduvalai nets yield more catches than Rangoon nets because the bottom-feeding fishes (*Barbus* spp.) form the important group of fishes in the area.

A survey of the nets and tackle used by fishermen were undertaken during the year under report. Drag nets with stakes are used during the monsoon months near the margin for catching minnows. Larger drag nets are used at Hampasagaram during May, when the water level goes down. Long lines are used by fishermen throughout the year. Main fishing gear is Uduvalai, 100 to 200 yards long, 1″ to 3″ mesh and about a metre in height. Local fishermen do not use Rangoon nets. The catch per unit of effort for the tackles worked out to:

Drag net—4·3 kgm. per hour.

Uduvalai net—0·28 kgm. per 100 yds. per 12 hours in monsoon, 0·21 kgm. in post-monsoon and 1·9 kgm. in winter months.

Hook and line and long line—0·25 kgm. per 1,000 hooks per hour.

Over 2·0 lakhs of fingerlings of Catla, Rohu and Mrigal have been released in the reservoir during December 1959.

Biological studies on the more important species of fish were continued. Fecundity studies on 17 species are being made.

Plankton studies were regular and it was seen that generally zooplankton was predominant. There was a peak of phytoplankton in July to August due to blue-green and green algæ and a second peak during January to February due to diatoms. In zooplankton, copepods, rotifers and cladocerans and in phytoplankton, *Nitzschia*, *Merismopedia* and *Pediastrum* were the important constituents.

Surface water temperature varied between 22·9° C. and 31·3° C., with maxima in May and September. Two minimum values were obtained, one in July and the other in January. pH varied between 7·5 and 8·4. Turbidity was maximum in July (Sechi disc reading 15·8 cm.) and minimum in February (233·68 cm.). Dissolved oxygen showed two maxima, in August and January, and two minima, in April and October. During April to May the difference

in oxygen values at surface and bottom was 2·7 mg./e. and during other months the same was between 0·3 to 0·6 mg./e. Carbonates were in very low concentration between July and December 1959. The maximum amount of bicarbonates was found in June (101·3 mg./1.). Maximum phosphate was found in March (0·113 mg./1.) and minimum in October (0·024 mg./1.). Nitrates were in traces during June and 0·153 mg./1. in November. The increase in nitrate and phosphate concentration took place after the entry of the flood waters in the reservoir during July. Oxidisable organic matter in surface waters was 0·025 mg./1. in April, 0·09 mg./l. in August and 0·052 mg. during September to March.

To assess the production of organic matter and rate of photosynthesis at different depths, a series of experiments was conducted and it was found that at 2 metre depth, there was maximum photosynthesis, while below 8 metres it was negligible. The average figures of glucose production in mg. per cm. for the top 8-metre-layer were as follows:

November, 76·0; December, 46·9; January, 58·9; February, 71·96; and March, 89·98.

A direct relationship between the production values and concentration of phytoplankton has been observed. Soil analysis of bottom mud of the reservoir were made during three months with the following results:

	October 1959	January 1960	February 1960
Organic carbon ..	0·246	0·268	0·202
Total nitrogen ..	0·068	0·042	0·058
Calcium carbonate ..	4·2	4·1	3·9

Bottom fauna studies indicated that Gastropoda are more up to 15 meter depths and bivalves decrease in number with increase of depth. Oligochætes predominate between 21 to 25 metre depths and Ephemeroptera are found in shallower regions (upto 10 metres). Dipteran larvae are more between 6·10 metres than between 16–20 metres depths, but again increase between 21 and 25 metres. Ostracoda predominate at 11 to 15 metre depths.

Rapid survey of Collair Lake

The Fisheries of Collair lake was surveyed during the year under report. There are about 5,200 fishermen having 2,500 dug-out boats. The fishing

in the main lake region is conducted by rectangular basket traps, fixed in two tiers in series over ½ mile long and called as "Dodakattu". Carps and cat-fishes form the main catches in these traps. In the Akhividu region on the river Uputeru stake-nets are used; 10 to 15 such nets are put in a series and the catches comprise mostly of estuarine forms like *Lates calcarifer*, *Sciæna* sp. and eels. During the summer months the main catches in the lake consist of air-breathing fish like *Saccobranchus* and *Anabas*.

Water samples from different regions of the lake were analysed and the results obtained are summarised below:

	Total alkalinity		Phosphate		Nitrate	
	June	November	June	November	June	November
Sriparu ..	148	168	0·08	0·148	Trace	0·08
Kaiklur ..	204	184	0·007	0·06	0·12	0·13
Akhividu	190	160	0·002	0·038	0·01	0·12

Studies at Krishnaraj Sagar

Analysis of data obtained from the catches of the lake area showed that *Barbus carnaticus* (275 to 468 mm.) formed nearly 25% of the catches. Mature males were found in June and mature females in July. *Barbus dubius* (303 to 760 mm.) formed nearly 15% of the catches, with mature males in July and October. *Barbus micropagon*, *Labeo kontius* and *Labeo fimbriatus* come next in order of importance. Amongst cat-fishes *Wallago attu* is more common. The chemical conditions of the water was found to be as follows:

	P.H.	Turbi-dity	Alka-linity	Phosphate (mg./1.)	Nitrate (mg./1.)	Iron (mg./1.)
June ..	8·2	24″	120	0·1	0·12	..
July ..	7·5	13″	22	0·09	0·16	2·03
October ..	8·0	..	65	0·045	0·14	0·08
December ..	8·3	..	97	0·026	0·14	0·08

Estuarine Division

Investigations on the Fisheries of the Hooghly, Matlah and Mahanadi Estuaries

The year under report envisaged the commencement of the second phase of this programme of investigations. During the first phase, data were collected on all the species of fish and prawns caught in the estuaries, which yielded information on various aspects of fishery biology. In the second phase, 26 species of fishes and 5 of prawns, each of which forms not less than 1% of the total landings of the estuary, were selected for more intensive studies of population dynamics.

With a view to estimate the sampling error and assess the suitability of the design now followed for the collection of catch statistics, a pilot survey was conducted in Zone II of the Hooghly. Interpenetrating sampling technique was adopted in six selected villages, one enumerator sampling three villages. The monthly coefficient of variation was found to be 3·5% during the period of survey. However, during the period of sampling all the types of gear normally operated were not represented. Since there is an appreciable variation in the types of gear operated in each centre from time to time, it is proposed to increase the number of sampling centres in each zone to four and reduce the period of sampling to two days.

After an initial survey of the dry and fresh fish markets in the Mahanadi estuary area, a new market sampling procedure was designed for the estimation of total catch. For the assessment of catch-per-unit-of-effort, the entire estuary north of Devi River has been divided into seven zones where sampling survey is being carried out fortnightly.

There was a marked increase in total landings of fish in the Hooghly and Matlah estuaries as compared to the previous year, which was due mainly to increased catches in the lower Sunderbans and Zones III and IV (Rupnarain) of the Hooghly. Catches in Zones I and II of the Hooghly and the upper reaches of Matlah were however poorer than during last year. Moderate success was achieved by the bag net fishermen during the winter months in the lower Sunderbans.

The combination of sampling survey and total enumeration methods was continued to estimate the total catch and catch-per-unit-of-effort in the estuaries. The data for Hooghly and Matlah are summarised below.

Zone-wise total catch figures of Hooghly and Matlah estuaries.

	Zone	Weight in metric tons
Hooghly ..	I	465·3
Do. ..	II	103·0
Do. ..	III	1940·6
Do. ..	IV (Rupnarain)	349·7
Matlah ..	V	102·5
Lower Sunderbans		1177·5
	TOTAL ..	4138·6

Analysis of Commercial Catches

During the year under report, the failure of Hilsa fishery brought down the percentage composition of clupeoids group in the total landings to nearly 8·4%. Details regarding *Hilsa ilisha* which is the most important species in this group are given elsewhere. Among the other clupeoids only *Setipinna taty*, *S. phasa*, *Coilia borneensis*, *C. ramcarati* and *Ilisha elongata* contribute significantly to the fishery and these were studied in detail.

Setipinna phasa afforded a fishery of some importance in the estuaries. Juveniles (modal length 75 mm.) were predominant in the catches of the Rupnarain and the middle and upper zones of the Hooghly during March to July. From August onwards, maturing fishes started appearing in the catches mainly from the upper zone of the Hooghly and in lesser numbers from the Matlah. August to October were lean months and from November to February both uveniles and maturing adults (ranging from 20 to 270 mm.) were represented in the catches from all the zones of the Hooghly (mainly from the upper zone), whereas juveniles continued to contribute to the catches from Rupnarain. The fish was not caught from the Matlah estuary till July when juveniles (modal length 65 mm.) started appearing. Bigger size-groups of maturing individuals entered the fishery in October and persisted throughout the winter months.

Annual catch-per-unit-of-effort figures (in kgm.) March 1959 to February 1960

	Hooghly			Rupnarain	Matlah
	Zone I	Zone II	Zone III	Zone IV	Zone I
Bagnets :					
Standard unit (800–1000)	4·23	2·41	178·0	6·08	13·09
Drift nets:					
Kona ..	0·89	..	..	..	..
Ghai kona ..	3·13	..	..	..	..
Chandi ..	..	0·87	..	2·26	..
Lift nets: ..					
N. vashali ..	2·83	0·52	..	..	..
Scitki ..	0·92	2·07	..	..	..
Purse nets:					
Sanglow ..	0·30	0·44	..	..	..
Cast nets:					
Vachari ..	2·09	..	16·8	..	
Khepla ..	1·26	..		..	..
Trawl nets: ..					
Moi ..	2·15	2·67	..	..	..
Buro ..	1·23	..	..	..	..
Tangle nets:					
Janglo ..	7·38	..	..	..	..
Seine nets:					
Ber ..	..	..	30·4	..	7·26
Berpata ..	..	..	58·7	8·86	..
Chatber ..	9·28	..	..	..	..
Khalpata ..	..	..	38·0	..	6·61
Khani ..	..	..	..	..	5·38
Dhali ..	1·40		..	..	..
Pata ..	1·19	..	..	..	..
Kochal ..	7·73	..	..	..	..
Hooks and line:					
(100 units) ..	0·31	0·38	8·0	1·82	1·11
Traps ..	0·14	..	..	..	..

S. taty contributed more to the catches of the estuaries than even Hilsa this year, accounting for nearly 2·8% of the total landings. Its fishery,

however, was restricted mainly to the lower zone of the Hooghly and Matlah. Small quantities of immature and maturing individuals were landed from the lower zone of the Hooghly, Matlah and Rupnarain during March to October. The fishery increased in magnitude in winter months particularly in the lower zone of the Hooghly, where fishes with a modal length of 85 mm. constituted the catches. Maturing, mature and partly spent individuals also were landed from this region.

Of the two selected species of Coilia, *C. borneensis* was more abundant in Rupnarain and middle zone of the Hooghly estuary, whereas *C. ramcarati* was represented mainly in the catches from lower Sunderbans and lower zone of the Hooghly. Juveniles of *C. borneensis*, (41 to 70 mm.), predominated in the catches from January to April and November and December. Maturing adults (80 to 142 mm.) were caught during the period April to June from the middle zone of the Hooghly, Matlah and Rupnarain, where they appear to spawn. *C. ramcarati* was landed in good quantities from lower Sunderbans during winter months, when three different size-groups (modal lengths 75, 120 and 165 mm.) constituted the fishery. New recruits having a modal length of 53 mm. entered the fishery in January and February. The fish appears to spawn during December to February. Juveniles of *Ilisha elongata* ranging from 31 to 55 mm. were landed from all the zones of the estuary during almost all the months of the year.

Perches contributed to nearly 1·5% of the total landings of the Hooghly estuarine system, with *Sillago panijius* and *Lates calcarifer* being the more important species. *Lates calcarifer* caught in the estuaries ranged between 12·0 and 88·2 cm. in length, the dominant size-group being the younger ones measuring 14 to 20 cm. The fish was caught in greater abundance from Matlah and Ichamati and was rare in the Hooghly. *Sillago panijius* was represented in the catches of the Hooghly and Matlah almost throughout the year by three distinct size-groups with modes at about 35, 125 and 205 mm. of which the second size-group was predominant. Generally maturing and mature adults were caught in the lower reaches of the estuary, whereas the younger size-groups were more abundant in the other zones.

Of the four species of mullets that contribute to the fishery, *Mugil tade* and *M. parsia* were found to constitute a predominant part and hence were selected for detailed studies. Mullet landings accounted for a little over 1% of the total catches of the estuary. *Mugil corsula* was caught throughout the estuary and was represented in the upper and middle zones by ' 0 ' group individuals and in the lower zone by maturing and mature I and II year groups.

M. tade was represented in the lower Sunderbans by three distinct size-groups, having modal lengths of 68, 125 and 300 mm.

Cat-fishes formed a very important group accounting for nearly 6% of the total landings. *Tachysurus jella*, *Pangasius pangasius*, *Osteogeneiosus militaris* and *Plotosus canius* were found to contribute significantly to the fishery and hence were studied in detail.

I and II year class *T. jella* (modal lengths 115 mm. and 205 mm.) were landed from the middle zone and Rupnarain during February to July. In the later months, *i.e.*, August to January, the landings of the species were confined to the lower zone of the Hooghly, lower Sunderbans and Ichamati, where in addition to the above age groups, bigger fish ranging between 500 to 830 mm. were caught. During winter months fishes of larger size-groups were abundant in the catches. Individuals in the IV stage of maturity were obtained from Rupnarain and Middle zone of Hooghly during April and May.

Pangasius pangasius was represented in the catches of the upper and middle zones of the Hooghly, Rupnarain and Ichamati from February to July. During February to April, only I year class (110 mm.) constituted the fishery and during May to July, II year class (225 mm.) also were represented. From August to January the fishery extended to the lower zone also, where two additional age groups (*i.e.*, III and IV) were present. During winter mainly bigger size-groups, ranging from 500 to 960 mm. were landed from lower Sunderbans. New recruits (early 0 group, modal length 45 mm.) entered the fishery in large numbers during August to November in the upper and middle zones of the Hooghly and Rupnarain, and '0' and I year classes were caught in Matlah in small numbers during most of the months.

The catches of *O. militaris* were confined to the middle zone of the Hooghly and Rupnarain during March to August where I, II and III year classes, having modal lengths 145, 225 and 335 mm. respectively, constituted the fishery, the II year class being predominant. During November to February the fishery shifted to the lower zone where, in addition to the above age groups, '0' year class (75 mm.) was also present. All individuals belonging to II and III year classes were found to be in an advanced stage of maturity during the months April to June, when they appear to congregate in the middle zone of the Hooghly and Rupnarain for spawning. Capture of adult males with eggs in the buccal cavity confirmed the above conclusion.

P. canius was caught mainly in the Ichamati estuary throughout the year and stray specimens were obtained in the lower zone of the Hooghly

during May, August and December. In the Ichamati one size-group (modal length 115 mm.) only constituted the fishery during February to July, but in August three more size-groups (modal lengths 295·5, 375·5 and 655·5 respectively) entered the fishery. However, the bigger size-groups occurred only for a short period and from October onwards only the first three groups persisted till February.

Harpodon nehereus formed an important constituent of the fishery in the Hooghly, Matlah and Rupnarain, accounting for nearly 28% of the total landings. Immature size-groups, ranging from 60 to 90 mm. were caught almost all the year round from the middle zone of the Hooghly, Rupnarain and Matlah. During winter months appreciable quantities of this fish were landed in the lower zone of the Hooghly. These catches comprised of four size-groups, having modal lengths of 163, 203, 258 and 305 mm. respectively. Mature and spent individuals measuring over 132 mm. were captured from the mouth of the estuary only during the winter months. Fresh recruits (modal size 45 mm.) entered the fishery during February to April mainly in the lower zone of the Hooghly.

Sciænids constituted nearly 2·6% of the total landings. Of the ten species caught in the estuaries, only *Pama pama*, *Sciæna biaurtus* and *S. miles* were landed in any appreciable quantities. *P. pama* was the most important species and during March to May, three size-groups of this species, having modal lengths of 25, 125 and 205 mm., comprised the catches mainly from the upper and middle zones of the Hooghly and the Rupnarain. From June onwards the species started appearing in the catches of the lower zone also. An additional size-group, having a modal length of 345 mm., entered the fishery in September and continued to occur for the rest of the year. In general, bigger size-groups only were landed from the lower zone of the estuary, whereas all the size-groups were represented in the other zones. '0' group individuals dominated the fishery in the earlier months, whereas the 205 mm. size-group was predominant during the winter months. Fresh recruits having a modal size of 25 mm. entered the fishery during all the months of the year except August to October. Individuals with gonads in an advanced stage of maturity and also spent ones were obtained from the upper and middle zones of Hooghly and Rupnarain during January, February and June to August, indicating thereby that the fish spawns in these zones. *Sciæna biauratus* and *S. miles* were landed mainly from the lower Sunderbans during winter months.

Among threadfins, which accounted for 2·9% of the total landings, only *Polynemus paradiseus* and *E. tetradactylum* constituted a significant propor-

tion. Juveniles of *E. tetradactylum* (2·5 to 15·5 cm.) were represented in the catches of the Matlah throughout the year, whereas in the Hooghly three distinct size-groups having modes at 23·6, 30·6 and 41·6 cm. contributed to the fishery of the lower zone and lower Sunderbans during December to February, the smaller size groups being predominant. In the upper and middle zones and the Rupnarain, stray specimens of '0' group were caught. *P. paradiseus* belonging to 0, II and III year classes (modal length 6·2; 11·5; 16·2 and 21·5 cm. respectively), of which I and II year classes predominated, were landed in large quantities in lower Sunderbans and lower zone of the Hooghly during January to March. All these size-groups constituted the fishery of the rest of the zones of the Hooghly during April to August. Mature adults were present in the catches from the middle and upper zones of the Hooghly and Rupnarain during April and May. New recruits (modal length 4·7 cm.) entered the fishery and formed the predominant group from June to August.

Trichiurus savala and *T. haumela* formed the important species of ribbon fishes which constituted nearly 13·4% of the total landings. The catches of these species were confined to the lower zone of the Hooghly and other areas of lower Sunderbans from November to February. Maturing individuals of *T. savala*, ranging in length from 21·6 to 42·6 cm., formed the fishery in Hooghly, whereas immature and maturing fish ranging between 18·5 and 29·5 cm. were caught in the Matlah. Immature and maturing *T. haumela* ranging from 18·6 to 36·4 cm., of which the bigger size-groups were predominant, were landed from the lower zone of the Hooghly and lower Sunderbans only.

Among the five species of prawns selected for detailed studies, *Palæmon mirabilis*, *Leander styliferus* and *Metapenæus brevicornis* were landed in appreciable numbers. *P. mirabilis* was caught mainly from the Rupnarain and upper and middle zones of the Hooghly, during all the months of the year, except September and October. Smaller size-groups (11 to 35 mm.) dominated the catches during November to February, while bigger size-groups (16 to 50 mm.) were present during other periods. The species appeared to mature when it attained a length of 30–38 mm. Berried individuals were obtained from the catches in the Hooghly and the Rupnarain river throughout the year. *Leander styliferus* was represented mainly from the catches of Matlah and lower zone of the Hooghly estuary by four size-groups. Size-groups having modal lengths of 43 and 78 mm. were landed during January to June. New recruits (modal length 18 mm.) entered the fishery in July and continued till November. A fourth size-group of adults (modal length

92 mm.) entered the fishery during November to December. Berried females (modal lengths 78 and 92 mm.) were caught in the lower zone of the Hooghly during November to February.

M. brevicorinis occurred mainly in the middle and lower zones of the Hooghly, Rupnarain and Matlah estuaries, majority of the catches being from the Matlah. Two size-groups having modal lengths of 33 and 67 mm. were represented during August to February. During the winter months, however, size groups ranging from 70 to 115 mm. were caught in large numbers from lower Sunderbans. No mature females have so far been obtained. *P. carcinus* ranging between 46 and 210 mm. occurred in the upper and middle zones during July to November and in the lower zone of the Hooghly from December to March. Females with maturing ovaries were caught both from Kolaghat and Fuleswar area, during December to February. *P. malcomsonii* ranging from 21 to 135 mm. occurred in the catches of the middle zone of the Hooghly and the Rupnarain. Berried individuals of the species were caught from May to July in the middle zone, which appears to be the spawning ground of the species.

Fishing in the Mahanadi estuary was restricted largely to the lower reaches. There was a significant decrease in the fishing 'effort' in the Hukitola lake area because of the restrictions enforced on non-indigenous fishermen. Hilsa fishing of some magnitude was conducted in this area after a lapse of four years. Other important species that constituted the fisheries were *Mugil cephalus*, *M. troscheli*, *Polydactylus indicus*, *Eleutheronema tetradactylum*, *Sciæna* spp., *Setipinna phasa* and *Lates calcarifer*. *M. cephalus*, ranging from 21 to 39·6 cm. in length, were landed from the lower reaches of the estuary, the dominant size-group being between 25 and 33 cm. The majority *M. troscheli* landed were from the neighbourhood of Paradeep, Karnasi and Jatadharmohan and ranged from 19 to 48·9 cm. *Setipinna phasa*, which ranged in size between 15 and 20 cm. with a modal length of 17·5 cm., formed significant part of the catches in all the areas. *P. indicus* ranging in length from 12·7 to 89·0 cm. were caught in the lower reaches, the dominant size-group having a modal length of 38 cm.

Hydrobiological Observations

Surface temperature and salinity ranges in all the estuaries under observation were significantly lower this year than during previous year. Surface temperature in the Hooghly ranged from 20·4° to 30·87° C. and in Rupnarain and Matlah from 19·2 to 31·1 and 20·72 to 30·77° C. respectively. The Hooghly estuary extending from Fraserganj to Medgachi could be divided into three zones on the basis of salinity: (1) an upper zone (between

Khusigoli and Medgachi) which had only traces of salinity during all the months of the year (except May and June when maximum salinity reached 0·6‰); (2) a middle zone (comprising the area between Khusigoli and Diamond Harbour) where the salinity ranged between traces and 19·78‰ and (3) a lower zone (the area between Frasergunj and Diamond Harbour) where the salinity ranged between 9·48 and 32·11‰. In the Matlah and Rupnarain the ranges were from 4·49 to 27·52‰ and traces to 16·00‰ respectively.

The general decline observed in the production of both zoo- and phytoplankton during the previous year continued except for occasional spurts of increase at a few isolated centres. During the pre-monsoon months (April to June) production of zoo-plankton was uniformly low in all the zones, mainly due to decrease in rotifers and cladocerans in the upper zone and copepods in the lower and middle zones. An increase was registered during the monsoon months in Rupnarain, Matlah and lower zone of the Hooghly. An increase in phytoplankton was observed in the upper and lower zones during the pre-monsoon months. This was followed by a gradual decline from June onwards in all the centres and was attributable mainly to failure of diatom crop. During the post-monsoon months a slight but significant increase was noticeable in the lower zone and Rupnarain. Freshwater and marine forms predominated in the upper and lower zones respectively, whereas both freshwater and marine forms were present in the middle zone.

Coscinodiscus, *Melosira*, *Synedra*, *Spirogyra*, *Pediastrum* and *Eudorina* were the more important phytoplankters, and copepods and rotifers were more dominant in zooplankton from the upper zone. In the lower zone, brackishwater copepods like *Paracalanus* spp., *Pseudodiaptomus* spp., *Acartiella* spp. and marine diatoms such as *Coscinodiscus*, *Biddulphia*, *Lithodesmium*, *Chætoceros*, etc. and algæ, like Trichodesmium, were predominant.

Larval and Young Fish Surveys

It was observed that larvæ of various species were generally more abundant in the Rupnarain as compared to other centres. Larvae and post-larvae of *P. pama*, *E. tetradactylum*, *Mugil* spp. and *Coilia* spp., ranging between 5 and 8 mm., were collected from Rupnarain, Matlah and the middle zone of the Hooghly during June to August. Larvæ of *Mugil* spp. and *P. pama* were obtained from lower and upper zones of the Hooghly also during August and September. Post-larvae of *P. paradiseus* measuring about 8 mm. were represented only in collections from the Matlah during July.

Larvae and post-larvae of *S. phasa* were collected from the Hooghly and Matlah and those of *Anchoviella* sp. from lower zone of the Hooghly and the Rupnarain during June to September. Larvae of other sciænids and perches were present mainly in Rupnarain during June to September.

In the Mahanadi estuary, young ones of *Chanos chanos*, *Lates calcarifer*, *Anchoviella* spp. and other clupeoids and prawns were abundant in Ostar and Narayanpur centres during May and June, whereas larvae were scarce in Jamboo area. During July, August and September, larvae and young fish were rare in all the three centres.

Studies on the Culture of Brackishwater Fishes

The brackishwater fish culture unit commenced its work at the Kiragachamadeli fish farm belonging to the Orissa Fisheries Department. As a result of intensive survey it has been possible to locate mullet-seed collection centres near the farm site. Surveys to locate suitable collection centres for young of prawns suitable for cultivation are in progress. Experiments on the comparative merits of transporting conditioned and 'unconditioned' fry indicated that unconditioned fry stand transportation better.

After removing extraneous fishes and undesirable fauna, the ponds at the fish farm were stocked with mullet fry at the rate of 1000 per acre. Observations were made at regular intervals to assess their growth and survival. Observations on the soil nutrients, algal production and other hydrological features of the ponds were also made. To explore the possibilities of increasing production of benthic algæ and thereby fish production in ponds, experiments with chemical fertilizers and green manure were initiated. Four tanks are being manured with NPK in the ratio of 1 : 1 : 0·6 and two with semi-decomposed mangrove leaves at 2,000 lb./acre. A sudden increase in nitrogen was observed in the soil phase subsequent to fertilization. No such increase was discernible in the case of phosphorus, and this difference may be attributable to the fact that ammonium sulphate, unlike superphosphate, dissolves in water immediately.

A new set of pot culture experiments to study the major factors governing the growth and multiplication of benthic algæ in brackishwater ponds has been taken up. Experiments were conducted with salinities ranging from 0 to 30‰, and it appears that 15‰ salinity is the most favourable for the growth of *Oscillatoria* sp. Observations on the probable effects of salinity on the distribution of fertilizer elements on soil and water were also initiated. Experiments with ammonium sulphate indicated that in salinity ranges of 0 to 15‰ the presence of Na + ions does not significantly affect

the distribution of available nitrogen in soil and water. However, the possibility that in higher salinities the presence of excess Na + ions might effect the exchange of NH_4 + ion between soil and water, exists.

Investigations on the Hilsa Fisheries

The monsoon fisheries for Hilsa in all the major river systems were poor during the year. Slight improvement in catches was observed when there was good rainfall and consequent flooding of the rivers. The very heavy rainfall and extensive flooding in West Bengal late in the season did not help the upriver migration of Hilsa. The winter fishery for Hilsa in the West Bengal waters was also very poor. However, in the coastal areas adjacent to the lower Sunderbans, there were abundant catches of Hilsa in November to December, but this lasted for only about a fortnight. This is of special significance in view of a similar sporadic Hilsa fishery in the lower Sunderbans during the winter of 1958–59. Environmental studies indicate that turbidity and the quantity of plankton play an important part in the establishment of the Hilsa fishery in the lower Sunderbans. The late flooding of the rivers of West Bengal at the close of the monsoon season appears to have proved a handicap to the Hilsa fishery of the lower Sunderbans this year also.

The total Hilsa catch for the year in the area covered by the Hooghly, Rupnarain and Matlah river system including lower Sunderbans was approximately 139 Metric Tonnes. The zone wise landing figures for the period March 1959 to February 1960 are given below:

	kg.
Zone I ..	26,464
Zone II ..	5,368
Rupnarain ..	28,783
Lower sunderbans ..	78,097

The catch-per-unit-effort (in kg.) of the more important Hilsa nets in in the area is indicated below:

Name of net	Zone I	Zone II	Rupnarain
Konajal ..	0·89	..	..
Chandijal ..	..	0·87	2·26
Sanglojal ..	0·3	0·44	..

The total catch of Hilsa for the year from the Padma in the neighbourhood of Lalgola was 645·83 Metric Tonnes.

In the Godavari there was a Hilsa fishery of small magnitude during the monsoon season commencing in the later half of July. Below the anicut at Dowlaiswaram the catches were good during the last week of September. The fishery, however, declined rapidly and came to a close by the second fortnight of October. The winter fishery for Hilsa was extremely poor during the year. Moderately good catches were reported at Masakapalli during the last week of February. Juvenile Hilsa were caught in fairly good numbers in Jaruguvala and Gaminivala at Kotipalli during January to February.

The analyses of meristic and non-meristic characters of samples of Hilsa from the different river systems indicated that the stocks of all the major river systems sustain independent populations. The age structure of the populations are being analysed to ascertain whether significant differences in age structure are recognisable between populations.

The comparative study of fat content of Hilsa from different localities was continued and the results are summarised below:

Origin of samples		Average percentage of fat content
Sourashtra	..	16·73
Brahmaputra	..	7·15
Krishna	..	8·5
Godavari	..	2·5

The composition of the commercial catches of Hilsa from Padma, Ganga, Brahmaputra, Chilka Lake and the Sourashtra coast were studied in detail. The bulk of the catches in Padma, Ganga and Brahmaputra comprised of the $4\frac{1}{2}$-year age class. In Chilka lake 1 to 5 years' old Hilsa contributed to the fishery, the 2nd and 3 year groups forming the predominant age classes. The bulk of the catches of Hilsa on the Sourashtra coast appears to belong to the 5-year age class.

Efforts were made to tag as many Hilsa as possible during the year. Fish caught in Chandijal and other gill-nets were found unsuitable for tagging, while those caught in clap nets like the Sanglojal and its various modifications were the best suited. The total number of Hilsa tagged during the year was 578, of which 54 have been recovered in good condition. From observations made so far there appears to be great variations in the speed of movement of Hilsa. It also appears that the Hilsa shoals show a certain amount of dispersal in the area covered. The longest time interval between the release and recapture of tagged Hilsa has been 3½ months.

Intensive propaganda among the fishermen and fish traders of Bengal, Bihar and Uttar Pradesh was carried out for increased return of recovered tags. A 16 mm. colour film on tagging of Hilsa has been prepared for the propaganda work.

Exploratory Fishing

Preliminary bottom contour surveys and exploratory fishing in the lower Sunderban areas with the Research and exploratory fishing vessel M. V. "Sunderbans" were started in December 1959 and continued upto February 1960. During the above period the vessel made 6 voyages covering the entire stretch of Sunderban waters, from the river Muriganga on the west to Haribhanga river on the east. Extensive operations were carried out in the river Muriganga, Saptamukhi and lower Matlah. The work done consisted mainly of bottom survey by echo-sounding, location of fishing grounds and experimental mechanised fishing.

Preliminary surveys showed that the average depth in the area varied between 5 and 8 fathoms and in most cases river-beds were very uneven and muddy. It was also seen that a few grounds suitable for trawling existed in rivers Muriganga near Frasergunj, Saptamukhi near Dwariknagar and east and west of Lothian Island, river Thakuran and in the lower reaches of river Matlah, where the river bottoms were fairly even and less muddy.

Fishing experiments were conducted mostly with trawl nets, although drift gill-nets and long lines were also tried. Results of trawling operations were satisfactory in the river Muriganga, Saptamukhi and lower Matlah. River Thakuran appeared to be very poor in fish stock. *Harpodon nehereus*, *Arius* spp., *Pangasius* sp., *Pama pama*, *S. biauritus*, *S. bruniuss*, *Parapenæopsis sculptilis* and *Leander styliferus* were the most important species collected and are mentioned here in the order of their abundance in the landings.

CHILKA LAKE INVESTIGATIONS

Tagging Operations in Chilka Lake

An intensive tagging programme of six commercially important fishes of the Chilka Lake was launched in September 1959 and the details of tagging operations conducted are summarised in the table below:

Name of fish	No. tagged during Sept.–Dec. 1959	Number recovered in					Total recoveries upto 31–3–1960	Overall percentage of recovery
		Nov. 1959	Dec. 1959	Jan. 1960	Feb. 1960	March 1960		
1 *Mugil cephalus*	2,355	59	75	47	12	5	198	8·41
2 *Liza troscheli*	2,873	7	95	55	8	12	177	6·16
3 *Eleutheronema tetradactylum*	544	11	20	8	4	..	43	7·90
4 *Lates calcarifer*	206	1	8	2	2	..	13	6·31
5 *Sparus sarba* ..	693	..	4	7	..	3	14	2·02
6 *Pseudosciæna albida*	43	..	..	..	..	..	..	..
TOTAL ..	6,714	78	202	119	26	20	445	6·63

These studies are expected to throw light on the migration and local movement of fish, their growth, rate of exploitation and other aspects of the population dynamics.

Fisheries of the Chilka Lake

During the 12 months' period ending 31st December 1959, 37, 96, 767 kgm. (1,01,723 md.) of fish are estimated to have been captured from the Chilka lake. Of these 32·16% (1,221 metric tonnes) were prawns, 14·29% (543 metric tonnes) mullets, 13·33% (506 metric tonnes) clupeids, 11·49% (436 metric tonnes) cat-fishes, 9·96% (378 metric tonnes) threadfins, 5·78% (219 metric tonnes) perches, and 5·07% (193 metric tonnes) sciænids. August had the heaviest production when 11·5% of the year's catch, comprising 21·9% of the lake's annual prawn production, was harvested. February was the leanest month in 1959 when only 6·1% of the annual catch was made. Among prawns *Penæus indicus* and *P. semisulcatus* were the most dominant

species, the former comprising 22·64% and the latter 7·45% of the lake's total production. Within the group, these two species together made up about 89·11% of the production. *Mugil cephalus* was the most dominant species among mullets, contributing 8·78% of the lake's annual production. Among clupeids the mud shad *Nematalosa nasus* followed by *Hilsa ilisha* were the most important species caught, contributing to 4·66% and 4·57% respectively of the annual production. *Mystus gulio* was the most dominant cat-fish, contributing to 7·80% of the annual yield, followed by *Arius* sp. and *Plotosus canius*, together making up about 3·30% of the crop. Among perches *Lates calcarifer* was the most important species and made up 3·62% of the year's yield. Species of *Gerres* and *Sparus* together formed 1·27% of catch. *Eleutheronema tetradactylum* was dominant among threadfins, contributing to 10·88% of annual production and *Pseudosciæna albida* the most important among sciænids, forming 3·83%.

The data obtained regarding catches from prawn traps are summarised below:

Prawn catches-per-trap-per-day (in grams)

Month	Type of trap	Catch-per-trap-in-grams in sectors				Catch per trap in entire lake
		Northern	Central	South	Satpara	
1959—						
April ..	Baza	67	12	..	..	26
	Dhaudi	..	54	28	..	40
May	Baza	69	48	..	..	54
..	Dhaudi	..	72	101	..	100
June ..	Baza	54	36	..	..	42
	Dhaudi	..	74	154	1746	351
July ..	Baza	31	40	..	1530	205
	Dhaudi	..	28	73	1437	198
August ..	Baza	29	78	..	348	175
	Dhaudi	..	139	85	295	92
1960—						
March ..	Baza	48	21	..	156	44
	Dhaudi	..	46	..	92	78

Biological Observations on Commercial Fisheries

Mugil cephalus formed 60·23% of the production among mullets. The results obtained by tagging tend to show that one-year old immature specimens of this fish (largely females) stay in the lake. The recovery of one mature tagged *Mugil cephalus* (male) from the sea about 5 miles South-East of Chilka lake mouth confirms some of the observations made last year on seaward migration of the species. While, as in earlier years, lakeward migrating advanced fingerlings of *Mugil cephalus* entered commercial fishery in appreciable numbers in May, departmental collections made with finer meshed nets revealed the availability of smaller fingerlings (41 to 55 mm.) in February 1960. A similar occurrence of Juveniles was observed in January and February 1959. The recovery of one tagged mature *Liza trocsheli* from the sea near Chilka mouth tends to confirm the earlier observations on seaward breeding migration of the species. Further studies are in progress.

Penæus indicus formed 56·95% and *P. semisulcatus* 22·64% of the production of Penaeid prawns. The post-larvæ of both the species have been observed to enter the lake from the sea along with the tide practically throughout the year. The period of availability of large sized prawns of these species in the lake mouth regions commenced in April 1959 and extended upto September. Large prawn catches at the lake mouth centre is due to their seaward drift migration with low tide, which has a correlation with the phases of the moon, the catches being during 4 to 5 days following new moon and full moon.

Eleutheronema tetradactylum upto 100 mm. in total length feed largely on mysids (55%), amphipods (10%), isopods, Cumacea, decapod larvae, etc. The bigger size-group measuring upto 300 mm. subsists largely on prawns (48%), mysids (16%) and other fish (*Mystus gulio*, *Barbus* sp., *Thrissocles*, *Anchoviella*, etc.). The largest size-group measuring 301 mm. and above subsists on prawns (50·7%) and other fish (37%).

There is great abundance of specimens measuring 76 to 300 mm. in the commercial catches practically throughout the year, which is caused by protracted breeding with brief interruptions during the period January to July.

Sparus sarba formed 9·21% of perches landed. Tagging results have confirmed the earlier observations on breeding and migration of the species. Several mature specimens tagged near Satpara in November to December have been recovered from the lake mouth area and this confirms the view

about sea breeding of this species during November to January. Juveniles, (10 to 50 mm.) enter the lake in January to February. New recruits enter commercial fishery by April forming a peak at 83 mm. class and by October form another peak at 143 mm. class. A peak centred at 173 mm. class in February has been interpreted as that of the fish of second year.

Lates calcarifer formed 64·76% of perch catches. Specimens measuring upto 50 mm. feed mostly on copepods, decapod larvae, insect larvae, diatoms etc. Those of the size range 50 to 300 mm. subsist mainly on larger crustacea (60%) comprising prawns, stomatopods etc., and other species of fish (30%) like small clupeids, gobieds etc. (301 mm. and above). Since the fish attains very large size numerous age groups enter the commercial fishery.

Gerres setifer formed 13·5% of the annual production of perches. The juveniles of this species feed on copepods (25%), ostracods (10%) and miscellaneous matter like fragments of algæ, insect remains, etc. (32%). Adults feed on Crustacea (42%), molluscs (31%), algæ (3%), decayed organic matter (1·3%), amphipods (*Orchestia* sp., *Quadrivisio* sp.), isopods (*Synidotea, Cirolina* sp.), copepods (*Nitocra* sp., *Pseudodiaptomus*, etc.), Cladocera and Ostracoda (*Cyprts* sp.) form the important items among Crustacea. The species breeds in the lake from May to September. Fish of the year enter the commercial fishery in September, forming a conspicuous mode at 53 mm. class and attain a length of about 113 mm. by July of the next year.

Pseudosciæna coitor formed 77·9% of the catches of sciænds. A tentative analysis of age and growth from length-frequency studies shows that the young of the year enter the commercial fishery in August. One-year-old individuals appear to be centred around 300 mm. length, 2-year-old ones around 500, 3-year-old about 675 and 4-year-old and above about 800 mm. Young "Borogo" upto about 75 mm. long, feed mostly on amphipods. Bigger forms upto 275 mm. length feed on amphipods (30·6%), prawns (17·1%) and fish (12·4%). Still bigger forms subsist on prawns (46·1%), fish (22·2%), stomatopods (10·0%) and algæ (6·5%). The allied species *Sciæna russelli* feeds largely on debris, amphipods and prawns.

Mystus gulio formed 69·58% of the cat-fishes caught in 1959. This species feeds largely on amphipods which form 54·1%, 32·2% and 22·1% of the diet of small, medium and large age groups respectively. Other items of diet of small specimens comprise Cladocera (15·6%), mysids (10·9%), debris (7%), etc. Algæ (21·7%) and prawns (13·4%) appear prominently in the diet of medium-sized and fishes (17·9%) and prawns (15·0%) in that of large-sized forms.

Young *Osteogeneiosus militaris* (upto 250 mm.) subsist largely on amphipods (38·9%), arachnids (33·3%) and insects (11·1%). Bigger forms feed on lamellibranchs (29·2%), algæ (22·2%) and mud (18·5%).

Plotosus canius formed 13·81% of the cat-fishes. Specimens measuring 201 to 375 mm. thrive on prawns (20·7%) and fish (20·1%). The stomach contents of larger forms show 26·4% debris, 20·7% prawns and 16·3% lamellibranchs.

Tachysurus arius formed 15·59% of the annual production among cat-fishes. Very young fish (upto 100 mm.) feed exclusively on debris. Older forms (upto 276·0 mm.) show 23·6% debris, 23·5% prawns and crabs and 12·6% amphipods in their stomachs. Still bigger forms show 18·3% debris, 15·3% lamellibranchs, 15·1% prawns and 9·2% fish.

Physico-chemical Features of the Chilka Lake

Observations on water and air temperature, transparency, pH, salinity, total alkalinity, dissolved oxygen, silicates, phosphates, iron and nitrates were continued throughout the year at six centres of the lake. Water temperatures ranged from 21·4° C. (January) to 30·3° C. (June) and pH varied from 8·1 to 8·6. Salinity varied in the main body of the lake from 4·5‰ to 27·94‰, highest value being in June and lowest in September. The lake mouth centre showed 0·66‰ salinity in October and 34·8‰ in April. Alkalinity was of the order 98·5 p.p.m. in March and 59·6 p.p.m. in September; D.O. varied from 4·6 p.p.m. to 6·9 p.p.m.; silicates from 0·92 p.p.m. to 4·1 p.p.m.; phosphates from 0·002 p.p.m. to 0·2 p.p.m.; Iron from 0·005 to 0·064 p.p.m. and nitrates from 0·05 to 0·103 p.p.m.

Fish Pathology Investigations

Studies on Fish Mortality in Jute-retting Tanks

A fresh series of experiments were initiated during the year in the experimental tanks of the Jute Agricultural Research Institute. Significant differences in the plankton production were observed and it appears that these have a direct bearing on the quantity of jute used for retting. Laboratory experiments using fingerlings of major carps and small pieces of the two species of jute plants were undertaken at Nilganj and Barrackpore. A few more observations are to be made during the next jute season of 1960.

Studies on Fish Diseases and Mortality

Detailed investigations on an eye-disease which caused extensive mortality of *Catla catla* were made during the later half of the year. This

disease, prevalent in many areas of West Bengal, was specific to *Catla catla*, affecting the eyes only, which in the earlier stages of infection became reddish and later changed to an opaque milky white nature. Eventually the eye got petrefied completely, leaving a punctured cornea or only the hollow eye cup. It was found that a bacterium and an actinomycete were responsible for the disease.

Group treatment for the above disease was tried in five fishery tanks and a minimum of Rs. 35,000 worth of fish were saved. It was noticed that provision of high dissolved oxygen content, removal of decaying matter and disinfection with dilute potassium permanganate solution (upto 0·5 p.p.m.) were effective in preventing the spread of the disease.

Investigations on "Exophthalmus" and "Dropsy" were also conducted during the year under report. Co-existence of these two diseases in major carps was a noteworthy feature. Preventive methods for "Dropsy" were tried and it was possible to save fishes valued at about Rs. 10,000 in a Jheel near Barrackpore.

Incidence of tumour disease in a big stock of Gold fish was investigated and control experiments using antibiotics and sulpha drugs have been taken up.

A preliminary survey of *Ligula* infection in Tilaya and neighbouring areas was made in August and necessary biological data on the parasites, as well as their hosts have been collected. Since the life-history of the parasite is not known, attempts are being made to collect the adults from water-birds and the first stages from planktonic copepods.

Investigations on Parasites of Hilsa

Detailed investigations on parasites may reveal the migratory routes of the hosts and also knowledge about raciation. With this end in view studies on the parasites of *Hilsa ilisha* have been initiated.

Miscellaneous Studies

In view of reports received about the large-scale destruction of wooden fishing implements by the action of aquatic wood-boring organisms in Chilka Lake, an investigation into this problem was considered worthwhile. Data on the concerned organisms and the intensity of their attack in the lake mouth area and the entire stretch of the outer channel have so far been collected.

Investigations were made on large-scale fish mortalities reported in several stocking tanks at Barrackpore, Pulta, Nilganj, Shamnagar, and Calcutta and suitable control methods were suggested to the owners.

A series of experiments on the use of tea-seed powder, seeds of wild poppy and some indigenous plant barks as fish poisons was taken up and the data obtained are being analysed.

As Chandigarh Lake fishery is reported to be affected by high turbidity, a series of laboratory experiments and spot surveys were conducted with a view to evolve a suitable solution to the problem. A preliminary report on the problem and a pilot scheme to clear the water have been prepared.

Encouraging results have been obtained from preliminary experiments on the use of silkworm pupæ as artificial food for carp fingerlings.

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