GOVERNMENT OF INDIA

CENTRAL INLAND FISHERIES RESEARCH STATION
CALCUTTA

ANNUAL REPORT FOR THE YEAR 1957-58

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ANNUAL REPORT OF THE CENTRAL INLAND FISHERIES RESEARCH STATION, CALCUTTA, FOR THE YEAR 1957-58

General

During the year 1957–58 the research programmes of the Central Inland Fisheries Research Station were intensified and the various research units were strengthened by the addition of more research and field staff and equipment. In addition to the Second Plan Schemes already in operation, two additional schemes were initiated during the year by the appointment of nucleus staff for an additional Pond Culture Unit in Jaysagar (Assam) and the Godavari-Krishna and Narmada-Tapti Fisheries Research Unit. The Lacustrine Fisheries Research Unit, which was established in Calcutta during the previous year, was shifted to the Tungabhadra reservoir site at Hospet.

Shri V. Ramachandran, Research Assistant (Chemistry), who was on other duties as Assistant Fisheries Extension Officer, was appointed Assistant Research Officer (Chemistry) and Shri H. P. C. Shetty, Research Assistant (Estuarine) as Assistant Research Officer (Hooghly-Matlah-Mahanadi). Shri A. V. Natarajan took up appointment as Assistant Research Officer (Ganga Survey).

During the year under report considerable progress was achieved in all the lines of investigations under way at the Research Station. In the Pond Culture Section at Cuttack it was possible to induce some of the Indian Carps to breed in confined waters by injection of pituitary gland hormones. The work carried out at the Riverine and Lacustrine Section at Allahabad included studies on the fisheries and fish populations of the Ganga river system and biological investigations of some of the commercially important fishes. In the Estuarine Section satisfactory progress was maintained in all the schemes of work including the study of the fisheries and fish populations of the Hooghly, Matlah and Mahanadi estuaries, the productive potential of brackishwater bheris and investigations relating to Hilsa fisheries of the Indian region. The Lacustrine Unit was able to complete the inventory of the lacustrine fisheries in India, and detailed investigations on the fish and fisheries of the Tungabhadra reservoir have been initiated. A few successful preliminary experiments in tagging of fish were made at the Chilka Unit and in the Estuarine Section.

Training

The 10th Session of the Inland Fisheries Training Course was conducted during the year. Thirty-one candidates, consisting of 9 government deputees and 10 government stipendiaries from the various States and 12 private candidates, were trained in inland fisheries development and administration. In the final examination conducted in January 1958, 30 candidates from this year's batch and one candidate from the previous year's were declared to have passed.

Twenty-two trainees deputed by the various fisheries departments were given lectures and demonstrations on the technique of inducing carps to breed by pituitary hormone injections, on hatching and nursery management practices and the technique of breeding the common carp, *Cyprinus carpio*.

Mr. Fernando Obregon Fernandez, a trainee from Mexico under the Extended Technical Assistance Programme, was given training at Calcutta and Cuttack in fish culture methods. Dr. Morawa who visited the Research Station under the Indo-German Exchange Programme was given facilities to acquaint himself with the investigations conducted here.

Meetings

The Chief Research Officer, who is a member of the Standing Fisheries Research Committee, attended the deliberations of the Committee on the 28th and 29th October 1957 and the final meeting of the Committee on Standardisation of Names of Fishes and Fishery Subjects on the 30th October and 1st November 1957, at Hyderabad. The Assistant Research Officer (Estuarine Fishery Biology) also attended the Fisheries Research Committee Meeting as a co-opted member. The Chief Research Officer, all other Officers and senior Research Assistants of the Station attended the first All-India Fisheries Research Workers' Conference held at Mandapam from the 10th to the 14th January 1958.

Deputations

Shri V. R. Pantulu, Assistant Research Officer (Pond Biology), left on deputation for training in biological investigations connected with the design of fish-ladders in Canada under the Colombo Plan. Dr. T. V. R. Pillay, Research Officer (Estuarine), was deputed for training in biological investigations relating to exploratory fishing surveys in the U.S.A. under the Point Four Programme.

Visitors

During the year, there were a number of visitors to the Research Station, among whom may be mentioned, Mr. G. A. Baron Von Maydell, Leader

of the Deutsche Indian Expedition, Dr. and Mrs. J. B. S. Haldane, Dr. G. L. Clarke of Harvard, Dr. J. H. Ryther of Woodshole Oceanographic Institution, Prof. Shen Chia-Jui of the Institute of Zoology, Academia Sinica, Peking, Messrs. Woodbury and Varshneya of the U.S. Technical Co-operation Mission, Mr. Tadashi Yamamoto, Deputy Chief of Fisheries Statistics Section, Ministry of Agriculture and Forestry, Tokyo, Japan, Dr. R. L. Jhonson, Fisheries Adviser, U.S.A. International Co-operative Administration, Washington, and Dr. T. J. Job, Fishery Biologist, F.A.O., Rome. Dr. N. K. Panikkar, Fisheries Development Adviser to the Government of India, Dr. D. Bhatia, Deputy Fisheries Development Adviser to the Government of India and Mr. C. L. Kaufmann, T.C.M. Fisheries Adviser, also visited the Station during the year.

A report of the results of investigations conducted in the various Sections and Units is given below. A list of publications from the Station is given at the end of the report.

Pond Culture Section

Studies on fish breeding in confined waters

By flooding.—Experiments to induce major carps to breed in fish ponds by controlled flooding of the ponds were carried out at Angul and Sambalpur fish farms. The experiments were not successful. Owing to marked shortage of rainfall no satisfactory flooding experiments could be tried at Cuttack. However, the attempts at Angul were partially successful in that *Barbus sarana* responded to flooding and spawned in the flooded fields.

By injection of pituitary hormones.—Inducing breeding by pituitary gland hormones was taken up as one of the major items of work of the Substation for this year and facilities for this work were arranged at 2 centres in Orissa, *viz.*, Cuttack and Angul. Pituitary glands for injection were collected from mature carps locally and from Calcutta and ripe male and female breeders were injected with various doses of preserved as well as fresh pituitary gland, intramuscularly as well as intraperitonially. Some of the fishes spawned 6–8 hours after injection. In certain cases 2 injections were required to induce spawning; while in some others even repeated injections did not succeed. The work at both the centres was quite successful, and *Labeo rohita*, *Cirrhina mrigala*, *Labeo calbasu*, *Labeo bata*, *Cirrhina reba* and *Barbus sarana* spawned successfully by this method. The eggs hatched successfully and the fry thrived under laboratory as well as field conditions.

The successful breeding of major carps, induced by injection of pituitary gland hormones, is an outstanding achievement which opens up an interest-

ing line of work which will not only ensure supply of quality fish-seed but also production of various strains of any particular species by selective breeding.

To find out whether the gonads will mature in the Indian carps during the off-seasons also, if periodic injections of pituitary gland hormones are given, an experiment of three weeks' duration was carried out in 2 cement cisterns. Adult specimens of *Labeo bata* and *L. calbasu* were kept in the cisterns and weekly injections (intramuscular) of extracts of pituitary gland of Tilapia preserved at room temperature were given. Though the period October–November was the least favourable for the maturation of gonads, one male *L. calbasu* attained oozing condition after 2 weekly injections. Dissection of the specimen at the end of the experiments showed the testes in the V stage of maturity. The females, however, did not respond.

With the successful breeding of various specimens of Indian carps it has been possible to attempt to identify the early fry of the different species. Successful correct identification of the early fry of the different species would enable segregation of fry of uneconomic species from fry collections made in the rivers.

A preliminary experiment in inducing spawning of grey mullets by injection of pituitary gland extracts was conducted in the Cranganore back-waters. Ripe specimens in excellent condition were selected from the dip net catches, kept in cloth hapas fixed in shallow water and various doses of injections were tried with preserved mullet glands as well as Tilapia glands. While the results with the former were not conclusive, a single intramuscular injection of preserved Tilapia gland, at 0·2 gm. per fish, induced spawning within 8 hours. The eggs, however, were not fertilised. The attempt has shown that this salt-water fish also responds similarly to hormone injections as the carps.

Breeding of the common carp, Cyprinus carpio.—A consignment of early fingerlings (2·4–5·6 cm. long) of the common carp, obtained from Bangkok during early August 1957 and released in the Kila nursery ponds, attained sexual maturity by the end of November 1957. Presuming that the fingerlings were 1 month old at the time of receipt at Cuttack, they attained maturity by the 5th month of their life, when they had attained an average length of 17 cm. Natural breeding in 2 of the 6 ponds in which they were stocked commenced during January 1958, but natural production of fry and fingerlings in the ponds was extremely poor, being less than 2,000 till the end of March 1958.

The first successful attempt to induce this fish to breed by providing egg collectors was made on 16-2-1958 and thereafter till the end of March 1958. Over 30 female fish were successfully induced to breed, in cement cisterns, in cloth hapas fixed in the pond itself or in cisterns and on egg collectors fixed in the stock ponds. Breeding takes place within 10–36 hours after keeping the fish in cisterns or hapas, ordinarily during the early morning hours. The eggs attached to the weeds or egg collectors take about 45–53 hours for hatching. Two days after hatching the fry are ready for stocking in the prepared nursery ponds. In 15 days the fry attain 25–35 mm. size and are ready for distribution to rearing ponds.

A detailed study of the natural food of the specimens in our waters during various stages of growth has been initiated. Laboratory experiments have shown that like the fry of Indian carps the common carp fry also subsist mainly on a diet of zooplankton during early stages of alimentation. They however appear to be less adaptable to artificial food like oil-cakes, than the fry of Indian carps, during early fry stage.

By the end of March 1958 nearly 3 lakhs of fry were produced by induced breeding in cisterns and hapas. Nursery ponds were repeatedly stocked and harvested of advanced fry. Nearly 1,20,000 fry and about 20,000 advanced fry and early fingerlings were supplied to the Orissa Fisheries Department for experimental rearing in various farms; experimental consignments each of 200 fry, 1–1½" long, were supplied to Bengal, Bihar, Madras, Madhya Pradesh, Manipur, Punjab and the Extension Units at Bangalore and Hyderabad; and a stock of over 20,000 fingerlings have been kept in the Kila farm for various experiments.

The successful breeding of the common carp, which compares in growth and size with our major carps and has the added advantage of breeding in confined waters, now adequately meets the requirements for which Tilapia was being suggested in certain States.

Observations on the Growth of Common Carp (Cyprinus carpio)

Early fingerlings of the common carp, 2·4–5·6 cm. long, brought from Bangkok in August 1957, attained sizes of 7·5–21·75 cm. in nursery ponds stocked at the rate of 7,500 per acre (without artificial feeding), 11·8–23·8 cm. when stocked at the rate of 3,000 per acre (with limited artificial feeding), and 16·2–25·2 cm. when stocked at the rate of 1,000 per acre (with limited artificial feeding), within a period of 3 months. The maximum size the fish attained so far is 32 cm., weighing 655 gm. (about 1¼ lb.), in a period of 9 months.

Studies on fish culture in paddy fields

Experimental work in irrigated paddy fields covering an area of about 12 acres was carried out with reference to the extent of deeper trench area required, effect of manuring with cow-dung, oilcake and sulphate of ammonia on fish production and yield of paddy, effect of artificial feeding and effect of stocking fish before transplanting paddy. But the results as a whole were disappointing and the fish production in the various plots was extremely poor. Fresh experiments in 8 plots covering 1·8 acres have been taken up with the summer crop of paddy. Tilapia has been stocked in these fields.

Detailed studies on the fish seed catches from irrigated paddy fields at the Samalkot Centre, East Godavari District, Andhra Pradesh, were continued during the 1957 season also. Selected fields covering an area of 55 acres were under observation. Partial analysis of the departmental collection figures indicate production for the 100 days' season as 3,529 fingerlings of *Catla* and 6,561 fingerlings of *Labeo fimbriatus* per acre of field.

Tilapia investigation

Owing to the inherent poor productivity of the Puri ponds, the survival and production of fish in the carp-Tilapia combination experiments at the Brickfield farm were poor. While definite conclusions are not warranted from the data now available, it appears that when more Tilapia and Mrigal are stocked together the survival of the latter is adversely affected markedly. Such a marked trend is not evident in the case of *Catla* and *Rohu*.

Presence of Tilapia in carp nursery ponds has definite adverse effect on the survival and growth of carp fry. Tilapia, up to 50 mm. long, have been observed to feed directly on young carp fry. Extreme competition for food is also demonstrated by the very low survival of Catla, Rohu, Mrigal and Bata fry. The relatively poor growth of even the few surviving fry further indicates the extent of competition. Fry of Reba appear to be less affected than those of the other carps. The weight of fish produced in ponds where Tilapia and carp fry were stocked together was also much less than the weight of fish in ponds where carp fry alone were stocked.

Fortnightly harvesting of Tilapia from a one acre stocking pond has been found to yield fairly satisfactory results so far as production in terms of weight is concerned. Within a period of six months over 560 lb. of Tilapia have been harvested. The size of the marketable fish however remains very small, 4–5" only, and consumer preferences in Cuttack are the lowest

for this fish probably because of the small size, the very dull and uninviting appearance when dead and the relatively poor taste.

Pond Culture Work in Assam

The opening of a Pond Culture Research Unit in Assam, with a view to test under different environmental conditions the various fish culture practices evolved at Cuttack and popularise fish culture in the north-eastern part of India, is one of the significant steps in extending the work of the Cuttack Substation to other parts of the country. This Unit is located temporarily at the Joysagar fish farm of the State Fisheries Department, which has placed fifteen nursery ponds and four stocking ponds at the disposal of the Unit. Six nursery ponds were stocked with carp spawn transported from Calcutta and a fair crop of fingerlings was raised there for stocking experiments. With the active co-operation of the State Department, arrangements are being made to carry out large scale fish breeding work at the Joysagar farm during the ensuing season.

Nursery operations

Application of Endrin for eradication of insects and fish.—Laboratory experiments have shown that a very low dose of Endrin (0·001 p.p.m.) was effective in killing fishes, insects, prawns, etc., without affecting zooplankton. Experiments in Puri ponds stocked with *Tilapia* and carp in combination were completed, but in spite of repeated netting whole population could not be recovered. For eliminating *Tilapia* from the ponds completely and also to procure the specimens early, for measurements, a higher dose of 0·01 p.p.m. of Endrin was sprayed in 20 ponds. Within 30–40 minutes most of the fishes came near the edge of the ponds and died. All insects, tadpoles, prawns and crabs were killed, but zooplankters were not affected. It takes only two days for the water to lose toxicity with 0·001 p.p.m., but with the higher dose of 0·01 p.p.m. the toxicity continues for about 2 weeks.

During the 1957 season 18 nursery ponds in the Kila and 6 at Chaudwar were stocked with fry obtained from the Naupara collection centre, for routine rearing of advanced fry and fingerlings required for various experiments. The quality of the spawn was poorer than in previous years as the percentage of uneconomic species was more this year. After meeting the stocking requirements at Kila, Chaudwar, Linghipur, Puri and the paddy-*cum*-fish culture plots, about 1,25,000 early fingerlings were supplied to the Orissa Fisheries Department.

Studies on soil composition in relation to fish production

Determination of soil reaction and available micro-nutrient status of the soil in 48 tanks managed by the State Fisheries Department and in 24 fish farms distributed all over the 13 districts of the State showed that mostly the soils are either slightly alkaline (pH 7·0–8·0) or slightly acidic (pH 6·0–7·0). In some areas, *viz.*, Keonjhar, Dhenkanal, Angul, Berhampur, Belgunta and Bolangir Tank, soils showed relatively more alkaline reaction (pH 7·8–8·2), while Nuapara (Puri) soil pH was less than 6·0. Available phosphorus was rather poor in all the areas except Athmallik, Berhampur, Sambalpur and Nuapara and available nitrogen fluctuated irregularly bearing no correlation with available phosphorus.

A series of manuring experiments conducted in 24 ponds at the Linghipur fish farm showed that the soil, though slightly acidic (pH 6·3–6·6), does not appear to respond to liming at doses 200 lb./acre and 600 lb./acre. Observations after one month of adding the lime showed that there was practically no increase in soil pH, all the soils remaining slightly acidic as before. This evidently showed that the reserve soil acidity was considerably high, even a dose of 600 lb./acre of lime being unable to make the soil reaction slightly alkaline. It was also noted that even a heavy liming was not able to increase the soluble inorganic phosphate of the water by releasing the absorbed phosphate of the soil. This may, however, be accounted for by the fact that the available soil phosphate itself is very low.

Just after liming some increase in soluble alkalinity was observed as compared to that in control ponds, both for low liming and heavy liming. A marked increase in alkalinity to about 300 p.p.m. was observed in ponds treated with high lime and high organic manure, but this increase was only temporary. At the end of September the total alkalinity in all the ponds came down to about 60–70 p.p.m. Addition of phosphatic fertilisers at high dose (600 lb./acre) of organic manures (cow-dung 30,000 lb./acre) increased the soil phosphate appreciably. It is interesting to note that lime played an important role in increasing the available soil phosphate. Thus the increase of available soil phosphate for combinations (1) high lime and high phosphate and (2) high lime and low phosphate, was greater than that for low lime and high phosphate.

To study the growth rate of the major carps Rohu, Catla and Mrigal under different soil conditions, 12 selected tanks in the State of Orissa and 6 tanks in Madhya Pradesh have been stocked with carp fingerlings Rohu, Catla, Mrigal in the ratio 1 : 1 : 1 as far as practicable. The Orissa tanks have been stocked at the rate of 1,000 fingerlings per acre and Madhya

Pradesh Tanks have been stocked at the rate of 2,000 fingerlings per acre. Observations made so far on soil quality show that both in Orissa and in Madhya Pradesh soil reaction is generally either slightly acidic or slightly alkaline. The available phosphorus is rather poor in piscicultural soils of Orissa while for Madhya Pradesh soils, phosphorus status is quite fair. Available soil nitrogen is quite appreciable both in Orissa and in Madhya Pradesh.

Weed control studies

Yard experiments in earthenware gumlas showed that *Salvinia*, *Pistia* and *Lemna* are completely killed by powerine and h.s.d. applied at the rate of 75–100 gl. per acre under condition of bright sunshine, the killed plants decomposing and dissolving in water in about 3–5 weeks. In the case of *Salvinia* a lower concentration of 50 gl. per acre was also effective. If, however, there was rain before the plants were completely killed, there was a tendency for the plants to revive. The effect of these oils on water hyacinth was not so marked even when two treatments at 75–100 gl. per acre were given within 10 days. Though the leaves were affected, the plants revived gradually again. The effect of these oils on fish life is under study.

The principle of starving out the underground parts of water lily was applied in a pond of 0·32 acre choked with the plant. The floating leaves were cut about 1–1½′ below the water surface during the first week of October. By four subsequent clearances of 29%, 19%, 32% and 1·4% (in terms of the number of leaves present at the outset) of fresh leaves which came up, the pond could be kept thoroughly clean in two months' time. Even though 4 months have passed after complete clearance, the plant has not reappeared, indicating thereby that the underground parts have been completely killed. The cost of labour at 60 man-hours for the 0·32 acre pond worked out to about Rs. 45·00 per acre.

Hydrilla and *Naias* grown in cement cisterns were treated with nigrosine at the rates of 100 and 250 lb. per acre. Though the water in these cisterns remained black for 3–3½ months, there was only a slight arrest in the growth of the plants from the second to the third month after treatment, compared to vigorous growth of the same plants in an untreated cistern. When the water cleared in the treated cisterns at the end of 3½ months, the weeds started growing vigorously again, thereby showing that nigrosine is not a very effective shading agent.

Preliminary trials in aquaria and cisterns with fernoxone, Dicotox, 2, 4-D at various doses did not yield encouraging results.

Experiments conducted at Calcutta previously had indicated that superphosphate at 150–500 p.p.m. (single application or in instalments at close intervals) killed submerged weeds like *Hydrillà* and *Vallisneria* almost completely. Any unaffected plant which remained was cleared manually. The experiment was repeated at Cuttack on *Hydrilla* and *Naias* grown in cement cisterns. Within a few days after treatment a bloom of algæ appeared in the treated cisterns and 90–95% of the plants were killed within 2–2½ months. Thereafter the algæ bloom disappeared and the surviving *Hydrilla* multiplied rapidly from underground parts, while *Naias* did not reappear.

Much the same result was obtained when commercial urea was applied on *Hydrilla* and *Naias* grown in cement cisterns at the rates of 250–500 p.p.m. (in one instalment) and 300 p.p.m. in 12 instalments. However, the algal bloom which appeared was thicker and the destruction of plants more complete than in the case of superphosphate. Small shoots started coming up in the cisterns treated with 250 and 300 p.p.m. only at the end of 3½ months, when the water cleared. In the cistern treated with 500 p.p.m. no shoots appeared even after 4½ months, though some underground parts of *Hydrilla* still remained in the mud.

With lower concentration (50–125 p.p.m.) of the fertiliser, 50–90% control of *Hydrilla* was obtained under the same conditions and in a field experiment conducted in a pond choked with *Hydrilla* and *Naias* 50 p.p.m. of the fertiliser killed 50–60% of the submerged weeds. In the pond there was partial mortality of fish 2 days after treatment owing to the depletion of oxygen in the early morning hours. Some of the distressed fish caught and released in fresh water revived quickly.

Preliminary experiments in earthenware gumlas indicate that ammonium sulphate of 100 p.p.m. is useful in cleaning *Hydrilla ceratophyllum* and *Pistia* and a large percentage of *Vallisneria* and *Lemna*. Further experiments in different concentrations have to be carried out before drawing definite conclusions.

Comparative estimates of cost of clearing weeds by manual labour and by chemical treatment (sodium arsenite) revealed that in manual labour, 720 man-hours each at a cost of Rs. 180 per acre had to be put in, which works out to Rs. 240 per acre per annum, whereas in chemical treatment one application every 6 months at a cost of about Rs. 40, which works out to Rs. 80 per acre per annum was sufficient, the cost per acre foot for one application being Rs. 13–15.

Riverine and Lacustrine Section

Studies on the fisheries and fish population of the Ganga river system, observations on the catch-per-unit-of-effort for different commercial fishing gear and biological investigations of certain commercially important fishes were among the main items of work carried out in this section during the year under report.

Fishery investigations in the Ganga river system

Disposition of commercial fisheries of the rivers Ganga and Jamuna at Allahabad: Sadiapur Assembly Centre on the River Jamuna.—This centre handles mostly the fish catches of Jamuna river. A total of over 1,93,890 kg. of fish were estimated to have landed during the year as against 4,81,650 kg. in 1956–57 and 3,44,430 kg. in 1955–56.

The maximum catches were made in October and the minimum in August. As in 1956–57, the period October to January was found to be the season of heaviest catches and over 41% of the annual catches were landed during these months. A comparison of the commercial catches of the last 3–4 years shows that the fluctuations therein are influenced mainly by *Hilsa* fishery.

Year	Catches other than *Hilsa* (kg.)	*Hilsa* catches (kg.)	Total catches (kg.)
1955–56	.. 2,13,755	1,20,672	3,44,427
1956–57	.. 1,75,783	3,05,875	4,81,658
1957–58	.. 1,42,719	51,174	1,93,893

There has been a progressive downward trend in the catches from year to year and the decline in the catches has been 17·7% in 1956–57 as compared to the catches of the previous year and 18·7% in 1957–58 as compared to those in 1956–57. The possible causes for the decline may be (i) extreme draught conditions or excessive and untimely floods, (ii) switch over of the profession of a section of fishermen, (iii) general economic conditions of fishermen who were unable to replace old and worn-out fishing gears and (iv) silting up of some fishing grounds.

The comparison of size composition of various fishes, which enter the commercial catches, for the last 3 years, does not seem to suggest that the fisheries are over-exploited.

Hilsa.—The fishery of Hilsa was found to be poor and made up 26·4% of the total annual landings. Hilsa was available throughout the year but in smaller quantities, with heavy catches in the months April–June, October and November and the catches made in these 5 months accounted for over 87% of the annual Hilsa landings. The heaviest catches were made in October (13·778 kg.) and lowest in August (286 kg.). The trend of the fishery during the year under report was considered rather unusual in a sense that Hilsa constituted a very good fishery in the summer months of April–June, whereas in other years poor catches of Hilsa were made in these months. The size group 41·0–52·0 cm. was found to be the most predominant group in all the months excepting December and represented over 83·7% of the total Hilsa landings of the year. The juveniles (up to 24·0 cm.) which accounted for 1·2% of the Hilsa catches during the year made their first appearance in the commercial catches in November and were totally absent in the months April–October. The large fish (53·0 cm. and upwards) made up only 0·2% and were present only in May and a few stray specimens were noticed in September.

Major carps.—The fishery of major carps was found to be the most important, constituting 35·1% of the total annual landings and it follows the same pattern as observed in the previous years with *C. mrigala* contributing the maximum. The fishery was on the whole quite steady throughout the year with good landings recorded in the months September–January. During the year under report some decline in the catches was noticed which formed slightly over 83% of that in the previous year (67,888 kg. as against 81,764 in 1956–57).

Among the major carps *C. mrigala* continued to form the most important fishery contributing 17·0% of the total annual landings and 48·4% of the annual carp catches. A total of 32,912 kg. of Mrigal were estimated to have landed during the year showing a fall in production of about 30% when compared to the *Mrigal* catches of 1956–57. The possible reasons for the decline of this fishery have been already mentioned. The juveniles (up to 32·0 cm.) which formed 8·6% of the annual Mrigal catches were available throughout the year but the fishery was of some importance in the months October–December. Commercial catches of Mrigal were mainly represented by 53·0–67·5 cm. size group (28·8%), closely followed by 33·0–52·0 cm. size group (24·7%) and 68·0–77·5 cm. group (17·9%). The larger fish

(78·0–87·0 cm. and 88·0 cm.—upwards size groups) together accounted for 20·0% of the Mrigal catches. There does not appear to be any marked difference in the representation of various size groups in the commercial catches of Mrigal when compared to that of the previous year, which might indicate the reasons of the decline of this fishery in the present year.

The fishery of *Rohu* was the next most important closely followed by that of *Catla*. The contribution of Rohu, Catla and Calbasu in the total annual landings was respectively 14,950, 13,435 and 6,590 kg. In the previous year the catches of the three species was respectively 14,168, 10,843 and 9,305 kg., showing a definite upward trend in production of Rohu and Catla and a decline of the same order in Calbasu. Rohu was mainly represented by 53·0–67·5 cm. size group (28·4%), closely followed by 68·0–77·5 cm. group (21·7%). The other size groups were adequately represented. The juveniles were mostly absent in the summer and monsoon months of March–August and the juvenile fishery was important in November–December. The fishery of Catla was mainly represented by juveniles (33·9%) and the other size groups were fairly equally represented. The juveniles formed the most prominent fishery in November–December. The fishery of Calbasu was mainly represented by 43–54·5 cm. groups (44·0%) and 28·0–42·0 cm. group (30·8%). As in the case of Catla and Rohu, juveniles of Calbasu formed important fishery in November–December.

Cat-fishes.—The cat-fish fishery represented by ten species was of considerable importance and contributed 30·9% of the total annual landings during the year under report. The pattern of fisheries of different species of cat-fishes did not evince any marked fluctuation as compared to the cat-fish landings of 1956–57 although there was noticeable decline in the cat-fish fisheries (59,820 kg. as against 74,160 kg. in 1956–57). This was mainly due to poor returns from the fishery of *Wallago* (9,623 kg. as against 18,190 kg. in 1956–57), Silondia and *Rita*. The fishery of Vacha had considerably improved during the year, the other fisheries registering minor fluctuations.

Among the cat-fishes, the fishery of *Mystus* spp. (represented by two species: *M. aor* and *M. seenghala*) continued to be the most important, contributing 15% of total annual landings and over 49·0% of the annual cat-fish catches. *Wallago* formed the next most important fishery (16·1% of the total cat-fish catches) closely followed by *Pangasius* and *Rita*.

The catches of *Mystus aor* were mainly represented by bigger size groups and fish of size groups above 88·0 cm. accounted for 27·5%, closely followed by the size group 79·0 cm. (23·0%). These size groups, however, were

totally absent in the commercial catches of April and May. Juveniles (up to 20·0 cm.) were well represented (7·7%) and in July, August and September they formed the most predominant group. Similar pattern of size distribution was observed in the case of *Seenghala*. *Wallago* was more or less uniformly represented by all the size groups, with the size groups 66–78·0 cm. slightly more predominant than others. Juveniles (6·2%) were totally absent in the months February–August and were adequately represented in the catches of November–January.

Miscellaneous.—Among the miscellaneous group, the fishery of featherbacks *Notopterus* spp. was of considerable importance (0·9% of the total annual landings). These forms were available in the commercial catches in all the months excepting December. The lesser species belonging to the genus, *Aspidoparia*, *Mystus*, *Chela*, *Puntius*, *Amblypharyngodon* and some clupeids other than *Hilsa ilisha* and *S. phasa* together formed a fishery of some importance (4·6% of total annual landings) and heavy landings were recorded in the monsoon months, June–August. The freshwater prawns and shrimps formed a seasonal fishery of some importance during June and July. The Freshwater rays were available only occasionally except in the month of March when over 472 kg. were recorded.

Daraganj assembly centre on river Ganga.—Following demarcation of fishing areas in the Ganga and the Jamuna rivers the Daraganj assembly centre located on river Ganga has assumed some importance and the catches from the Ganga are mostly assembled at Daraganj. The work on collection of catch statistics at this centre was commenced from May 1957. A total of about 54,970 kg. of fish were estimated to have been landed at Daraganj during the year. The heaviest landings were recorded in May, but the months June and September were also almost equally good with lowest catches recorded in January.

The species composition of the fisheries of the two rivers apparently appears to be comparable, with Hilsa, Mrigal and *Mystus* spp. constituting the major fisheries in the two rivers. It is, however, observed that the fishery of major carps in the Ganga is comparatively poorer than in the Jamuna. The Ganga is shallow and wide with swift current during most of the year, thus offering fewer shelters to larger fishes. The Schilbeid fishes (Vacha, Garua, *Ailia*) formed a fishery of great importance and together accounted for over 23·5% of the total annual landings. The contribution of Hilsa and major carps in the catch was respectively 19·8% and 20·2%. The Schilbeid fisheries were of considerably less importance in the Jamuna river. The observations have shown that these fishes are available in shallow

areas along the river inundated by flood waters during the monsoon months and their fishery assumes importance generally in the winter and summer months, December–June.

Fish population studies in the Ganga and the Jamuna based on sampling fishing method.—This study was commenced in September 1957. The gear which was a composite type Mahajal was operated once a week and at least three hauls were made in the same general area on the day of fishing. The catches from each successive haul were separately examined. The fishing in the Ganga was possible only in September and October and has once again been resumed since March.

The species composition of the fishes from the Ganga appears to follow the same trend as that observed from the Jamuna. The first point that emerged from the analysis of the data available from the sample fishing was that the species composition was found to be very much different from the commercial catches. Different types of fishing gear are used by commercial fishermen in different months and the areas of fishing also change with the season. It is interesting to note that Schilbeid fishes were the most important species in our sample fishing. These species are small and medium-sized and since in the commercial catches at Sadiapur these species formed only a fishery of minor importance, it follows that commercial fishermen employ highly selective gears. The departmental gear is now being modified and improved upon. The comparison of the data, however, shows that the composition of different species had not much varied from month to month excepting for Hilsa which is a migratory fish and its fishery is important in winter months. Thus it is reasonable to conclude that the gear is effective for providing a representative sample of a population of the area where the fishing is done. This would suggest that some attempts have to be made for establishing the geographical limits of various fish populations since the species composition of the commercial catches from the Jamuna (at a distance of about 20–40 miles upstream from where the departmental fishing is done) is different.

Fishing effort was calculated for the composite type of gear operated by the department once a week in the Jamuna. The fishing in the Ganga river was possible in the two months September 1957 and February 1958.

Average catch in kg. per haul per hour of fishing with the predominant species present in the catches

River Ganga—

September 1957 .. 14·705 kg. (*E. vacha*, Rays, *S. Phasa*, *Mystus*, *Hilsa*)

February 1958 .. 1·99 kg. (*C. garua*, *E. vacha*, *S. phasa*, *A. coila*)

River Jamuna—

October 1957	..	8·76 kg. (*C. garua, E. vacha, S.phasa, Hilsa*)
November 1957	..	7·95 kg. (*E. vacha, C. garua, S. phasa, Chela* spp.)
December 1957	..	3·96 kg. (*A. coila, E. vacha, Hilsa, C. garua*)
January 1958	..	3·31 kg. (*C. garua, E. vacha, S. phasa, G. chapra*)
February 1958	..	2·36 kg. (*C. garua, E. vacha, S. phasa, G. chapra*)
March 1958	..	6·27 kg. (*C. garua, E. vacha, S. phasa, G. chapra*)

It is seen from the above table that there is a gradual fall in the catches till February 1958 and thence the upward trend is discerned. It is interesting to note that the fishes largely caught with the composite type Mahajal are *C. garua, E. vacha, S. phasa, G. chapra* and *Hilsa.*

Observations on catches-per-unit-of-effort for different commercial gear in the river Jamuna.—Fish catches made by the fishermen in the vicinity of Allahabad by the different types of gear were recorded. The types of gear used are Mahajal, Chhata, Chaubandi, Darwari, Do-dandi, Bandal, Gopaljal, Kuriar, Hook and Lines, Tiar, Kamel, Gochail, Jali, Sirka and Rod and line. Among these, Mahajal and Darwari were found to yield highest catch-per-unit-of-effort, with the catch of the former consisting mainly of Hilsa, Rohu, Catla, Mrigal, *Pangasius* and *Mystus* and that of the latter Garua, Vacha *Pangasius, Ailia* Silondia, Hilsa, *Mystus*, Prawns, Mrigal, and *Wallago.*

Disposition of commercial fisheries of the river Ganga at Buxar.—Buxar on the Ganga is located about 250 miles east of Allahabad. Considering the overall picture for the year under report, the species composition of the commercial catches at Buxar followed a similar trend as observed at Sadiapur and Daraganj in Allahabad, the fisheries of Hilsa, major carps, *Mystus* and *Wallago* forming the bulk of the catches. Hilsa, however, continued to be the most important fishery of the area accounting for over 37·7% of the total annual landings, whereas at Allahabad (Sadiapur and Daraganj), the most important fishery of the year was that of major carps with Hilsa fishery a close second. Hilsa was caught throughout the year and it is interesting to note that heavy catches were made during the period April–October. A similar pattern of fishery was observed at Allhabad also. The size range which entered the commercial catches was 293–518 mm., but the bulk of the catches were in the size range 370–465 mm. The juveniles (200–255 mm.) made their first appearance in December.

The major carps together accounted for 16·5% of the annual landings with Mrigal forming the most predominant fishery among major carps.

Poor landings of major carps were observed in the months July–October and heavy landings of Hilsa were recorded during this period, suggesting that the fishing effort was mostly diverted to Hilsa fishing.

The cat-fishes as a group formed a substantial fishery at Buxar constituting over 25·4% of the annual catches. The fishery of cat-fishes was on the whole quite steady, but heavy landings were recorded in March, April and June with lowest catches in the month of October. Among the cat-fishes, the fisheries of *Mystus*, *Wallago* and Garua were the most important, contributing 30·3%, 29·9% and 16·5% respectively of the total cat-fish catches of the year. The fishery of Garua was most important in the months January–April and the catches in the four months accounted for over 76·6% of the annual Garua landings.

It is interesting to note that the fishery of Rays and Tortoises was quite important at Buxar specially in the months of December–March and August–September and together accounted for over 14·9% of total annual landings. The fishery of freshwater Rays is negligible and only stray specimens of Tortoise are recorded at Allahabad. While considering the broad groups, the pattern of fisheries both at Allahabad and Buxar appears to be similar, but there are considerable fluctuations in the species composition.

Biological investigations

Fishery biology of Mystus aor *and* Mystus seenghala.—A total of over 25,831 kg. of *M. aor* and 12,028 kg. of *M. seenghala* were estimated to have been landed at the two assembly centres at Allahabad during the year 1957–58. The value of the *Mystus* fishery was estimated to be about Rs. 43,500. The fishery was found to be more important in the months November–March than in April–October. Individuals of *M. aor* measuring up to 29 cm. dominated (by weight) the commercial catches landed at Daraganj, while at Sadiapur it was dominated by the bigger individuals of 89 cm. and upwards. As for *M. seenghala*, the 48–65 cm. group and 89 cm. upwards group dominated the catches landed at Daraganj and Sadiapur respectively.

The correlation between total length (mm.) and weight (kg.) for the two species was found to be high with the value of "*r*" being 0·9979 in *M. aor* and 0·9968 in *M. seenghala*. The general length/weight relationship in *M. aor* is expressed as $\log W = -5{\cdot}30358 + 3{\cdot}05 \log L$ and in *M. seenghala* it is expressed as $\log W = -5{\cdot}61369 + 3{\cdot}15 \log L$.

The sex ratio in the commercial catches of the two species for the year 1957–58 was calculated to be (*males first*) 45–55 in *M. aor* and 45·8–54·2

in *M. seenghala*. The males of the two species were comparatively in larger numbers during summer months March–July, but females were found to be in greater numbers in about all the other months. The gonado-somatic indices for both the species have been calculated monthwise. The fish with ripe ovaries are first observed in November and the values progressively increase up to February–March. Thereafter the values show a sudden fall suggesting the commencement of breeding season in April. The low values persist up to August suggesting continuous breeding. It is interesting to note that one female specimen of *M. aor* with spent gonads was recorded in the month of November.

The fecundity of *M. aor* of the size range 869–970 mm. was found to be 82,800–1,22,400 ova, and the number of ova per gram weight of the ovary was found to be 810–1,196. The fecundity of *M. seenghala* of the size range 855–1,020 mm. was 40,800–95,000 ova and the number of ova per gram weight of the ovary was found to be 770–1,116.

As reported earlier, the composition of food appears to be more or less the same in both the species, consisting mainly of small Teleost fish and insects. Among others may be mentioned shrimps, crabs and plant debris.

It is interesting to note that juveniles of *M. aor* subsist on teleosts in greater percentage than the adults of the species. The juveniles of *M. seenghala* subsist mainly on teleosts but the percentage of insect feed is higher in juveniles than in adults. The adults of *M. aor* which subsist mainly on insects have higher percentage of mucus, the phenomenon which was reported in the case of *E. vacha* and *C. garua*.

Age or size class composition, maturity and feeding of fish stocks

Clupeids.—Besides *Hilsa illisha*, *S. phasa* and *G. chapra* were the most important species in the catches from the Jamuna. Hilsa of the size range 38–48 cm. formed the bulk of the catches although smaller sizes 27–31 cm. and 33–36 cm. were also encountered. The mature specimens (33–48 cm.) were available in October and thereafter spent species were encountered. The fish subsisted mainly on zooplankton. *S. phasa* and *G. chapra* were available in good numbers in all the months. The size of *S. phasa* ranged between 15 cm. and 300 cm. in total length with the most predominant groups being 15–22 cm. and 25–28 cm. The condition of the gonads showed that *S. phasa* commence breeding from February and running ripe gonads were observed in February and March. The fish subsists mainly on insects and shrimps. *G. chapra* of the size range between 9 cm. and 20 cm. were encountered, but the predominant group ranged between 13 cm. and 17 cm. A few stray specimens with mature gonads were encountered in February

but comparatively greater number of mature specimens were observed in March suggesting that this fish breeds a month or so later than *S. phasa*. The fish subsists mainly on zooplankton.

Cat-fishes.—Eight species of cat-fishes were caught but the bulk of the cat-fish catches was represented by *C. garua*, *E. vacha*, *G. cenia*, *P. murius* and *A. coila*. The fishery of Vacha, Garua, and *Ailia* was most important in all the months since the study was commenced. *C. garua* of the size range between 15 cm. and 36·0 cm. were caught but the predominant group in almost all the months ranged between 19·0 cm. and 30·0 cm. *E. vacha* of the size range between 15 cm. and 24 cm. and *A. coila* of the size range between 11 cm. and 18 cm. formed the bulk of the catches in almost all the months. *G. cenia* and *P. murius* are small-sized cat-fishes and the largest species of *G. cenia* measured 8·8 cm. and that of *P. murius* 14·6 cm. No mature specimens of *C. garua* were encountered in the catches, but the size range of juveniles encountered in October and November seem to suggest that the fish breeds in monsoon months like most of the freshwater cat-fishes. Mature specimens of *E. vacha* were observed from December onwards, although larger percentage of mature specimens were encountered in March suggesting the commencement of breeding from that month or April. Mature specimens of *A. coila* and *P. murius* were not observed during the period of study. The intensity of feed in *E. vacha* was varied. From October–December the fish subsisted actively on insects and teleosts and thereafter the intensity of feed became low. This may have some bearing on the conditions of gonads in these months. *P. murius* subsists mostly on insect food.

Carps.—The major carps were mostly represented by only a few stray specimens and the catches were mainly of *Chela* spp., *A. morar*, *R. cotio* and *A. mola*. Among *Chela* spp., *C. gora* was the most dominant form and specimens of size range between 9·0 cm. and 26·0 cm. were encountered, although the dominant group present in the catches was between 21·0 cm. and 26·0 cm. In December only juveniles (9·0–10·0 cm.) were encountered. Mature species of *C. gora* were observed in March suggesting commencement of breeding from April onwards. *A. morar* of the size range 3·1–11·0 cm. were noticed with the juveniles (3·1–4·0 cm.) forming the bulk of the catches in March 1958. In other months the size ranged between 9·1 cm. and 11·0 cm. Mature specimens of *A. morar* were first observed in December and spent specimens were encountered in March, suggesting that this fish commences breeding from January or February. The intensity of feeding activity of *C. gora* was rather poor during the period. The fish subsists mainly on teleosts and insects. Likewise, the intensity of feed in *A. morar*

was also poor with the fish subsisting mainly on decayed organic matter and plankton.

Fish Eggs and larvæ of the Jamuna

The study on the breeding and breeding seasons of various species of fish inhabiting the river Jamuna was commenced during the year. Regular collections of eggs, larvæ and fry were made in the Jamuna by towing one metre and half-metre ring nets and by operating shooting nets. The material so far collected show that *Chela*, *Aspidoparia*, *Puntius* and other forage fishes breed earlier than major carps and cat-fishes. Among the cat-fishes, *Mystus aor*, *M. seenghala*, *C. garua*, *Rita* and *E. vacha* commence breeding before the onset of monsoon months and continue up to August–September suggesting a prolonged breeding period. Among the major carps, *Catla catla* closely followed by *L. rohita* breed earlier than *C. mrigala*. Hilsa commences breeding towards the end of July but the peak breeding season falls in the months September–November.

Ganga survey

The first phase of the programme, namely, inventory of all the fishing villages located along 920 miles stretch of the Ganga from Bulandsahr (Uttar Pradesh) to Lalgolaghat (West Bengal) has been completed as also a 500 miles stretch of the Jamuna from Agra to Allahabad.

The stretch of the Ganga has been subdivided into six fishery zones on the basis of similarity in fishing methods, season of operation of various gear and types of gear used. In the first 300 miles of the Ganga from Bulandsahr to Buxar (Unnao District), the western bank has greater fishermen population than the eastern bank, but the types of gear suggest that the fishing is mainly confined to ponds, lakes, canal waters, etc., and rarely to the main river. Most of the fishermen have switched over to agriculture as their main profession. In the next 330 miles stretch from Kanpur to Babura (Shahabad District of Bihar), it was found that the stretch east of Allahabad is important from viewpoint of fish production and the fishermen population actively engaged in fishing is considerable. In the stretch of 300 miles from Allahabad to Babura, the eastern or northern bank is far more important and fishermen employ varied types of fishing gear of considerable efficiency. In the next stretch of 290 miles from Lohatola (Bihar) to Lalgolaghat (West Bengal), the southern or west bank was found to be the more important with larger number of fishing villages and fishermen. The fishermen mostly depend on riverine fisheries in this area,

but the fishermen dwelling along the northern bank depend mainly on Jheel fisheries.

Studies on water pollution

The studies on the toxicity thresholds of over 36 chemicals likely to be present in trade wastes of paper and pulp mills, chemical industries, textile mills, leather tanneries, electroplating units, etc., have been made. The test animals *Daphnia* sp. were used in these bioassay experiments. Ammonium hydroxide is found to be most toxic of the alkalies tested, specially in hard alkaline waters. Sodium hydroxide, potassium hydroxide and calcium hydroxide were less toxic in hard waters. Among the metal salts, copper sulphate has been found to be the most toxic, with arsenic trioxide only slightly less toxic in the same concentration. Lead sulphate was toxic to animals in 16 hours at 100 p.p.m. concentration and in 36 hours at 600 p.p.m. Sulphates of zinc and iron were toxic to *Daphnia* within 12 hours when the concentration of chemicals was 250–300 p.p.m. Among the chlorides of sodium, potassium, lead, magnesium, ammonium, nickel, cobalt and iron (ferric), the last four chemicals were found to be toxic in about 12 hours at moderate concentration (300 p.p.m.) and the first three at much higher concentration (6,500 p.p.m., 1,000 p.p.m. and 1,000 p.p.m.), but magnesium chloride was toxic only in 70 hours at concentration of 1,000 p.p.m. Salts of aluminium are not found to be toxic because of the fact that much of the salts go to neutralise the natural alkalinity of the waters. With hydrochloric and sulphuric acids, the critical limits for toxicity has been observed near pH 4·0. Oxalic acid was only moderately toxic within 20 hours at concentration of 200 p.p.m. Although cyanides are known to be highly toxic, ammonium-thiocyanate has been found to be toxic only at 7·00 p.p.m. Organic acids like tartaric and tannic acids were observed to be toxic in 30 hours at concentration of about 300 p.p.m. Acetate of lead was toxic in 17 hours at the concentration of 80 p.p.m. but sodium acetate was found to be only mildly toxic (6,000 p.p.m. in 40 hours). Phenol, a disinfectant, was toxic at a concentration of 100 p.p.m. Among the gases, free chlorine was extremely toxic even at very low concentrations and hydrogen sulphide and carbon dioxide at concentrations of 20 p.p.m. These bioassay experiments are in progress.

Narmada-Tapti and Krishna-Godavari survey

A preliminary survey relating to (i) fish fauna, (ii) location and selection of potential centres for collection of carp fry and (iii) selection of suitable sites for pursuing survey programmes was undertaken. The Madhya Pradesh State Fisheries Department have established about nine

carp fry collection centres along the Narmada and it is reported that the percentage of major carps is fairly high. The last 150 miles of the river pass through the territory of Bombay State. One or two centres like Sukala-tirth in Bombay could, with advantage, be explored to yield good quality seed of major carps. The species of commercial importance are *C. mrigala*, *L. calbasu*, *Tor* spp., *Labeo fimbriata*, *M. aor*, *M. seenghala* and *W. attu*. River Narmada near Hoshangabad was visited and a Unit Headquarters at Hoshangabad has been established.

River Tapti has a total length of over 500 miles of which nearly 300 miles (in Madhya Pradesh and Bombay) offer fairly good fisheries. Owing to extreme conservatism of the population in this stretch, the fisheries of the Tapti are only nominally exploited. The fishing gear and tackle are found to be primitive. Fishermen are mostly concentrated at Burhanpur, Bhusaval, Prakasha, Taloda, Kukurnumola and Mandvi. The species of fish of commercial importance are the same as those found in the Narmada river. The river Tapti has not as yet been explored for collection of fry of major carps. The areas of the Tapti near Burhanpur, Prakasha, Taloda, Mandvi and Kamrej appear to be potential centres for major carp fry collection work.

A preliminary survey of similar nature of Krishna-Godavari rivers was undertaken in February and completed by the end of March 1958.

Survey of High Altitude Fisheries

During the year under report a faunistic survey of Himachal Pradesh was undertaken. The inquiry related to (i) assembling of such information as was available regarding the existing fisheries, (ii) collection of representative samples of fish fauna of the state with special reference to commercial species, (iii) inspection of some important fishing grounds and methods of fishing and (iv) visits to various centres of departmental activities. The survey was completed in 11 days during October 1957. 38 species of fish were recorded of which the endemic species like *Tor putitora*, *Oreinus* spp. formed fisheries of considerable importance and *Bagarius bagarius*, *Labeo deso*, *Mystus* spp. constituted good fisheries in restricted areas. A detailed report embodying information on the present status of the fisheries of Himachal Pradesh with special reference to Brown trout, Mirror carps, Snow trout and Mahseer has been prepared including specific recommendations for future development of these fisheries.

Estuarine Section

Satisfactory progress was maintained during the year in all the lines of investigations under way in the Estuarine Section, *viz.*, investigations

on the fisheries and fish populations of the Hooghly-Matlah-Mahanadi Estuarine system, investigations on the Hilsa fisheries and population structure of Hilsa stocks in the Indian Region and studies relating to the productive potential of brackishwater bheris. A Government of India Senior Research Scholar joined the Section in September 1957 and has started investigations on the maturation, breeding and early life-history of Palæmonid prawns.

Studies on the fisheries and fish populations of the Hooghly, Matlah and Mahanadi estuaries

During the year under report the inventory of fishing units in these three estuaries was completed and sampling programmes were drawn up for each of these and put into operation through a total of nine estuarine fishery survey centres. A combination of sampling survey and total enumeration methods is being followed to estimate the total catch and catch-per-unit-of-effort from these estuaries.

The total quantity of fish caught in the Hooghly estuary during the year 1957–58 was 50,04,729 lb. (22,70,095 kg.) against 42,92,921 lb. (19,47,226 kg.) during 1956–57.

The species composition of the fish catches in the Hooghly and Matlah during 1956–57 was compiled during the year. The estimated total quantities of the important groups of fishes, based on the sampling data, are as follows:

Name	Weight in lb.	Weight in kgm.
Hilsa ..	31,60,189	14,33,430
Other clupeids ..	1,13,782	51,610
Prawns and shrimps ..	8,21,418	3,72,587
Cat-fishes ..	4,60,773	2,09,002
Polynemids ..	1,36,517	61,923
Sciænids ..	3,20,790	1,45,507
Mullets ..	18,149	8,232
Gobieds ..	1,39,872	63,445
Bombay duck ..	3,392	1,539
Other miscellaneous estuarine fishes ..	29,202	13,246
Freshwater carps ..	46,416	21,054
TOTAL ..	52,50,500	23,81,575

Similar data for the year 1957–58 are under compilation.

In the Matlah estuary a total of 9,24,016 lb. (4,19,124 kg.) of fish were caught during the period June 1957 to March 1958. The data pertaining to fish catches in the Matlah and the Mahanadi estuaries collected during the year are being processed at present.

As in the previous year, the fishery in all the three estuaries was very poor during 1957–58. The fishery during winter, the chief fishing season in the Sundarbans, was a total failure this year also. Hilsa which forms the main winter fishery was totally absent and the catches from this area during the season were chiefly by bagnets. The total quantities of fish caught during the winter season (mid-November to mid-February) in the Hooghly and the Matlah are given below:

		lb.	kg.
Hooghly	Zone I ..	12,02,043	5,45,235
	Zone II ..	1,38,674	62,901
	Zone III ..	11,37,822	5,16,105
	Total ..	24,78,539	11,24,241
Matlah	.. ..	7,95,568	3,60,862
	GRAND TOTAL ..	32,74,107	14,85,103

Analysis of commercial catches

Representative fish samples of commercial catches were collected at fortnightly intervals from nine sampling points along the Hooghly and Matlah and studied in the laboratory. The salient features of the observations made are as follows:

Clupeioids

The observations regarding Hilsa which is the most important species in this group are given separately under the section dealing with Hilsa investigations. Among the other clupeioids, *Setipinna* spp., *Anchoviella* spp. and *Coilia* spp. were the more important forms in the catches during the year.

Setipinna phasa was caught throughout the year, mainly from the middle and upper zones of the Hooghly estuary and as in the previous year, the 0-year group (modal length 5·5 cm.) predominated the catches. Maturing and mature fish of size above 13·0 cm. and with modal value of 17·5 cm. were caught in fair numbers during the months December–June. Their food consisted of prawns, small fish, copepods, cladocerans and mysids.

Setipinna taty was represented in the catches from the Matlah estuary and the lower zone of the Hooghly. While those caught in the Matlah at Canning were all immature measuring between 2·0–9·0 cm. in length, maturing and mature fish ranging in size from 10·0–17·9 cm. were present in the winter catches from the lower zone of the Hooghly. Prawns, copepods and mysids formed the main food of this species.

Juveniles of *Anchoviella tri* and *A. indica* were present in the catches in smaller quantities, mainly in the Matlah and to a lesser extent in the Hooghly. *A. tri* ranged in size from 2·0–7·0 cm. and *A. indica* from 2·2–5·5 cm. Copepods, cladocerans, mysids and diatoms constituted their food.

Coilia ramcarati, C. borneensis, C. dussumieri and *C. reynaldi* were the four species of *Coilia* represented in the catches. Of these *C. ramcarati* far outweighed the other species, especially during the winter months, when maturing and mature fishes, all of them above 15·5 cm. length, were caught. During the summer months juveniles of size 4·0–6·0 cm. entered the fishery. Adult fish feed on small fishes, prawns and copepods, and the juveniles mainly on copepods and mysids. *C. borneensis* was also present in the catches in fair numbers during April–June. These were immature and ranged in size from 5·1–11·0 cm. A few maturing fish of size 13·0 cm. and above were obtained in November. The species had fed mainly on copepods and small prawns.

Grey mullets

Mugil parsia, M. cunnesius, M. corsula and *M. tade* were the 4 species that contributed to the fishery. The bulk of the catches of these species consisted of the 0-year class fish. *M. parsia, M. tade* and *M. cunnesius* were not caught in the upper zone of the Hooghly, while *M. corsula* was caught throughout the Hooghly and the Matlah. I and II year old *M. parsia* with mature gonads were caught in fair numbers in the lower zone of the Hooghly during the winter season. There were large-scale recruitments of young of *M. parsia* into the fishery from January to March–April and of *M. corsula* during August–October.

Perches

Sillago panijius was the only species of importance in this group caught from the estuaries. While maturing and mature fish were caught during winter months from the lower zone of the estuaries, juveniles were present throughout the year in the catches from the middle zone and in small numbers in the upper zone. These juvenile fish had a modal length of about 4·0 cm.

Copepods, amphipods, young prawns, prawn larvæ, small fishes, isopods, megalopa larvæ and occasionally plant matter formed the food of this fish.

Threadfins

Polynemus paradiseus formed the main species in the threadfin catches, especially in the upper zone of the estuary, while in the lower zone, nearer to the sea, *Polydactylus indicus* and *Eleutheronema tetradactylum* were caught in larger numbers. During the months May–July maturing and mature *P. paradiseus* were caught in the upper and middle zones of the estuary and spent ones in the lower zone during the winter months. Juveniles entering the fishery had a modal length of about 4·0 cm. Prawns and copepods formed the main food of this fish.

Polydactylus indicus and *Eleutheronema tetradactylum* were represented only in the catches from the lower zone of the Hooghly and from the Matlah. Adult fish with maturing and mature gonads were caught in good numbers in the lower Sundarban area during the winter months, while only immature fish were present in the catches from the Matlah.

Cat-fishes

Cat-fishes afforded an important group in the catches throughout the estuary and comprised of about 20 species. *Pangasius pangasius* and *Silonia silondia* were the two species caught in largest quantities, with *Osteogeniosus militaris*, *Arius* spp., *Mystus gulio* and *Eutropichthys vacha* being the other species of importance.

Pangasius pangasius occurred in the catches throughout the Hooghly and Matlah estuaries, the peak season of the fishery being July–September. The fishery was comparatively poor in the upper and middle zones of the estuaries during winter months. In these zones the fishery was derived solely from the smaller size groups, all of which were immature, and of 3·1–8·0 cm. length. Larger fish were, however, found in the catches in the lower Sundarbans during the winter months. Fresh recruitment of 0-year group fish of 3·1–3·5 cm. size into the fishery was noticed during October.

Silonia silondia formed a fishery only in the upper and middle zones of the Hooghly and was totally absent in the catches at Canning on the Matlah. The species afforded a good fishery during the winter months in the middle zone of the Hooghly. Fresh 0-year group fish of length 2·6–3·0 cm. entered the fishery in July and could be traced during the succeeding months up to October, by when they measured 5·6–6·0 cm. *Osteogeniosus*

militaris was present in the catches in small numbers in the lower zone during the winter months and in the lower and middle zones in the summer. The species was absent in the catches from the upper zone. The fishery comprised of only immature fish. *Arius* spp. jointly constituted a good fishery, mainly in the lower zone of the Hooghly during the winter months and to a lesser extent in the middle zone. *Arius jella*, *A. sona* and *A. nenga* were the species caught. The fishery for *Mystus gulio* was confined mainly to the lower zones of the estuaries, being caught in small numbers in the middle zone during the summer. During the monsoon and post-monsoon months maturing fish were present in fairly large numbers in the catches.

Bombay-duck

Harpodon nehereus formed an important constituent of the catches in the Matlah, except during the winter months. In the Hooghly they were caught in appreciable numbers in the lower Sundarbans during the winter months. The catches consisted of many maturing fish ranging in size from 21·0 cm. to about 30·0 cm. Smaller immature fish with modal length of about 12·5 cm. were also caught along with these. The 0-year group fish, which chiefly constituted the catches in the Matlah, had a modal value of about 7·0 cm. Smaller fishes, prawns and megalopa larvæ formed the main food of this fish.

Ribbon fishes

The fishery for ribbon fishes was confined to the lower zone of the Hooghly and to the Matlah and were caught in appreciable numbers during the winter months. *Trichiurus savala*, *T. haumela* and *T. muticus* comprised the catches, all of which were immature. *T. savala* with a size range of 19·0–45·0 cm. was the most abundant and was caught in appreciable numbers except during the summer months. Though majority of these fish caught were immature, occasionally spent fish were also observed in the catches from the Matlah. *T. haumela* was caught in lesser quantities and ranged in size from 16·0–44·0 cm. *T. muticus* had a size range of 14·0–34·0 cm. and were caught only in small numbers from the Matlah. Prawns and small fish formed the food of all the three species.

Jew fishes

As in the previous year *Pama pama* was the most common species of Jew fish in the catches during the year and was caught throughout the Hooghly estuary and was absent in the catches from the Matlah. The 0 age group fish ranging in size from 0·5–7·0 cm. occurred in the catches in large numbers throughout the year, fresh recruits entering the fishery during the months

October to March–April. These small size groups were more abundant in the upper zone of the estuary than in the middle or lower zones. Larger sized fish of 20·0 cm. and above in length were present in appreciable numbers in the catches from the lower zone. Maturing fish above 16·0 cm. in length were found in the catches during the months March–August. A few spent fish have been observed during June and July. Small fishes, prawns, megalopa larvæ, copepods and cladocerans composed the food of this species.

Sciæna coitor, *S. belengeri*, *S. ossea*, *S. vogleri*, *Sciænoides biauritus* and *Otolithus maculatus* were the other species of Jew fishes met with in the catches. All these species were caught only from the lower zone of the Hooghly and the Matlah and did not contribute appreciably to the fishery during the year.

Miscellaneous fishes

Among miscellaneous fishes, Gobeids were the only important group that contributed appreciably to the catches. *Glossogobius giuris*, *Odontomblyopus rubicundus* and *Apocryptes bato* were the common species caught especially in the upper zone of the Hooghly, where the juveniles of these formed appreciable part of the bag net catches. Maturing and mature *G. giuris* were observed in the catches from the middle and lower zones of the Hooghly during the winter months. In the Matlah and in the middle zone of the Hooghly larger size groups of *O. rubicundus* were often caught.

Prawns and shrimps

Palæmon birmanicus, *P. mirabilis*, *Leander styliferus* and *Metapenæus brevicornis* were the common species of prawns in the catches from the estuaries and these together constituted about 70% of the total prawns caught. *Parapenæopsis sculptilis*, *Palæmon rudis*, *P. scabriculus* and *Leander fluminicola* were caught in much lesser quantities. As in the previous year the prawns that grow to large size, *viz.*, *Penæus semisulcatus*, *P. indicus* and *Palæmon carcinus* were caught only in small numbers from the estuaries under study. The shrimp *Acetes indicus* was abundant this year also in the lower estuarine regions.

Palæmon birmanicus.—The fishery for this species was confined mainly to the upper zone of the Hooghly, though they were often present in small numbers in the catches from the middle zone also. Fresh recruits entered the fishery from July onwards and during July–November these juveniles of 1·5–4·5 cm. size formed about 60% of the total prawns caught in the upper zone. In the monsoon season, larger sized prawns of 7·5–10·5 cm.

size range were caught. Breeders appeared in the catches in May but the actual hatching of young appear to have been in July–August. Unlike in other prawns, algal filaments (Chlorophyceæ) formed a considerable part of the diet of this species.

Palæmon mirabilis was caught throughout the Hooghly all through the year except during the monsoons, when they were restricted to the upper zone and were caught only in small numbers. The size range of adult prawns in the catches was from 2·7–4·5 cm. Fresh recruits of size 0·6–1·8 cm. entered the fishery in the post-monsoon months of October and November and this 0-year group continued to predominate the catches until the onset of the monsoons. Female *P. mirabilis* appears to attain sexual maturity at the end of the 1st year of life at a size of 3·6–3·8 cm. Bottom debris and planktonic crustacea have been found to form the food of this species.

Leander styliferus.—During the year under report this species of prawn was caught mainly from the Matlah and only in small quantities from the Hooghly. Bigger size groups were caught in the estuaries during the winter months and during the monsoon a downward migration of these towards the sea was evident and by September the catches from the estuaries contained none of this group. Fresh recruits of juveniles entered the fishery from June onwards up to about October. *Acetes* and other small crustaceans formed the food of this prawn.

Metapenæus brevicornis.—As in the previous year, the fishery of this species was confined to the lower estuaries. A group of juvenile prawns had entered the fishery in March and these (of size 3·5–6·5 cm.) contributed to the bulk of the catches till November. This group was found present in the catches from the middle zone also during the pre-monsoon months. In October another group (of size 6·5–9·0 cm.) began entering the fishery and by November this group formed 40% of the catches and, as in the previous year, continued to contribute to the fishery throughout the winter in the lower zone of the estuaries. Only a few of these were, however, found to be in mature condition. Diatoms and planktonic crustacea were sometimes found to form the food of this prawn.

Hydrobiological observations

Along the Hooghly, the surface temperature of water ranged from 18·4–34·7° C. during the year, while those along Rupnarain and Matlah varied between 22·0–34·5° C. and 21·0–32·8° C. respectively. In the Hooghly the salinity of water in the region above Kakdwip was fresh during the monsoon and the maximum salinity, reached in March, was 18·0‰ at

Diamond Harbour. Along the lower reaches of the estuary below Kakdwip, the salinity varied from 1·3‰ during the monsoon to 27·0‰ in the month of March. Along the Rupnarain estuary the water was fresh during November–December and the maximum salinity recorded, in March, was 11·0‰. At Canning on the Matlah estuary the salinity was higher than that of the Hooghly, ranging from 15·0–29·8‰.

Qualitative and quantitative analysis of plankton was continued during this year and in addition to the Hooghly and Matlah estuaries the study of the plankton in the Rupnarain estuary was also taken up in the 3rd quarter of this year. In general, the plankton population along the Hooghly estuary has not shown any marked improvement after the sudden decline that set in during the monsoon of 1956. In fact, the available data for this year indicate a general trend towards decline and this might partly account for the poor fishery in many of the areas. The improvements had been only regional and sporadic. The upper zone has shown higher plankton production than that of the middle zone; and the lower zone which had consistently shown poor plankton production over the last two years, has shown an appreciable improvement, specially at Kakdwip, during the last quarter of this year.

As against the general decline along the Hooghly, there has been some substantial improvement in the quantity of plankton at Canning on the Matlah, except for some setback during the 3rd quarter. The plankton production along the Rupnarain estuary has been significantly poor.

Studies on the productive potential of brackishwater bheris

The distribution and the cycle of abundance of benthic algal flora were studied in six typical brackishwater bheris in different parts of the estuarine area in Bengal. Some of the benthic algæ common in brackishwater fish ponds of West Bengal (*Lyngbya æstuarii*, *Chætomorpha linum*, *Tribonema bombycinum* and *compsopogon cæruleus*) were analysed for organic Carbon, Nitrogen, Phosphorus, Potassium, Calcium and Magnesium in order to determine the pattern of their requirements of these essential elements. All these elements were found to be required in appreciable quantities by these algæ. Further, all the different possible sources of these elements, *viz.*, the water phase, soil-water interphase and the soil phase, were investigated in order to understand the contribution of each source to the abundance of benthic algæ. The investigation has revealed that the water phase and the soil-water interphase do not have any limiting factors and have no effect on the abundance of benthic algæ. On the other hand, the soil phase was found to have an important bearing on the growth and

abundance of algæ. Soil types with high values of Nitrogen and Phosphorus support richer algal growth and their concentrations may act as limiting factors in brackishwater fish ponds. It has also been found that there is a richer growth of algæ in soils with more sulphide. The sulphide formation in these soils, however, does not appear to be the result of chemical conversion, but is probably due to the activities of sulphur-reducing bacteria. Calcium and Magnesium which are present in all the three phases do not seem to have any influence on algal productivity, since they are not in such concentrations as to form limiting factors.

Pot-culture experiments

A series of pot-culture experiments revealed that a salinity ranging from 5–17‰ is most favourable for the growth of *Oscillatoria splendida* during the summer months. Another series of experiments to ascertain the quantitative relationship between the phosphorus content of the soil and the productivity of benthic algæ revealed that soils having phosphorus values of 2·8 mg. P/100 g. soil and above can be regarded as good soil in relation to their phosphorus content.

Periodicity in the abundance of benthic algæ

Studies on the periodicity and distribution of algæ in the six bheris have shown that blue-green algæ dominated during the post-monsoon and early winter months, while green algæ dominated over the former during the late winter and early summer months. In addition to this, an appreciable quantity of the yellow-green alga, *Tribonema bombycinum*, was encountered in February and March. Red alga (*Compsopogon cæruleus*) was observed in Taldi in appreciable quantity during the summer months. Prominent among the blue-green algæ were *Lyngbya æstuarii*, *Oscillatoria tenuis* and *O. splendida*, while those among the green algæ were *Chætomorpha linum*, *Cladophora glomerata*, *Spirogyra* sp. and *Chætophora* sp. The effect of water level and variations in salinity and temperature of water on the growth of benthic algæ in brackishwater bheris is under investigation.

Investigations on the Hilsa Fisheries of India

The studies, initiated during the previous year under the scheme of investigations of the Hilsa fisheries, were continued during the year under report. Observations were conducted on the fishery and commercial catches of Hilsa in the rivers Hooghly, Rupnarain, Padma, Ganga, Brahmaputra, Barak, Mahanadi, Godavari, Krishna, Cauvery and Narmada and on the Sourashtra Coast. Morphometric and meristic data were collected of samples from the various river systems for the identification and delimitation

of the Hilsa stocks in Indian waters. Further experiments were conducted to evolve a suitable method of quantitative assessment of young Hilsa in the Hooghly. Two survey centres for the collection of Hilsa catch statistics were established during the year, one at Lalgola on river Padma and the other at Dowleshwaram on the Godavari. Based on an inventory of the Hilsa fishing units in operation along these two rivers suitable sampling and enumeration techniques have been evolved and put into operation from these survey centres. A similar inventory of the Hilsa fishing units along river Krishna has been initiated for the purpose of evolving a suitable sampling technique for the collection of catch statistics of Hilsa in that river.

Hilsa fishery of the major river systems

The usually intensive Hilsa fishery in the Hooghly was very poor during the monsoon season of 1957 and a total failure in the winter of 1957–58. In the main Hooghly, during the monsoon fishery season, Hilsa appeared in small numbers in the catches in the lower zone in July and showed a slow increase up to September. In the middle and upper zones Hilsa began to be caught from August but the catches remained poor. The very low production of plankton in the Hooghly, since the decline in plankton population evident since the 1956 season, seems to be directly correlated with the poor Hilsa fishery in the river since the winter of 1956. In the Rupnarain which joins the Hooghly below Diamond Harbour, Hilsa afforded a good fishery during the monsoon season; but the fishery was a failure in winter.

Juveniles of Hilsa were present in fair numbers in the bagnet catches in the upper zone of the Hooghly throughout the year and in smaller numbers in the middle and lower zones during the post-monsoon months. Fresh recruitment of juveniles of size 2·0–2·9 cm. was evident in the upper zone during October–January and in the middle zone from November–January. Stray numbers of this size group were caught in the lower zone in December.

There was a fairly good fishery for Hilsa in the Padma at Lalgola where also the winter fishery was poorer than the monsoon fishery. It is estimated that a total of about 18,500 maunds (6,90,494 kg.) of Hilsa were caught near about Lalgola and exported to different parts of West Bengal during the period July 1957 to March 1958.

The Hilsa fishery in Brahmaputra during the monsoon of 1957 was better than during the corresponding period of 1956. In the Ganga and the Mahanadi the catches were poorer this year. In the Godavari, Hilsa were caught in small numbers in July, the number increasing through August–September. After September there was a sharp decline in the catches.

The winter fishery was a failure in this river also. A Hilsa fishery of some magnitude commenced in river Krishna in August and continued up to the end of October. The fishery was confined to the area below the anicut. In the Cauvery, however, an unusual abundance of Hilsa was observed during the months July–August, as in the corresponding period of the previous year. This appears to have been the result of the unusual flooding of the river below the anicuts because of the surplussage from Mettur Reservoir. There was a good fishery for Hilsa in the Narmada also during July–September, with the maximum catches in August. It is estimated that a total of 14,190 maunds (5,29,628 kg.) of Hilsa were caught from the Narmada at Broach during these 3 months. The fishery for Hilsa on the Sourashtra coast was not intensive. Hilsa were caught here from the sea, about 6–8 miles off the coast and the main season of fishery was during April–May, there being a secondary season in October–November.

Biological characteristics of the Hilsa stocks

In the commercial catches of Hilsa, age groups of 3–4½ years comprised the dominant groups in all the river systems during the year. In the Narmada, though the bulk of the catches consisted of 3-year old fish there was also a good percentage of older age groups (over 5 years old) ranging from 51·0–59·0 cm. in length. These older age groups were scarcely found in other rivers, but the 5½-year age group fish were present in the catches from the Sourashtra coast, along with the other age groups (2½–5½ years). In the Padma, 1½ and 2½-year old fish also contributed to the fishery along with the older groups. The Chilka catches studied, however, comprised of 1–2 year old fish only.

The maturing, mature and partly spent fish were represented in the catches from all the river systems during the peak fishing seasons. Spent and recovering fish were caught in the Sundarban area during November, in Ganga in October–November, in the Godavari in January and in the Saurashtra coast in May and November. Immature juvenile Hilsa below 7·0 cm. size, were present in the catches in the Hooghly throughout the year. Intermediate size groups of immature Hilsa, measuring in length between 8·0–11·0 cm., were caught from the sea at Digha (West Bengal) in February and those between 9·3 cm. and 13·2 cm. from Godavari in the month of January.

In general, plankton formed the food of adult and juvenile Hilsa. The mature and partly spent fishes in the samples studied from all the various river systems showed very low feeding intensity.

Population structure of Hilsa stocks

Morphometric and meristic characters of large samples of Hilsa from all the river systems and from the Sourashtra coast were studied and analysed by using standard statistical methods for determining the population characterisitcs of Hilsa in our waters and delimiting the various populations. Taking the Hilsa of the Hooghly as the basis of comparison and determining the degree of variation between the Hilsa from the different waters, certain patterns of "clusters" of affinity have been worked out. The significance of these "clusters" is being studied against the background of the biological characteristics of Hilsa in the different areas. The study is in progress.

CHILKA INVESTIGATION UNIT

A survey of the fisheries of the lake and collection of catch and biological statistics of the commercial catches formed the chief programme of work during the year and steady progress was maintained in the collection of data. It was possible to initiate tagging experiments with *Mugil cephalus* in the lake, with some success.

Fishery of the Chilka lake as a whole

Based on sampling of fish landings carried out throughout the year it was gathered that prawns constituted 31·04%, Mullets 21·03%, Cat-fishes 14·34%, Clupeoids 12·78%, Sciænidæ 7·05%, Threadfins 6·30% and Perches 4·36% of the total catches in the year 1957–58. Prawns figured abundantly in the period April–September in 1957 and again in February–March 1958. Heaviest catches were made in August 1957 followed by May 1957 when prawns formed 63·38% and 62·23% respectively of the lake's total catches during those months. The principal fishing season of the mullets was during the period October 1957 to January 1958, the peak month of production being October followed by November when mullets formed 54·03% and 50·76%, of the lake's total catches during those months. Cat-fish production recorded its maximum in July 1957 followed by April 1957 and February 1958 when they formed 29·99%, 22·74% and 22·52% of the total catches. Clupeoids were most abundant in commercial catches in December 1957 when they formed 33·03% of total catch. They formed 18·80% of the total catches each in April and June 1957. Threadfins were most dominant in March 1958 and figured next best in September 1957, forming 11·05% and 10·20% of the catches during those months. Perches were most abundant in November 1957, forming 10·60% of the catches in November 1957. *Panæus indicus*, *P. semisulcatus* and *Metapenæus monoceros* are the more important species among prawns; *Mugil cephalus* and *Liza troschelli* among mullets;

Mystus gulio, *Osteogeniosus militaris* and *Arius* sp. among cat-fishes, *Hilsa ilisha*, *Nematalosa nasus* and *Thrissocles* sp. among clupeoids, *Pseudosciæna* sp. among Sciænids, *Eleutheronema tetradactylum* among threadfins and *Lates calcarifer*, *Geres oyena*, *Sparus sarba* and *S. datnia* among perches.

Important features of the fisheries of each sector of the lake are given below:

Northern sector.—Taking the year as a whole, prawns followed by cat-fishes, mullets, clupeids, sciænids and threadfins formed 29·04, 17·76, 17·26, 11·94, 11·51 and 7·49% of the catches of this sector respectively. Prawns were most abundant during the season April 1957 to September 1957 and again in February–March 1958. Cat-fishes were abundant throughout the year except in August and September. Their peak production was in February when they formed 35·87% of the catch of the sector. Mullets formed an important fishery in the season September 1957 to January 1958. Clupeoids were most abundant during the period September 1957 to February 1958. Sciænids formed important fishery in the period June–September, the peak being in June 1957 when they formed 47·92% of the catches of that month in the sector. Except during the months May–September 1957, threadfins formed fairly important fishery throughout the year, the peak month of production being January 1958 when they formed 15·47% of the catch of the sector for that month.

Central sector.—The Central Sector of Chilka is more representative of the lake and the relative abundance of various groups in the year are more or less the same as stated for the entire lake except that the mullets occur in greater abundance here as compared to other groups of fishes. In this sector mullets formed 28·19% of the catch followed by cat-fishes, clupeids, perches, threadfins and sciænids which formed 12·99, 9·30, 6·17, 6·15 and 5·43% of the catches. The mullet season began in October 1958 and continued right up to March 1958, the peak having been reached in November when they constituted 81·43% of the catches of that month. The cat-fishes reached their peak production in January 1958 and clupeids in December 1957 when they formed 24·63% and 37·58% of the catches of these months in this sector. Threadfins were most abundant in September 1957, forming 33·34% of the catch of the month.

Southern sector.—Next to prawns which formed 30·05% of the catches during the course of the year the most predominant group in this sector was the Clupeoids followed by mullets, perches, cat-fishes and threadfins which formed 29·26, 6·90, 3·19 and 2·50% of the catches respectively. Clupeids were relatively more abundant in all the months except the period

July–November 1957. The peak production was recorded in June when they formed 79·06% of the landings of the month of this sector. The seasonal distribution of the mullets was the same here as in other sectors, the peak production having been recorded in January 1958 when they formed 63·91% of the catches of that month. Perches were most abundant in November 1957 when they formed 28·33% of the catch of the month. Cat-fishes and threadfins formed only fisheries of minor importance in this sector. The former were available in somewhat greater abundance in July 1957 (20·98%) and the latter in March 1958 (6·41%).

Outer channel sector.—The outstanding feature of the fishery of this sector was the abundance of ripe *M. cephalus*, in their migratory phase, during the months October–December 1957, of *Liza troschelli*, also in ripe condition and in their migratory phase, in January 1958 and *Mugil speigleri* in the same condition and phase, in February 1958. The perches *Sparus datnia* and *S. sarba* were available in fair numbers in ripe condition in November and December 1957.

Biological and bionomical observations on commercial fisheries

Mullets.—Mugil cephalus figured most prominently in the commercial catches of the lake followed by *Liza troschelli*. Besides observations on 7,131 specimens of *M. cephalus* captured in the Janos of the lake, 1,118 specimens of this species were measured in the outer channel or the sea during their migratory phase from the lake to the sea. All these latter specimens were in the 5th–6th stage of maturity in the season October–December. In October 1957 the average size of the migrating female was 534·24 mm. and that of the migrating male 373·5 mm. In November the average size of migrating female was 505·24 mm. and that of the male was 360·5 mm. In December migrating females and males averaged 482·11 mm. and 352·6 mm. respectively. In contrast with this the catches of *M. cephalus* in Janos show very few large-sized specimens clearly indicating that only few mature females are caught therein. The Jano catches largely consist of juveniles. *M. cephalus* centred round 300 mm. class including some mature males, but only a negligible number of mature females. It is believed that a vast majority of migrating males are one year old and females 2–3 years old. The males seem to far outnumber females in the outer channel. *Liza troschelli* migrates to the sea later than *M. cephalus* and the main migration in 1957–58 season occurred in January 1958. The average size of the migrating males came down to 287·9 mm. in January 1958 from 344·9 mm. in October 1957. In the case of the migrating females the average fish measured 397·5 mm. in October 1957, but the January 1958 run showed a bimodal

frequency distribution with the peaks at 287·9 and 410·0 mm. classes. Evidence to demonstrate similar migrating habit of certain other mullets like *M. subviridis*, *M. speigleri*, *Liza borneensis* and *L. ceruleomaculatus* have been gathered and it has been proved that all these six species of mullets undergo annual breeding migration to the sea, the young ones returning to the lake evidently for feeding and growth.

Clupeoids.—Year round gonadial observations of the mud shad *Nematolosa nasus* show that the species is fully ripe and breeds during the period April–July when highest values of gonado-somatic indices 10·12–16·05 are reached. Lowest value of g. index (0·8) is met in December. New recruits (zero group) enter the fishery in August averaging about 60 mm. when the I year old individuals are about 175 mm. long and II year old individuals about 250 mm. long. The maximum size recorded from the lake is 292 mm. The species is a bottom feeder and largely subsists on decayed organic matter (64·49%), miscellaneous food materials like copepods, foraminiferans, larval molluscs, etc. (11·04%), diatoms such as *Melosira*, *Chætoceros*, *Navicula*, *Pleurosigma*, *Gammatophora*, etc. (4·53%), algæ consisting of *Spirogyra*, *Lyngbya*, *Zygnema*, *Oscillatoria* and *Anabæna* (3·59%) and mud and sand (17·35%). The period of maximum intensity of feeding is June–November with the peak at August–September. Fecundity of *Nematolosa* varying in total length from 146–252 mm. was found to vary from 44,939–2,32,002. The co-occurrence of fully ripe and spent fishes in the lake and the availability of the young ones show that the species breeds in the lake.

Year round observations of *Thrissocles purava* show that the species is fully ripe and breeds during the period April–June. The maximum gonado-somatic indices (4·1–6·47) are recorded during this period.

Observations on the gonads of *Hilsa ilisha* show that maximum gonado-somatic index (19·04–20·22) is reached during the months August–September, while during the rest of the months it is of a very low order. From the co-occurrence of fully ripe, oozing and spent individuals in the Northern Sector of the lake it is inferred that the fish breeds either in the lake and/or in the rivulets discharging into the lake in August and September. The recruits enter the fishery in December when they are about 4 months old and form a peak at 1,375 mm. class in which month the other peaks at 288·5 mm. and 413·5 mm. class represent specimens about 1¼ year and 2¼ years old respectively.

Cat-fishes.—Gonadial observations on 344 specimens of *Mystus gulio*, carried out all the year round, reveal that the fish spawns profusely during

the period June–October, preceded by a minor spawning activity in April–May. Gonado-somatic index value of 8·5 in April showed a fall to 6·2 in May showing partial breeding. In June it rose up to 14·8 and dropped to 8·2 in August to 1·1 in September–October and further dropped to 0·4 in November–December and 0·1 in January. Although the first recruitment of a new brood into the commercial fishery takes place in September, it gains fuller representation only by January with a peak centred at 83 mm. class. The fish attains maturity at 110–20 mm. size range when it is about one year old and breeds in the lake itself. Its fecundity varies from 18,000–39,350 in the size range 123–211 mm. and the diameter range of ripe ovarian eggs is 0·5–1·0, the average being 0·78 mm.

Tachysurus arius.—Observations on 225 specimens of this species show that the gonado-somatic index of females increased from 1·5 in April to 8·8 in May indicating maturing of ovaries. Subsequently a drop in g. index was observed from 8·8 (May) to 0·2 in November through 7·1 in June, 6·2 in July–August, 0·4 in September and 0·3 in October, indicating that breeding commences in May–June and is over by August–September. The species exhibits oral incubation and there is no doubt that it breeds in the lake. Fecundity increases in direct proportions with size. Fishes measuring 243, 262, 337, 407, 430 and 520 had 23, 32, 51, 76, 97 and 107 ripe ova respectively in their ovaries. The diameter of ripe ovarian eggs varies from 9·5–14·0 mm., average diameter being 11·5 mm. From the number of eggs encountered in the mouth of the males it is inferred that all the ovarian eggs are extruded in one spawning act.

Osteogeniosus militaris.—Observations on 151 specimens of the species show a maximum gonado-somatic index value (6·85) in April. Further observations on the gonado-somatic index values throughout the year have shown that the major spawning activity takes place from April/May to July/August and is preceded by a minor spawning act in January/March. That these interpretations of data are correct is borne out by the occurrence of developing eggs in the mouth during corresponding months. This species also exhibits oral incubation and there is no doubt that it breeds in the lake. The number of ovarian eggs produced in one spawning season and extruded in one spawning act range from 72–120 in fishes ranging in total length from 310–40 mm. The ova diameter varies from 7·2–9·4 mm. the average being 7·9 mm.

Plotosus canius.—The maximum gonado-somatic index (7·4) was recorded in June. It dropped to 4·4 in August and to 0·3 in November. Before attaining its peak value in June it again showed a subsidiary rise in

March in some individuals. The interpretation of these data is that there is a minor spawning activity in March–April which is followed by main spawning activity commencing in June and ending by November. Post-larvæ (30–59 mm.) of the species were available from October–December which fact confirms breeding of the species in the lake at the time stated above.

Early life-histories of *Tachysurus arius*, *T. cælatus* and *Osteogeniosus militaris* were studied.

Perches: Sparus sarba.—Higher values of gonado-somatic index (varying from 1·2–1·9) were recorded in the period November–January. In February the index value fell to 0·11 and then steadily rose to the peak value of 1·9 in November. Fully ripe and oozing males and females of this species, averaging 195·98 and 251·7 mm. length respectively, were seen concentrating in large numbers near the lake mouth in the period November–January and could be traced along the route as well. Some ripe and oozing individuals were recorded from the sea also. These data are interpreted to show that the fish breeds in the region of the lake mouth and/or sea in the period November–January. New recruits enter the commercial fishery in the period April–June (peak 83 mm. class) when the next peak at 173 mm. class represent fish about 1½ years old. These latter spawn in the next breeding season when they are about 2 years old. A similar breeding and migration pattern has been worked out for *S. datnia*, the males of which average 221·9 mm. and females 335·0 mm. in fully ripe condition. *S. datnia* is a slightly bigger species than *S. sarba*.

Gerres oyena.—Although peak value (5·01) of gonado-somatic index of females is reached in July, high index values are recorded during the period May–September, which period is regarded as the breeding season of the fish. Juveniles of the size range 17–25 mm. were collected in large numbers in early July from the lake mouth, but some were collected in the southern part of the lake also in August. Growth of juveniles of *Gerres* revealed that in September/October when breeding ceases, the brood of earlier months of the same season form a peak at 55 mm. class, while, the brooders themselves form a peak at 113 mm. class and are about a year old. Observation on 7,224 specimens were made during the year to elucidate the growth pattern. Fecundity of a large number of specimens has been worked out.

Lates calcarifer.—A large number of juveniles of the size range 69–218 mm. were recorded from the commercial catches during the period July–December. Mature specimens were recorded in May and the breeding season of this fish appears to be prolonged.

Threadfins.—Ripe specimens of *Eleutheronema tetradactylum* were recorded during the period January–July which is also borne out by the high values of gonado-somatic index. Occurrence of specimens in oozing and spent condition in the lake shows that the fish probably breeds in the lake and has a very prolonged breeding season. Juveniles of the species measuring 64–180 mm. long were found in large numbers throughout the lake practically all the year round.

Sciænids.—Sufficient number of specimens of *Pseudosciæna albida* could not be procured to warrant definite conclusions about the breeding of the species. The present indications are that it breeds from April–June.

A thousand specimens of *Mugil cephalus* were tagged with Petersen's type of tags (locally made) in the month of November 1957. Nearly 5% of the tagged fish were returned up to March 1958. In spite of the success of this experiment, as judged from the returned fish, the tagging operation needs further improvement. In majority of the recovered fish there had developed a septic wound at the site of the tag.

Lacustrine Unit

During the year lacustrine fishery surveys in the States of Orissa, Mysore West Bengal, Bihar, Uttar Pradesh and southern part of Madhya Pradesh were carried out and the report on the inventory of lacustrine fishery in India was completed. Detailed work on the fish and fisheries of Tungabhadra reservoir has been started since January 1958.

Lacustrine fishery survey

West Bengal.—In the Mayurakshi reservoir (25 sq.mls.) no fishery development work has been undertaken. The turbidity of the water remains high throughout the year due to fine suspended silt. A small ditch nearby is used as a nursery. Mostly minnows are caught from the marginal area by the Santhals.

Down below the river Mayurakshi a fish pass has been constructed at Tilpara barrage. This pass is of baffle type. Fishes below 12" in length are reported to pass through it.

Bihar.—Among the reservoirs in the Damodar Valley Corporation area fishery development work has been undertaken only in the Tilaya reservoir. It was proposed to take up work on Konar reservoir also, while the other reservoirs have not been stocked.

Mysore.—A general survey of Krishnaraja Sagar and Tungabhadra reservoirs has revealed that in both the reservoirs much development work

is required for commercial exploitation. *Barbus kolus, B. carnaticus* and *Labeo fimbriatus* form the main fishery in this area.

Orissa.—The Hirakud reservoir (244 sq.mls.), at present the biggest in India, has been taken up for fishery development by the Orissa Fisheries Department. A large fish farm has been constructed near the reservoir. The reservoir is full of trees which will hamper fishing operations very much. Under these conditions the rate of stocking will have to be much more to get an economic yield.

Madhya Pradesh.—In Raipur District the Tandula reservoir was visited. It is reported that fish breed in this reservoir which requires proper stocking and development work to yield a good crop.

Uttar Pradesh.—4 reservoirs in Uttar Pradesh were surveyed. Of these Phauj (Jhansi), Ramgarh (Gorakhpur) and Surah Tal (Balia) only are exploited at present. The last two get connected with the river during monsoon and so natural stocking takes place. No development work has been undertaken for Matatila reservoir (on Betwa river) so far.

Fish and fisheries of Tungabhadra reservoir

Fishing.—Since legally nobody is permitted to fish in the reservoir, there is no commercial exploitation of fishes. A few fishermen from Hospet and Hampi do the fishing in shallower parts of the reservoir by Uduvalai nets. As they are not licensed fishermen it is difficult to examine their catches. A few fishermen do fishing in the upper reaches of the reservoir. The Research Unit operates Uduvalai nets in 4–5′ depth of water. 3 nets, each 90′×2′, two having mesh of $\frac{1}{2}$″ and one of 1″ mesh, are operated for 8 hours daily. This is taken as catch-per-unit-of-effort. During the 3 months the catch-per-unit-of-effort has been more or less steady, it being 1·37 kg. in January to 1·18 kg. in February and 1·36 kg. in March.

Barbus kolus was obtained in largest numbers, constituting on an average 41·61% of the total catches, followed by *Rohtee belangeri* (21·13%) and *Barbus pinnauratus* (16·06%). Other fishes were encountered in smaller numbers.

Data from the fish market are also being collected. Fishes are brought here from the reservoir and the river and Kamalapur tank (near Hampi). The total catch in January was only 254·8 kg., but this improved considerably to 1351·2 kg. and 2221·9 kg. during February and March respectively. Carps dominated the catches forming 70% of the total followed by the catfishes, constituting another 25%. All the other species together formed about 5%.

Biological studies

Barbus kolus.—74 specimens measuring 119–392 mm. were examined during January–March 1958. Food consisted mainly of Chironomid larvæ, small gastropods and diatoms, while Copepods, *Cypris* and Bivalves formed a minor part. Sand particles form over 25% of the food and the fish appears to be a bottom feeder.

Scales, otoliths and opercular bones were studied in connection with the age and growth of the fish. The latter two did not show any clear rings, while among the former, those few which were not regenerated showed what are presumably annual rings. The size rings of those with one, two and three rings were 190–270 mm., 271–327 mm. and 335–70 mm. respectively.

Females above 300 mm. were found to be mature with 'running' ovary. Breeding season appears to be a prolonged one. Young forms (102–40 mm.) have been caught in cast nets from the reservoir.

Barbus pinnauratus.—105 specimens of this fish (148–326 mm.) have been examined. Its food consists of Gastropods, Diatoms, *Microcystis* and *Spirogyra*. Mud and sand form 30% of the total food and thus it appears to be a bottom feeder.

Scales show clear rings but otoliths do not show any ring. As in *B. kolus* only scales show clear rings, which are presumed to be annual and the size ranges of those with 1, 2 and 3 rings were 170–90 mm., 230–60 mm. and 299–326 mm. respectively. Mature females measured 225 mm. and over. No female was found in ripe (running) condition.

Rohtee belangeri.—172 specimens measuring 51–335 mm. were examined. Their food consisted mainly of small fish, insect larvæ, prawns and gastropods. Younger fishes (below 150 mm.) feed mainly on insect larvæ and *Vivipara* young ones. Green filamentous algæ and diatoms are also found at times.

Both the scales and the opercular bones show growth rings in this species. The following sizes are attained by the fish showing growth rings: 1 ring—166–90 mm. ; 2 rings—191–255 mm.; 3 rings—226–320 mm. and 4 rings—306–35 mm.

Rohtee ogilbii.—70 specimens were examined during January–March 1958. The gut contents consisted mostly of digested matter. In a few stomachs the following items were identified—*Ulothrix*, Diatoms, *Microcystis*, *Chironomus* and *Silmulium* larvæ.

The age of this fish could not be studied since most of the scales are regenerated and deciduous. Opercular bone, cleithrum and otoliths also do not show clear rings. Fishes about 171 mm. size were found in 'running stage'. Males above 98 mm. were mature. The breeding season appears to be from December–February.

Cat-fishes.—Biology of 5 species of Cat-fishes, *viz*., *Mystus seenghala*, *M. aor*, *M. cavasius*, *Silonia silondia* and *Rita pavimentata* is being studied. For age determinations the Cleithrum bone is found to give better results than other structures in these fishes.

Among other fishes, young ones of *Glossogobius giuris* measuring 45–125 mm. in length were generally caught in cast nets in February 1958. The eggs of this species were also collected from the marginal areas on two occasions in February 1958, showing that the fish breeds in the reservoir. Adults have not been caught in the net. Other fishes caught in cast nets are *Chela bacaila*, *Laubuca atpar*, *Amblypharyngodon mola*, *Garra* sp. and *Nemachilus* spp.

Young ones of *Labeo fimbriatus* (79–150 mm. long) are also generally caught in cast nets, showing that probably this species breeds in the reservoir. Young forms of other *Labeo* spp. less than 6″ caught in the reservoir are *Labeo ariza*, *L. kontius* and *L. dussumieri* and also *Barbus tor*.

Survey of fishing sites

The right bank of the reservoir has been surveyed with a view to select suitable fishing sites and to know the fishermen population in the villages. The area up to Chikka Hagari (a tributary of Tungabhadra) is mostly rocky and with submerged trees and shrubs. After the confluence of Chikka Hagari the area is sandy. Up to 8 miles upstream from the dam fishermen from Hospet and Kamalapur area come sometimes and do the fishing. As they have no fixed places it is difficult to find their total number. Near Tambrahalli (after Chikka Hagari) there are two villages Kittanur and Siginahalli where 20–30 fishermen live. They use Uduvalai near the shore. During the summer months, they catch nearly 20–30 seers of fish per day. Further up at Hampasagaram there are about 20 fishermen families. Beyond this there are no fishermen and the reservoir beocmes less wide.

Most of the reservoir area is full of trees and it is difficult to use any other type of net except gill-nets and even these get entangled in submerged trees and shrubs and get torn.

Limnology.—pH of water varies between 8·0–8·3, surface temperature (January–March) between 22·6–30·0° C. and turbidity between 60–68″

(by Secchi Disc). The plankton which is collected from the margin is dominated by the blue-green algæ forming more than 75% of the total volume. Green algæ and diatoms together constitute about 24%, and less than 1% consists of zooplankton.

CENTRAL INLAND FISHERIES
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List of scientific papers, based on the work done at the Research Station, published during 1957–58:—

1. K. H. ALIKUNHI. Fish Culture in India. *Farm Bull.*, No. 2, I.C.A.R., New Delhi.
2. H. CHAUDHURI AND K. H. ALIKUNHI. 1957. Observations on the spawning of Indian carps induced by injection of pituitary gland hormones. *Curr. Sci.*, **26** (12), 381–82.
3. M. P. MOTWANI, V. G. JHINGRAN AND S. J. KARAMCHANDANI. 1957. A note on the breeding of Indian Shad, *Hilsa ilisha* (Ham.) in freshwaters. *Science and Culture*, **23**, 47–48.
4. ——— AND B. B. BOSE. 1957. Oxygen requirements of fry of the Indian Major Carp, *Labeo rohita* (Ham.). *Proc. nat. Inst. Sci. India*, **23 B** (1–2), 8–16.
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6. T. V. R. PILLAY. 1957. On the abundance of the Hilsa, *Hilsa ilisha* (Hamilton) in the Hooghly and Padma rivers during 1955. *Indian J. Fish.*, **4** (1), 150–59.
7. K. K. SAROJINI. 1957. Biology and fisheries of the grey mullets of Bengal—I. Biology of *Mugil parsia* Hamilton, with notes on its fishery in Bengal. *Ibid.*, **4** (1), 160–207.
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