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CENTRAL INLAND FISHERIES RESEARCH STATION
CALCUTTA

ANNUAL REPORT OF THE CENTRAL INLAND FISHERIES RESEARCH STATION, BARRACKPORE, FOR THE YEAR 1958-59

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General

There was an all-round intensification of the research programmes of the Central Inland Fisheries Research Station during the year 1958–59 and the various research units were strengthened by more research staff and equipment. The Krishna-Godavary Fisheries Research Unit established during the Second Five-Year Plan was shifted to Rajahmundry.

Dr. V. Gopalakrishnan took over as Assistant Research Officer (Pathology) and Shri J. C. Malhotra as Assistant Research Officer (Estuarine).

Training

The 11th Session of the Inland Fisheries Training Course was conducted during the year. 39 trainees consisting of 13 Government deputees from the States of Madhya Pradesh, Orissa and Mysore, 5 Government stipendiaries from the States of Orissa, West Bengal and Assam, 15 private candidates from the States of West Bengal, Kerala, Punjab, Bihar and Mysore and 6 foreign trainees—2 from Malaya, 2 from Thailand, 1 from Burma and 1 from Uganda—were trained in Inland Fisheries Development and Administration. In the final examination conducted in January 1958, 7 candidates were placed in the First Class, 23 in the Second Class and 10 in the Third Class. This includes one candidate from the 10th Session who appeared for examination during the year.

Mr. T. Lashin, F.A.O. Fellow, was given facilities at this Research Station to acquaint himself with the system of collection of fisheries statistics.

Three batches of trainees, numbering 81, from the Directorate of Fisheries, Orissa, were given brief demonstrations on the method of artificial breeding of the common carp, *Cyprinus carpio*, at the Cuttack Sub-Station. Special lectures and demonstrations on fish breeding and fish culture were given at the same station to the Post-Graduate Zoology students of the Delhi University, students of the Andhra Polytechnic, Kakinada, and Agricultural Extension Officers from Assam, North-East Frontier Agency, Tripura and Manipur.

A brief demonstration training on the various aspects of fish breeding by injection of pituitary gland hormone was held at Allahabad for the benefit of Senior Fishery Officers of Uttar Pradesh. Similar demonstration training was given to the District Fishery Officers of the Department of Fisheries, Assam, at the Pond Culture Unit in Joysagar.

A Refresher Course in Fish Culture was conducted for a period of one month at the Pond Culture Sub-Station, which was attended by 10 Senior Officers from State Fisheries Departments, 4 Assistant Fisheries Extension Officers and 1 Fisheries Extension Assistant. The programme of the Course included lectures, demonstrations and field studies in the various aspects of culture fisheries.

A special one week's course of training in methods of induced breeding of Indian carps and breeding of common carp was also held at Cuttack, in which 22 Officers from various States and the extension service participated.

Meetings

Dr. B. S. Bhimachar, Chief Research Officer, attended the Fisheries Research Committee Meeting at Srinagar from 3rd to 6th July 1958 and the State Fisheries Ministers' Conference at Mysore from 14th to 16th July 1958. He also represented the Government of India at the 8th Session of the Indo-Pacific Fisheries Council Meeting at Colombo from 4th to 22nd December 1958.

Equipment

An exploratory fishing and research vessel specially designed for operation in the Sunderbans was received at this Research Station under the T.C.M. Programme during the year under report. The vessel was rigged up for trawling and trial fishing was carried out in the neighbourhood of Kakdwip. A Jeep was also procured.

Visitors

Mr. Tadashi Yammamoto, Deputy Chief of Fisheries Statistics Section, Statistical Research Division, Ministry of Agriculture and Forestry, Tokyo, Japan; Dr. M. R. Khan, Assistant Regional Fisheries Officer, F.A.O.; Shri M. V. Krishnappa, Deputy Minister for Agriculture, in-charge of Fisheries; Shri Krishan Chand, I.C.S., Joint Secretary, Ministry of Food and Agriculture; Dr. N. K. Panikkar, Fisheries Development Adviser; The Hon'ble Mr. G. C. Granado, Minister of Labour, Co-operative Development and Social Services and the Hon'ble Mr. Kamaluddin Mohammed, Minister of Agriculture, Lands and Fisheries of Trinidad; Mr. Talbot, F.A.O./E.T.A.P. Fisheries Officer; Mr. A. K. E. Imam, F.A.O. Fellowship

Holder from Egypt and Mr. Y. Niyake of Fisheries Economic Branch, Fisheries Division, F.A.O., Rome; Shri S. Miskeith, Superintending Engineer; Mr. George Mekenzie, F.A.O., Fishing Fleet Manager, Deep Sea Fishing Station; Mr. K. Chidambaram, Assistant Fisheries Development Adviser; Mr. James Haratani of the University of California; Mr. Noel L. H. Karuss of the Board of Agriculture and Forestry, Honolulu, Hawaii ; Mr. Peter Gurtner, F.A.O. Naval Architect; Dr. S. W. Ling, F.A.O./E.T.A.P. Fish Culture Expert; Dr. K. Kuronuma, Director-Chief, Freshwater Fisheries Research Laboratory, Tokyo and Chairman of the Indo-Pacific Fisheries Council, visited this Research Station during the year.

The Fisheries Education Committee consisting of Dr. N. K. Panikkar (*Chairman*), Dr. B. N. Chopra and Prof. G. M. Gerhardsen (*Members*) visited this Research Station on the 27th and 28th January 1959. The Committee also visited the Pond Culture Sub-Station, Cuttack, on the 29th January 1959.

Pond Culture Division

2. *Induced breeding of Indian carps*

During the earlier part of May 1958, over 100 pituitary glands of maturing major carps were collected from Calcutta fish markets. The glands were preserved in absolute alcohol and used for experiments in Assam. During June 1958, over 600 pituitary glands of mature and maturing major carps, grown in ponds and reservoirs, were collected at Allahabad and Jhansi through the courtesy of the Department of Fisheries, Uttar Pradesh. These glands were also preserved in absolute alcohol and were used for experiments at Cuttack. Over 400 glands from immature as well as maturing major carps were similarly collected during June–July 1958 from the Kila and Chaudwar farms and used for experiments at Cuttack.

Fish breeding experiments were carried out at Joysagar, Assam, from the middle of May till the 1st week of July 1958. Breeders collected from different ponds and kept in stocking ponds were fed with artificial food. At the onset of monsoon, they were netted out from these ponds, segregated sex-wise and released in smaller nursery ponds to facilitate their capture at the time of giving injections. The dose of injection was according to the weight of the fish. The males were given a smaller dose than the females. Intramuscular injections were administered in the caudal peduncular region. The injected fishes, usually a male and a female or two males with one female, were then introduced inside a closed hapa fixed in shallow water. Usually on cool rainy days the fishes spawned within 6–8 hours after the

1st injection. In some cases a second injection after 10–12 hours of the first was necessary. The optimum temperature for breeding was found to be between 24 and 31° C. The eggs were collected when the embryo started twitching movement. The eggs were then transferred to a number of hatching hapas and the fry were stocked in nursery ponds on the 3rd/4th day after spawning.

The experiments were most successful with Rohu. Excepting a few cases when the temperature was high, Rohu spawned as and when injected. Mrigal spawned readily except on two occasions when the females were found to be immature. Several specimens of *Gonius* also spawned. Besides these major carps, Bata, Reba, Sarana, and *Rasbora elanga* also spawned. In the majority of cases the percentage of hatching was quite high especially when the day was cloudy and temperature low. In one instance, almost all eggs of a Mrigal hatched out. It was observed that the percentage of fertilised eggs was higher when a bigger male was put with a smaller female. On certain occasions, the majority of eggs were spoiled, probably due to premature spawning and high temperature.

Little over 10 lakhs of major carp fry were produced at Joysagar by hormone injection and were stocked in nursery ponds, showing thereby that the new technique can profitably be employed for commercial production of quality fish seed at very little expenditure. Due to heavy rains a number of nursery ponds got merged with the stocking ponds and the fingerlings from those ponds could not be harvested. However, more than one lakh of major carp fingerlings could be netted out. This enabled the Fisheries Department, Assam, to cancel their indent for carp fingerlings from Calcutta, for supplies to Joysagar Fish Farm and Upper Assam Area.

A very easy and sure method of identifying the sexes of mature, major and medium-sized carps has been found out. The pectoral fin in mature males during the breeding season has a very rough dorsal surface which in the case of the females is very smooth. This distinguishing character has been observed in all mature males of Catla, Rohu, Mrigal, Calbasu, Gonius, Bata, Reba and Pangusia.

Fish breeding experiments at Cuttack were at first conducted in the cement cisterns. Although in majority of cases the injected fishes bred, in some cases the fertilised eggs started coming to the surface of water, being buoyed up by oxygen bubbles liberated through photosynthesis by the algal crust formed at the bottom of the cisterns. The percentage of hatching was very low. On some occasions the eggs stopped development after few cell division stages. Better results were however obtained by

fixing the breeding hapa in the river. The river-water was much cooler than the pond or cistern water and experiments could be successfully conducted in spite of considerable variations in air temperature. Rohu, Mrigal and Calbasu spawned several times. A single mature female Catla spawned in a cement cistern after 2 injections. The eggs were fully swollen and fertilised but development did not proceed after the initial few stages of cleavage.

Preliminary experiments carried out in cement cisterns and ponds by giving periodic injections of pituitary glands to adults of Rohu, Mrigal and Calbasu during February to June indicated that at least a few of the injected males show positive response. No such response was obtained in females. The experiments are being continued.

A series of experiments on the effect of injections of comparable doses of pituitary glands collected from fishes in various stages of maturity were conducted on *Cirrhina reba* with a view to find out whether glands collected from immature fishes or those in the early stages of maturity would induce spawning when injected. While experiments so far conducted do not warrant any definite conclusions, it appears that pituitary glands of fishes in which the maturation cycle of the gonads has started would induce spawning.

Out of a total of 2,35,000 Rohu fry produced and stocked, the total number of fingerlings recovered so far is over 1,34,000. The average percentage of survival up to the fingerling stage comes to slightly over 57%, the maximum survival being 83·4%. By proper nursery management it has been possible to obtain 1,06,000 Rohu fingerlings by breeding one pair of Rohu. A female Rohu weighing approximately 1·8 kg. laid about 2,98,000 eggs out of which 1,63,000 fry were obtained for stocking. The percentage of survival of fry was 65.

Successful results have been obtained generally by injection of 5–6 mg. dry weight of pituitary gland to a pair of breeders weighing 1·5–2·5 kg. each. In terms of whole glands this means that 1–3 glands obtained from fully ripe fishes, when injected into a pair of breeders of the same species and having more or less similar weight as the donar fishes, usually induces spawning. Sometimes, probably depending upon the state of maturity of the female, even appreciably smaller doses induce spawning. With smaller fishes, proportionately lower doses are required. Very low doses, of the order of 1/10th to 1/4th of an ordinary gland, even when repeated, do not usually induce spawning though the fishes often became excited. It has been observed that breeders injected with lower doses producing negative results

could be released in the pond and then successfully induced to spawn weeks after when higher doses of injections are given. It is also felt that such low dose injections, somewhat early in the season, probably keep these breeders in relatively better maturity condition than in others. This however needs confirmation.

Success has been achieved in stripping carp eggs and artificially fertilising them. Injected males and females are released in the cistern or hapa and the breeders are caught at the right moment when the eggs could be easily stripped out and then fertilised by the milt from the males. Preliminary experiments have given encouraging results. On one occasion more than 90% of the eggs hatched out and about 70% of the fry survived.

With the success of induced breeding of carps, hybridisation among them could be easily attempted and the preliminary experiments carried out have met with immense success. It has been possible to obtain 12 different hybrids by inter-crossing major and medium-sized carps belonging to 3 genera (*Catla*, *Labeo* and *Cirrhina*) and six species. In addition, another hybrid has also been obtained by inter-crossing *Labeo rohita* with *Cyprinus carpio*. Preliminary observations on the growth of some of the hybrids were found to be very satisfactory. Further studies on the subsequent generations (if any) might help in raising new strains of better culturable qualities by selective breeding.

3. *Breeding and Propagation of the Common Carp*, Cyprinus carpio

A consignment of the Chinese strain of the common carp (Scale carp) was brought from Bangkok to Cuttack, in August 1957 for experimental purposes. Intensive work carried out on various aspects of the biology and propagation of the species in Indian waters has yielded very valuable information. The specimens have during the past 18 months attained a maximum weight of 8 lb. (3·6 kg.) and length of 55 cm., the average weight of the breeding females being 2–2·5 kg. (4–5·5 lb.). For males of the same stock average weight is 1–1·5 kg. Specimens from the first breed in India, now just one year old, have attained a maximum weight of over 4 lb. Under identical conditions growth of fingerlings of the common carp is far quicker than that of Mrigal; as good as that of Rohu and slower than of Catla.

Observations so far made confirm the omnivorous feeding habit of the fish. Fry subsist largely on zooplankton, and do not thrive well when algal blooms predominate. Food and feeding habits of young fry are similar to those of the fry of Indian carps. Feeding habits of fingerlings and adults are similar to those of Mrigal and resemble those of Rohu only

to a certain extent. The fish responds to artificial food, better than Catla or Rohu.

Sexual maturity is often attained when the fish is only about 6 months old, males attaining maturity earlier than females. Fecundity was found to increase with size. Ovaries, when fully ripe, weigh 1/5th to ¼th of the total weight in smaller specimens and ⅓th–½th in larger specimens. Number of mature ova per gm. weight of ovary is approximately 1,000.

The common carp breeds almost throughout the year. A single female specimen can spawn at least 4 times a year, the period required for recoupment and maturity of ova after one spawning being 2½–3 months. Mature males are found in the oozing condition throughout the year and single specimen could be repeatedly used even on succeeding days for spawning. The quantity of milt shed at a spawning ranges from 1/20th to 1/25th of the total weight of the fish. Eggs of the fish are small, 1·3–1·5 mm. in diameter and adhesive. Though natural spawning takes place occasionally, the fry or fingerlings produced thereby are very limited in number.

Fully ripe specimens of the carp can be easily induced to breed in cement cisterns or in cloth hapas. Material for depositing eggs, in the form of aquatic weeds or some vegetable fibres (Kakabans) should be provided for successful breeding. Segregation of sexes for 1 or 2 days and then bringing them together is helpful to induce breeding. As the males are smaller, 2 or 3 males will be required to fertilise the eggs of a large female. Breeding generally takes place within 12–36 hours after putting the specimens together. In a cistern 12′×6′×3′ with 2′–2½′ of water, one female and two or three males can be successfully used. A female 2·5 kg. in weight, will lay about 3–3½ lakhs of eggs at one spawning. For successful hatching, the weeds with the attached eggs should be transferred to another cistern. Without running water, 40–50% of the eggs will hatch out within 46–55 hours after fertilisation. Percentage of hatching will be higher if running water is provided. The weeds with eggs can be kept in cloth hapas fixed in water and hatched. Two days after hatching the fry can be stocked in nursery ponds prepared in the same manner as for fry of Indian carps. Survival in nursery ponds during the first 15 days of rearing ranges from 20 to 60%. 12–15 days old fry (¾″–1¼″ long) can be successfully transported after conditioning for about 3 hours. 1,000 such fry, in 10 litres of water in a plastic bag, sealed with about 6 litres of oxygen can be transported for a period of 24 hours with mortality not exceeding 3%.

4. *Tilapia investigations*

A set of experiments designed to show the compatibility or otherwise of *Tilapia* in carp ponds have been in progress in 20 ponds at Puri. Experiments so far conducted indicate that *Tilapia* being an aggressive species, quickly establishes itself in the ponds and its population adversely affects the carps in their growth and survival. Of the major carps, Mrigal is the most affected.

An experiment on the role of *Tilapia* on the survival and growth of advanced fry (15 days old) of Rohu and Common carp indicated that the total production of fish in ponds stocked with Rohu and common carp fry is more than that (*a*) in ponds stocked with *Tilapia* alone or with a combination of *Tilapia*, Rohu and common carps, (*b*) the presence of *Tilapia* population appears to have resulted in a fall in the survival of Rohu fry by 17–22% and of common carp by 16%, (*c*) in the case of Rohu as well as common carps the presence of *Tilapia* appears to have caused very poor growth, the average individual weight attained being only about half that in the control ponds and (*d*) in ponds where all the three species were stocked together the presence of Rohu and common carp has adversely affected production by *Tilapia* to the extent of only 36% as compared to the controls, while the presence of *Tilapia* has adversely affected production of common carp to the extent of 61% and that of Rohu to about 64%. In another field experiment with *Tilapia* and common carp it was found that the presence of *Tilapia* lowers survival of common carp by about 18%, though the presence of common carp was not found to adversely affect survival of *Tilapia*. Production of common carp alone is about 60% more than that of *Tilapia* and does not exceed that of the latter stocked alone. When stocked together, the production of each species is lowered by about 38% as compared to ponds where the species are separately cultivated.

Preliminary experiments carried out on the role of *Tilapia* as a forage fish for the murrel, *O. striatus*, indicate that (*a*) adult *Tilapia* (sexes—equal) at the rate of 500 per acre and murrel fingerlings at 650 per acre, are stocked simultaneously in a pond, the latter keeps a complete check on the multiplication of *Tilapia*, (*b*) the survival and growth of murrels are very much better when stocked with *Tilapia*, indicating that the murrels utilize *Tilapia* as forage, (*c*) production of *Tilapia* alone (470 lb./acre) is almost double that of the combined production of murrels (128 lb./acre) and *Tilapia* (114 lb.) when stocked together and (*d*) the production of murrels alone, in the absence of Tilapia as forage is very low (25·5 lb./acre).

The parental care afforded to the young fry ensures a high rate of *Tilapia* survival and results in rapid over population. Growth is consequently retarded and the bulk of the natural population consists of small fish. Keeping down the population in the pond by periodic harvesting of the larger fish appears to meet the requirements to a certain extent. A one acre stocking pond was cleared and stocked with 120 adult *Tilapia* in September 1957. Fish from this pond was thereafter harvested at almost monthly and fortnightly intervals. The size of marketable fish, however, went down but large-scale thinning restored the size to certain extent. During a period of 12 months, a total of 14,805 specimens weighing 1,092·66 lb. were cropped from the pond. More regular and frequent harvesting was attempted thereafter. Approximately 50 lb. of *Tilapia* were removed every week and during the 6 months period from September 1958 to February 1959, a total number of 7,780 fish, weighing 1,129 lb., were harvested. This shows that compared to the first year, the average size of the fish has markedly improved as also the yield from the pond.

5. *Experiments on fish culture in paddy fields*

Experiments on the cultivation of fish in irrigated paddy fields were conducted and two of the exotic fishes in India, *viz.*, *Tilapia* and the common carp, were used. The experiments with *Tilapia* lasted for 3 months from February to May 1958. Fingerlings were stocked at the rate of 1,000 per acre. The fish repeatedly spawned in the fields during the course of the experiments. The total yield in the experimental plots ranged from 55·5 to 87·5 lb. per acre, with the average at 69 lb. Of these, more than half the quantity was made up of miscellaneous fish and *Tilapia* constituted only about 40%.

In the second experiment, fingerlings of common carp were stocked at the rate of 1,000 per acre. The duration of the experiment was 10 weeks during September–December 1958. The results indicated that (*a*) the survival of the stock was extremely low, ranging from 0 to 3% only, (*b*) the major cause of this low survival was predation by otters and birds of prey, (*c*) the average yield of fish from these plots was only 15 lb. per acre, with the maximum at 27·5 lb. and of this, common carp accounted only for a third, and (*d*) during the 10 weeks' period of the experiment the specimens of common carp that survived showed remarkable growth, reaching an average of ¼ lb. from the initial weight of 4 gm. The maximum weight attained by a specimen was 238 gm. The excellent condition of the survived specimens clearly indicated that but for predation, the plots could sustain a much larger number of fish.

The survival of the fry of Indian carps that entered the plots with irrigation water was also as low as that of common carp. Though all of them were approximately of the same age, the average weight of Catla alone was comparable with that of common carp; that of Rohu and Mrigal being very much lower.

6. *Weed control investigations*

About 40 weed infested ponds and tanks were surveyed in Balasore, Mayurbhanj, Keonjhar and some areas of Cuttack and Dehnkanal, taking into consideration the nature of the weeds in relation to the physico-chemical features of the water, soil and other casual factors. The majority of ponds with shallow water were infested with weeds. Most of the perennial tanks with a depth of over 15′ had practically no submerged vegetation even when the water was clear. Where the pond edge has been kept steep, the marginal fringe of plants was very much reduced. Tanks with bloom of *Microcystis* or constant turbid waters were also free of submerged vegetation.

The most common weeds in the areas surveyed were *Limnanthemum cristatum*, *Nymphea* spp., *Hydrilla naias*, *Vallisneria*, *Ottelia*, *Scirpus articulatus* and *Chara*. Occasionally, however, *Ceratophyllum*, *Utricularia*, *Nelumbium*, *Potamogeton*, *Limnanthemum indicum*, *Ipomea aquatica*, *Jussiæa repens*, *Trapa natans*, *Limnophila*, *Pistia*, *Azolla*, *Narsilea* and *Nitella* occurred in large numbers. Water hyacinth and *Salvinia* were also occasionally met with in shallow waters and swampy areas. Since the submerged weeds, particularly those with an anastomosing system of underground stems, are the most troublesome, more attention was devoted to the submerged weeds during the year under review.

Further experiments were carried out both in cement cisterns and nursery ponds to study the effect of urea on other plants like *Ottelia* and also to find out the exact cause of mortality of fish. *Ottelia* was completely killed and uprooted in concentrations of 50 p.p.m. or more (up to 125 p.p.m. was tried) in two weeks' time, whereas the plant was not affected with 25 p.p.m. There was also development of algal blooms when the concentration was 50 p.p.m. or more. *Tilapia* died in cisterns, treated with 50 p.p.m. or more, most probably due to the production of high concentrations (16–36 p.p.m.) of free ammonia, compared to the maximum of 1 p.p.m. in the control and 3·2 p.p.m. in the cistern treated with 25 p.p.m. In nursery ponds, urea at 50–75 p.p.m. was successfully employed in removing all unwanted fish. Further experiments indicated that it might be possible to kill submerged weeds like *Hydrilla* by two or more applications of the

fertiliser at intervals of 2–3 months or when the bloom disappears thereby maintaining a continuous algal bloom.

Organic fertilisers like mustard oil-cake, fish meal and compost were also tried in cement cisterns to find out whether they have any killing effect on submerged weeds and whether an algal bloom will develop with these fertilisers also. A very high dose of 5,000–10,000 lb. per acre was tried. Both the oil-cake and the fish meal killed the weeds completely within about 3 weeks and in course of time a bloom of algæ developed. The compost did not produce any appreciable effect, probably because the quality was not satisfactory. Because of the very high dose applied there was fouling of water to some extent and a large percentage of the fish in the cisterns died mainly due to oxygen depletion. Further experiments on economic doses of these organic manures are being taken up, both in cement cisterns and in the field.

It has been definitely established that sodium arsenite in concentrations of 4–6 p.p.m. kills most submerged vegetation thoroughly and the effect of one clearance lasts for 4–6 months, the cost of chemical being approximately Rs. 15 per acre foot. Observations carried out on field scale during 1957–58 and continued during 1958–59 have indicated that (*a*) on the wake of decomposition of the submerged weeds, an algal bloom appears always on account of the increased dissolved organic matter, (*b*) the nature of the algal bloom varies with the season and the presence or absence of the concerned algæ at the time of decomposition of the weeds, (*c*) the blue green bloom which usually appears last tends to become permanent, (*d*) when the permanent bloom is established, the submerged vegetation do not appear again, and (*e*) according to present indications the number of treatments of sodium arsenite required to create a permanent algal bloom is two to three.

Preliminary experiments carried out in glass jars indicate that borax at 500–1,000 p.p.m. kill *Hydrilla* in about 2 months. 250 p.p.m. was also found effective, but the time taken was about 3–5 months. 100 p.p.m. of the chemical had no appreciable effect. Plants treated with the higher doses first turned yellow and then into brown. At the end of the experiment it was found that the plants came off in bits, even though they did not actually dissolve in the water.

Field observations were carried out to determine the conditions favouring the growth and multiplication of a few common submerged weeds. In experiments with earthen gumlas and using different types of soil substrata, the best growth of the plant was observed in humus and combinations of humus with other types of soils. There was also a distinct correlation

between the humus content of the substratum and the total alkalinity of the water, the alkalinity being much higher wherever humus was included. Thus it appears that a fairly high amount of organic debris and high total alkalinity of the soil and water respectively encourages profuse growth of plants like *Hydrilla*.

Four tanks at Cuttack containing a large number of *Ottelia* have been kept under observation for a period of over six months. These waters showed a wide range in physico-chemical features. Reproduction in the plant appeared to be almost exclusively by seeds. Under favourable conditions a large percentage of the seeds are capable of germination, which usually takes place at the commencement of the monsoon season, the seedlings being almost indistinguishable from *Vallisneria* at the initial stage. The type of leaves characteristic of *Ottelia* are developed at a later stage. Control of *Ottelia* appears to be possible by the destruction of the plant before it starts producing fruits and seeds.

Year-round observations on the economics of chemical and manual clearance have shown that clearance of submerged weeds by the application of sodium arsenite is much cheaper than continuous manual clearance. A section of the Killa Moat (0·97 acre) required three treatments of sodium arsenite aggregating 103 lb. and another section of 1·33 acres required two applications totalling 108 lb. for completely clearing all submerged weeds and creating a permanent algal bloom in the course of one year. This worked out to Rs. 93·00 of chemical per acre three feet deep, whereas manual deweeding had to be done seven times in similar sections in the course of one year at a total cost of Rs. 265 per acre.

7. *Soil composition and fish production*

With a view to study the soil reaction and the available macro nutrient status of piscicultural soils of Orissa and Bengal and also to determine the water quality of these tanks, a programme was taken up to survey a large number of fishery tanks in Orissa and West Bengal. About 40 fishery tanks covering 10 districts in Orissa and about 30 fishery tanks in three districts of West Bengal have been surveyed so far.

Results obtained showed that many of the piscicultural tanks in the State of Orissa and Bengal are slightly alkaline or slightly acidic. Available soil phosphorus was rather poor in Orissa soil while in tanks studied so far in Bengal, it was comparatively better. In three fish farms in Howrah, available soil phosphorus in water showed a rather high figure and a somewhat direct correlation between available phosphorus of the soil and the soluble phosphorus in water.

To study the growth rate of Catla, Rohu and Mrigal under different soil conditions, the twelve selected tanks in the State of Orissa and six tanks in Madhya Pradesh were stocked with carp fingerlings at a uniform rate. Regular observations on soil and water conditions were continued and growth rate of fish was measured after about one year. The results obtained so far indicate that for these types of slightly acidic or slightly alkaline soils, available soil phosphorus play an important role in determining the fish production. Available soil nitrogen showed irregular fluctuations and does not appear to have any direct correlation either with available phosphorus or with fish production.

With a view to study whether poorly productive acidic soils can respond to corrective treatment by limeing and different combinations of inorganic fertilisers (superphosphate) and organic manure (cow-dung), the experiments taken up in 1957 in 24 nursery tanks at Lingipur were continued this year also. The dosage of chemicals and the method of treatment were the same as in previous year. This type of acid soil did not appear to respond to limeing very easily. It was observed that even a heavy limeing alone was not able to increase the soil pH appreciably nor was it able to increase the soluble alkalinity in water markedly, the increase in dissolved alkalinity being of a temporary nature only. This showed that reserve soil acidity was rather high for these soils. It was noted, however, that lime played an important role in increasing the available soil phosphorus when applied with superphosphate. Thus it was observed that increase in available phosphorus for combination (*a*) high lime *plus* low phosphate and (*b*) high lime *plus* high phosphate, was greater than that for low lime and high phosphate.

In order to study the role of the trace element manganese when applied with inorganic fertiliser superphosphate, an experiment was taken up in six nursery ponds at Chaudwar. Observations made so far indicate that in ponds fertilised with superphosphate alone and in conjunction with trace element manganese, there was a rapid increase in soluble phosphate which diminished gradually, but soluble manganese in water was maintained for a longer period in ponds treated with manganese. After the treatment, it was observed that in tanks treated with superphosphate and manganese, the production of plankton was greater than in both control ponds and in ponds treated with superphosphate alone. Later on, while the zooplankton concentration remained steady in tanks manured with superphosphate alone, there were wide fluctuations both in volume and quality of plankton in other tanks.

Riverine and Lacustrine Division

8. *Fishery investigations in the Ganga River system*

The annual fish landings at the Sadiapur Assembly Centre on the River Jumna were estimated to be 1,40,799 kg. as against 1,93,890 kg. in 1957–58, 4,81,650 kg. in 1956–57 and 3,44,430 kg. in 1955–56. A comparison of the monthly catches in different years shows that landings in the Jumna are higher during the post-monsoon and early winter months, September–January. The poor catches generally are in the monsoon months July and August. There is an obvious progressive decline in the total catches from year to year and it is mainly due to poor landings of *Hilsa* in these years.

It is obvious that there has been a continuance of progressive downward trend in the catches of "endemic" fisheries over the four years. The relevant frequency of occurrence of various size-groups of each fishery, constituting the commercial catches, does not appear to show any significant fluctuations from year to year, which might suggest that decline is mainly due to over-fishing. The other possible factors for the downward trend may be (*a*) extreme draught conditions or excessive and untimely floods, (*b*) switch over of profession of a section of fishermen, (*c*) general economic condition of fishermen and (*d*) silting up of chartered fishing grounds in the basin.

The fishery of *Hilsa* during the year under report was extremely poor and represented only 5·9% of the total annual landings. *Hilsa* was available in all the months excepting June and July, and the size-group 410–520 mm. was the most predominant throughout the year (56·2%). The size-group 255–395 mm. was the next important and these two groups together made up 93·3%. The juveniles (up to 240 mm.) appeared during January–April.

The fishery of major carps accounted for 36·7% of the total annual landings as against 35·1% in the previous year. Among these, Mrigal continued to be the most important (60%) with Catla making up 20·0%, Rohu 12·0% and Calbasu 8·0%. The larger size-groups of all the species were better represented in the catches during the present year than in the previous year. This would perhaps suggest that the gears used during the present year have been somewhat selective. Mrigal fishery was considerable during all the months.

The cat-fish fisheries was the most important during the year, contributing 43·2% of total annual landings. *Mystus* spp. (*aor* and *seenghala*) accounted for over 52% with *Wallago* making up 14·3%. The Scheilbeid fishes, Garua, Vacha and Coilia, made up together 11·8% of the annual cat-fish catches.

Among other fisheries, the miscellaneous group mainly represented by *Aspidoparia*, *Chela*, *Puntius*, *Amblypharyngodon*, *Mystus* (*vittatus*, *cavasius*), clupieds (*Gadusia* spp., *Corica*) was the most important contributing about 11·7% of the total annual landings.

At the Daraganj Assembly Centre on the Ganga, a total of 49,078 kg. of fish was landed during the year as against 54·968 kg. in 1957–58. The low catches during the year have been mainly due to poor landings of *Hilsa*.

The fishery of *Hilsa* was very poor in the Ganga River at Allahabad, being 3,115 kg. and represented only 6·3% of the total landings as compared to 19·8% in the previous year. Insignificant catches were made in most of the months excepting December and January. There was significant improvement in the catches of major carps, most of the cat-fishes and other endemic species.

The species composition of the fisheries of the Ganga (Daraganj) at Allahabad follows similar pattern as observed for the fisheries of Jumna (Sadiapur) with major groups of species represented in comparable proportions from year to year. It is, however, observed that the fishery of Sheilbeid fishes (Garua, Vacha and Coilia) as also that of *S. phasa* and Freshwater Rays are more important in the Ganga.

From an analysis of data collected for 1955–57, it is estimated that the total fish catches, exclusive of tortoises, in a 40-mile stretch of the Ganga and landed at Buxar were 2,44,531 kg. in 1955, 3,18,686 kg. in 1956 and 3,12,410 kg. in 1957. The tortoise catches in these years were 11,489, 7,386 and 7,970 respectively. During the year under report, the major carps were predominant in June and December–February. Among the carps, *C. mrigala* was the most important. Catla and Rohu contributed substantially to the carp catches in the summer months, March–June. Calbasu formed a minor fishery only. The cat-fishes predominated in April, June, July, September, December and February. *Mystus* was the most important in April–July and September and *Wallago* in October–December. *E. vacha* and *C. garua* formed fisheries of considerable importance during December–April, accounting for 11·7–20·7% of the total catches. The Freshwater Rays and Tortoises were caught in considerable numbers at Buxar in almost all the months.

9. *Biological investigations*

A total of over 27,996 kg. of *Mystus aor* and 17,093 kg. of *M. seenghala*, valued together at Rs. 55,950, were estimated to have landed

during the year at the two assembly centres of Allahabad. The fishery of *M. aor* and *M. seenghala* from the Jumna was comparatively more important than that from the Ganga, constituting 70·0% of the total *Mystus* landings. *Mystus aor* was generally represented by larger size-groups. The juveniles (up to 300 mm.), which constituted 9·1%, were available in almost all the months. In *M. seenghala*, while almost all the size-groups were adequately represented, the size-group 480–560 mm. was the more dominant with larger groups coming next. Juveniles constituted 12·8%.

Over 1,050 specimens of *M. aor* at Sadiapur and Daraganj centres were examined during the year. The sex ratio has been calculated to be 37·2 M.: 62·8 F. at Sadiapur and 44·8 M.: 55·2 F. at Daraganj. In *M. seenghala* the sex ratio was found to be 39·0 M.: 61·0 F. for Sadiapur and 44·2 M.: 55·8 F. for Daraganj. The females of both the species were available in comparatively larger numbers in almost all the months. The development of gonads towards maturity presumably commences early in December as reflected by fairly mature specimens encountered in January and February. The breeding commences in March and continues up to August. The fecundity of *M. aor* was determined to be between 45,410 and 1,18,183 in the size range of 856–984 mm. (range in ovary weight being 43·8–151·0 gm.). The fecundity of *M. seenghala* was found to be 65,660–1,066,64 in the size range of 938–45 mm. with range in ovary weight 53·6–107·2 gm.

The adults of *M. aor* subsist on teleosts (50·53%), insects (19·57%), crustaceans (4·86%) and plant debris (3·27%). The adult *M. seenghala* on the other hand subsists mainly on teleosts (85·34%) and only very small percentage of insects and crustaceans. The teleost diet is mainly made up by *Puntius, A. coila, R. cotio, A. morar, Mastacembalus* sp., *E. vacha, Chela* spp., *G. giuris* and insect diet of beetle larvæ, nymphs of May fly, Dragon fly and larvæ of *Eristalis, Dixia* and *Pedicia.*

While Peterson's method is primarily utilised for age and growth studies, the otoliths, vertebræ, spines and cleithrum bone are also examined to determine the validity of the markings for age determination.

The coefficient of condition K in respect of 499 specimens of females in 1954, 276 in 1955, 217 males in 1954 and 179 males in 1955 have been calculated separately with a view to study the ponderal index of *E. vacha* month-wise and season-wise. For females the values of coefficient condition K ranged between 0·524 and 0·854 in the size range of 121–385 mm. in total length in 1954 and between 0·438 and 0·952 in the size range of 148–361 mm. in total length. For males the values of K ranged between 0·451 and 0·918 in the size range 145–280 mm. in 1955.

An analysis of length-frequency data for *Chela gora* showed that the fish attains a total length of about 110 mm. in the first 1½ years, 170 mm. at the end of 2½ years and 215 mm. at the end of 3½ years. The largest specimen recorded from Allahabad was 230 mm. in total length. The monthly growth in the first 1½ years of its age has been calculated to be 6·0 mm.; 5 mm. between 1½ years and 2½ years and 3·75 mm. between 2½ years and 3½ years. The mature specimens were encountered during the period January–June and spent fish in June and July. The occurrence of hatchlings, larvæ and fry of *C. gora* in large numbers during the period February–July suggests that the fish breeds during these months. The fecundity of one specimen (T.L. 207 mm.) with ovary weight 5·70 gm. was 36,263. The stomach contents of 82 specimens have been analysed and it was seen that the fish subsists mostly on teleosts (54·6%). The insects made up 37·7% and crustaceans 5·0% of the diet.

The total length-frequency data of the four major carps landed at Sadiapur, have been analysed for the years 1954–57.

The size attained by *C. mrigala* at various ages has been estimated to be as follows:

1st year—340·5 mm.; 2nd year—540·5 mm.; 4th year—780·5; 6th year—860·5 mm.

The average monthly growth rate works out as:

Up to 1st year	..	28 mm.
Between 1st and 2nd year	..	17 mm.
Between 2nd and 4th year	..	10 mm.
Between 4th and 6th year	..	5 mm.

The mean length and standard error of monthly samples of *C. mrigala* landed at Sadiapur have been calculated for the period 1954–57.

Four centres, two in Jumna (A and B), one in Ganga (C) above the confluence of the two rivers and one below the confluence (D) were selected for the study of physico-chemical conditions. Ganga water at centre C was slightly turbid throughout. Dissolved oxygen, alkalinity and chloride content in the river Jumna are richer than the Ganga, but as regards phosphates, Ganga (C) showed a tendency for maintaining higher values. Nitrates and silicates did not, however, show any sharp differences between the two rivers.

Over 135 species of fish have been collected from the drainage including the hill stream, the lower reaches of Bramhaputra and its tributaties. The system of leasing out the Government waters is extremely defective and has resulted in excessive exploitation of all the waters in the State. The co-operative movement is still in its infancy and the fishermen have organised themselves into a co-operative society merely to avail of some benefits. It is interesting to note that the important office-bearers of these co-operative societies in most of the cases are not actual fishermen. The prime need of the fishing community of Assam appears to be a proper organisation of co-operative society of *bonafide* fishermen.

10. *The Ganga survey*

The total fish production for the year in the River Ganga has been estimated to be 7,11,383 kg. Lowest catches were recorded in August (1·6%) and highest in December (13·7%). The heavier landings were observed during October–March when over 67·2% of the annual catches were landed. The annual fish production from the Jumna has been computed to be 5,27,954 kg. and over 70% of the catches were landed during November–March. The lowest catches were recorded in August (2·3%) and highest in December (17·0%). The species composition of catches from the two rivers showed that the major carps constituted over 47·1% from the Jumna as against 29·3% from the Ganga, but the fishery of *C. mrigala* was the most important in the two rivers. The cat-fishes contributed over 36·3% in the Ganga as against 46·1% in the Jumna. *Hilsa* contributed substantially to the catches from the Ganga (15·4%) but it formed only negligent fishery in the Jumna (1·6%).

Over 59,154 kg. of *Catla*, constituting 8·3% of the total annual landings, have been estimated to have landed from the Ganga River between Fatehgarh and Rajmahal. The heaviest landings were recorded in December and January and lowest in August. The size-group 66–86·4 cm. was predominant during April–July and juveniles (up to 30·0 cm.) in August–November. The fish subsisted mainly on Diatoms (*Synedra* and *Pediastrum*) and *Spirogyra*. The gastrosomatic index ranged between 0·01 and 0·06.

The coefficient of condition K was determined month-wise for the fishes from Agra locality (Jumna) and the values were highest in June and July, which probably suggests a breeding season from late July or early August. The sex ratio for the year was found to be 10 M.: 9 F.

21,599 kg. and 5,720 kg. of *Silonia silondia* were landed from the Ganga and the Jumna respectively during the year. The heaviest catches were recorded in December and lowest in August. The fish subsists on teleosts

(*Mugil* sp., *S. phasa*, *Puntius*, etc.), and insects (larvæ of Diptera, Coleoptera, *Chironomus*, water bugs and nymphs of Odonata). The breeding season of *Silonia* is perhaps protracted, during April–September. The peak breeding period, as reflected by high values of gonado-somatic index in July (1·12) however is August–September. Fecundity of one specimen (1,220 mm. in total length) with ovary weight 220·36 gm. was calculated to be 4,26,783. The sex ratio for the year is 2 M.: 3. F. The general length/weight relationship is expressed as $W = 0{\cdot}0003158 < 2{\cdot}7578$.

11. *Water pollution studies in the River Ganga at Kanpur*

The problem of pollution at Kanpur arises out of about 60 major industrial undertakings—tanneries, textile, and woollen mills and the domestic sewage of the city, the wastes from which are discharged into the river system. Regular observations, as to physico-chemical conditions, plankton biota and fish fauna, were made at eight sampling stations in a 21-mile stretch of the river. The pollutional wastes tend to affect the quality of water by depressing the dissolved oxygen and pH values and by increasing the B.O.D. and Oxygen consumption capacity, Ammonia, Albuminoid ammonia, etc. The near septic conditions were noticed at station II (close to the Bridge) during June 1958 with lowest D.O. and high B.O.D. values. In September and December the conditions had improved to near normal conditions, but by January and February, the mild pollutional conditions had reappeared. At station V near the main sewage outfall, discharging over 20 million gallons of combined effluent and sewage, the pollution was very apparent in January and February with low D.O. and high B.O.D. values.

Septate and non-septate fungi, *Nebelia* and other protozoans occurred below sewage outfalls. *Difflugia* was predominant in natural unpolluted water. Among plankton organisms Rotifers were the most abundant group and various genera showed different responses to the changed conditions of the water. Copepods and cladocera had a tendency to avoid the pollution zones where they occurred in decidedly lower numbers. Myxophycea were abundant in polluted stretches and Chlorophycea in recovery zones. Over 90 planktonic forms have been identified and their distribution in different zones studied.

The apparent toxicity limits of six compounds, found in the tanneries and textile wastes, have been determined with *C. mrigala* and *P. sophore* as test animals.

The bioassay experiments have shown that the process waters do not exert a high degree of toxicity to fish life on account of great dilutions in the river.

12. *Narbada-Tapti survey*

The two fishing centres Hoshangabad and Shahganj handle the catches of the 30-mile stretch of the Narbada River. A total of about 20,200 kg. fish valued at Rs. 22,164 are estimated to have been landed at the two centres from August 1958 to March 1959. The fishery of *Barbus* (*tor*) *tor* was more important at Hoshangabad (30·15%) with *L. fimbriatus* contributing 10·3% and *C. mrigala, C. catla* and *L. rohita* small percentages. At Shahganj the fisheries of *Barbus* (*tor*) *tor* and *L. fimbriatus* were almost equal (19·73 and 19·43%) and *C. catla* and *L. rohita* were totally absent. *Rita pavimentata*, however, was the most predominant fish at both the centres among the cat-fishes, but at Hoshangabad it contributed to only to 12·94% of the total catches as against 24·29% at Shahganj.

Observations on catch-per-unit-of-effort for two main types of fishing gears, namely, long lines and cast nets, were made at Shahganj centre. 228 long lines for a total period of 2,577 hours and 151 cast nets for a period of 1,324 hours produced an average catch of (per 500 hooks per hour) 0·17 kg., as against 0·543 kg. per cast net per man-hour. The maximum catch-per-unit-of-effort for both the types of gears was in July–September and lowest in January–March. Drag nets were operated in December 1958 and March 1959. Average catch-per-net-per-man-per-hour for the two months together was 15·94 kg. Stomach contents of 419 specimens of *Rita pavimentata* were analysed and the feeding activity was found to decline progressively from July to February. The principal diet of the fish consisted of Prawns (12·3%), Molluscs (11·4%), Teleosts (10·9%) and Insects (9·4%). The juveniles (up to 120 mm.) subsisted mainly on insect larvæ and adults. Examination of gonads and ova diameter of the ovaries indicated that the fish breeds from July–September.

250 miles of Narbada (both banks) in Madhya Pradesh from Hoshangabad to Mandla, and 90 miles in Bombay State from Broach to Surpan were surveyed. Of the 292 villages in the 250-mile stretch in Madhya Pradesh, 157 are fishing villages with a total population of 26,608 persons, 1,824 being active fishermen. The fishing gears in the fishing villages were scoop nets (1,561), cast nets (3,279), gill nets (1,071), drag nets (17), long lines (3,373) and fishing rods (258). The number of boats available in these villages are: large (above 20′): 53, Medium (11–20′): 2,150, and small (up to 10′): 359. Out of 113 villages surveyed in the 90-mile stretch of Bombay State,

63 were fishing villages with a total population of 6,950, of which 482 were active fishermen. The fishing gears were scoop nets (1,623), gill nets (1,723), bag nets (300), drag nets (158), cast nets (217), long lines (1,306) and traps (12). The number of boats was Large: 233, Medium: 115 and Small: 4.

Day-to-day observations on the availability of carp seed from Narbada River at Hoshangabad were made for 28 days in July–August 1958. About 5,80,000 carp fry were collected from three fry collection nets in 84 hours. The percentage of major carps, comprising *L. fimbriatus*, *C. catla*, *C. mrigala* and *L. calbasu*, were extremely poor. The collections consisted mainly of fry of *C. reba* and *L. bata*.

Collections of fairly large number of hatchlings, larvæ and juveniles of *Barbus* (*tor*) *tor* were made in the first week of September 1958 for the first time during monsoon season. This clearly indicated that the breeding of this species commences in August–September. This was further supported by the partly spent condition of the ovaries in September. Collections of fry measuring 15–25 mm. in total length, caught from Narbada River during September 1958 to January 1959, have shown that in all probability the breeding period of this species of Mahseer extends over 3–4 months from August–September onwards.

13. *Krishna-Godavari survey*

A preliminary survey of the two systems to evaluate their fisheries resources was completed in April 1958 and Rajahmundry was selected as the Unit's Headquarters. The staff appointed under the scheme was given extensive training at Allahabad in survey and research investigations and posted at Rajahmundry from March 1959.

Rajahmundry is served by two main markets and catches during March have been estimated to be 12,422 kg., of which carps formed 31·05%, cat-fishes 15·99%, prawns 19·67% and miscellaneous 33·29%.

The fishermen population of Rajahmundry and Dowleswaram is 31 and 250 respectively. The fishermen at Rajahmundry use cast nets (159) and drag nets (4) only, whereas at Dowleswaram cast nets (29), Rangoon nets (125), Kathuwala or Theluvala (2) and Jariguvala (500) are used.

14. *Lacustrine investigations at Tungabhadra Dam*

During the year under report 20·67 metric tons of fish were sold at Hospet fish market. Predominant species were *Barbus kolus*, *Labeo fimbriatus* and *Barbus dobsoni*.

Fishing in the Tungabhadra reservoir is not organised and hence the Research Unit operated Uduvalai and Rangoon nets with the help of two fishermen and a coracle. This fishing was done on 134 days and a total of 467·2 kg. fish was caught, the average daily catch being 3·45 kg.

All the specimens of *L. fimbriatus* caught were immature and their guts were invariably empty. Scales collected from fishes from the market were examined for growth studies. The average length attained at the formation of different rings is as follows: 1 ring—172·3 mm.; 2nd ring—259·3 mm.; 3rd ring—339·4 mm., 4th ring—418 mm.; 5th ring—488 mm. and 6th ring—563·3 mm.

963 specimens of *Barbus kolus* were examined and it was seen that the food of the adult consists mostly of gastropods, followed by copepods, insect larvæ and ostracods. Young ones below 110 mm. feed mostly on *Cyclops*, *Diaptomus* and *nauplii*. The fish breeds throughout the year with a peak during June–July. The fingerlings have been collected during the months of April, May, June, July, August and September. The female matures when it reaches 3 years of age and is nearly 230–300 mm. in length. The number of mature eggs in an ovary varies from 1,430 to 9,500. The male matures earlier than the female. The growth in the male and female is nearly same and the lengths attained at different ages are as follows: 1st scale ring is formed at 51–140 mm.; 2nd ring at 121–200 mm.; 3rd ring at 151–250 mm.; 4th ring at 211–300 mm.; 5th ring at 261–340 mm.; 6th ring at 311–80 mm.; and 7th ring at 351–410 mm.

The food of *Barbus pinnauratus* consists mainly of *Spirogyra*, diatoms, insect larvæ and molluscs. Like *B. kolus* this fish also breeds throughout the year with peak in April and the number of ripe eggs varies from 24,455 to 1,52,655. Growth studies on scales show that the 1st ring is formed at 90–110 mm. length, 2nd at 145–60 mm., 3rd at 185–90 mm., 4th at 235–50 mm., 5th at 270–80 mm. and 6th at 310 mm.

27 specimens of *Barbus tor* were studied. They were caught in Rangoon nets only and not in Uduvalai. The average size of fish caught in different meshed nets is as follows:

1″ mesh—20·7 cm.; 2″ mesh—40·8 cm.; 2·5″ mesh—52·4″ and 3·5″ mesh—58·2″.

Barbus dobsoni feeds on molluscs and vegetable matter. The gonads in all the fishes caught were in immature condition.

Over 700 specimens of *Rohtee vigorsee* were examined and the food was found to consist of insect larvæ, small gastropods, fish fry and zooplankton. The ratio of male to female was nearly 1 : 5. Females in running condition of gonads were found in May. The number of mature eggs varied between 10,580 and 98,980. The fish appears to have a prolonged breeding season from April to October.

The age and growth studies on scales show that 1st ring is formed at 69·9 mm. average length, 2nd at 110·3 mm., 3rd at 170·2 mm., 4th at 222·2 mm., 5th at 272·8 mm. and 6th at 308·2 mm.

68 specimens of *M. seenghala* were examined, most of which had unripe gonads. Majority of them were caught in Rangoon nets of 1·5" and 2·5" mesh. The food consists of teleosts, specially *Chela* spp. and young ones of *Glossogobius giuris* and insect larvæ.

112 specimens of *Silonia silondia* were examined, of which 69 were caught in the month of May 1958 only. The fish feeds mostly on minnows. The cleitherum bone shows very good growth marks. The first mark appears at 170–90 mm. length, second at 240–60 mm., third at 290–320 mm., fourth at 345–65 mm., fifth at 404–60 mm., and sixth at 470–500 mm.

Efforts were made to locate the areas of spawning of fish in the reservoir and its inlets—the Hirahalla and Chilka Hagari River. Fry and fingerlings of major carps were not collected in the tow net in the reservoir. The fry of *L. fimbriatus* (14–53 mm.) were collected from the river and fry of *Cath* from Raya canal which joins the Kamalapuram tank.

Studies on the fisheries of Krishnaraj Sagar have also been started and experimental fishing was done for 5 days during the month of March 1959. A total of 17 nets (six Rangoon nets and 11 Uduvalai nets) were laid daily.

Studies on bottom fauna were made in the reservoir and collections obtained at different depths up to 20 meters. Gastropods and dipteran larvæ are found at all depths. Mayfly larvæ were found up to 10 metres. Chironomids and Mayfly larvæ were present at all periods except July–September. Other organisms were present throughout the year.

Plankton studies were made at the surface and at 2, 4, 6, 8, 10 and 12 metre depths. Blue-green algæ predominated in the phytoplankton and was followed by green algæ and diatoms. Maximum concentration was found during the months of May and June. Zooplankton was at its maximum during May and November.

Maximum surface temperature (30–31° C.) was during April and May and minimum during December and January (25° C.). There was indication of thermal stratification during April and May between 4–6 metre depths and again during March 1959. The temperature near the 20 metre depth was nearly 2–3° C. less than surface temperature. pH varied between 8·2 and 8·4. Due to floods, turbidity was high (8″) during July and August. Later, the water became clear and lowest turbidity was found during January (76″).

ESTUARINE DIVISION

15. *Investigation on the fisheries of the Hooghly, Matlah and Mahanadi estuaries*

The fisheries in all the three estuaries were slightly better than during the previous year but were much poorer than in normal years. The monsoon fishing for *Hilsa* was extremely disappointing in both Hooghly and Mahanadi. During the winter season for a very short period appreciable catches were made in the Sunderbans and certain areas of the Mahanadi estuaries, but for the rest of the period fishing was very poor. As the bag net fishery in the lower zone of the Hooghly was also very poor, the winter fishing camps broke up earlier than usual and only less number of fishing units operated in the area.

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

Zonewise total catch figures of Hooghly and Matlah estuaries

	Weight in kg.
Hooghly estuary—	
Zone I ..	10,28,488·56
Zone II ..	2,65,694·02
Zone III ..	14,76,832·44
Zone IV (Rupnarain) ..	2,84,812·94
TOTAL ..	30,55,827·96
Matlah Estuary—	
Zone I ..	2,63,501·80
Zone II ..	3,30,640·74
TOTAL ..	5,94,142·54
GRAND TOTAL ..	36,49,970·50

The inventory of the fishing units of the Mahanadi estuary was almost completed during the year. It was estimated that there are about 5,020 fishermen with about 45,833 nets of different types, fishing in the area.

The estimation of total catches of Mahanadi is in progress but a general increase in total landings is apparent as shown by the statistics of total quantity of fish exported during the year which was estimated to be 2,57,970 lb. (1,17,013 kg.) as against 1,86,900 lb. (84,776 kg.) in 1957–58.

A comparison of the fisheries of the three estuaries for the whole year brings out many interesting features. The bulk of the annual landings from the Hooghly is composed of *Hilsa* (about 55%) while there is hardly any *Hilsa* fishery in the Matlah estuary. It would appear that on account of the lack of an adequate supply of head waters, *Hilsa* does not ascend this estuary. Sciænids and cat-fishes form the other two important groups. In Matlah, crabs and perches contribute to the major portion of the catches, cat-fishes and miscellaneous clupeoids also being important constituents. Matlah contributes to a greater production of prawns and shrimps as also Polynemids. In Mahanadi the fishery is mainly for Bhekti, Mullets and Polynemids and the catch of miscellaneous fishes is markedly low, mainly on account of the selectivity of the nets operated.

16. *Analysis of commercial catches*

As during previous year, regular studies of samples of commercial catches collected at fortnightly intervals from selected sampling centres in the estuaries were carried out to provide the primary data for understanding the population characteristics.

Hilsa ilisha formed the most important species in Clupeoid group and details regarding this species are given under the section dealing with *Hilsa* investigations. Among other clupeids *Setipinna phasa*, *Anchoviella tri* and *Coila* spp. were the more important forms.

Setipinna phasa was represented mainly in the catches from the upper and middle zones of the Hooghly estuary by '0', I and II year groups. The '0' group dominated as in previous years, but I and II year groups which usually form the main spawning stock were comparatively rare. New recruits to the fishery ('0' group—modal length 8·5 cm.) appeared during the months of May and June. Availability of mature and spent specimens in the catches only during the months March–June and the appearance of early size-groups during subsequent months confirms the observation that the fish spawns during the pre-monsoon months (March–June). Prawns, copepods and

other fish formed the main food of the species. The feeding activity was found to be rather low during the year.

Anchoviella tri occurred in large numbers at Port Canning in Matlah throughout the year. Juveniles ranging in length from 21 to 77 mm. dominated the catches. In the Hooghly estuary the fish were comparatively scarce and were represented only in the catches from the lower Sunderbars. Copepods, cladocerans and diatoms formed the main food of the species. *Anchoviella indica*, which in the previous year formed a sizeable fishery, was almost totally absent. *Coilia ramacarati* and *C. borneensis* were mainly found in the catches from the lower Sunderbans. The size range was between 23 and 192 mm. Juveniles having a modal length of 50 mm. entered the fishery in the summer months and they had fed mainly on copepods and the adults on fish, prawns and copepods.

Mugil corsula, *M. cunnesius*, *M. parsia* and *M. tade* were the species of mullets that contributed to the fishery. Of these *M. corsula* was caught in all the zones of the estuary and others were restricted to the lower zone only. *M. corsula* was represented only by '0' group individuals in the upper or middle zones, whereas maturing and mature I and II year groups were caught only from the lower zone. In the other species also, the dominant class was '0' year group and the smaller size-groups entered the fishery in the winter months. Adults of *M. parsia* belonging to I and II year groups were found in the catches from lower Sunderbans during winter. *M. tade* was represented in the catches by three distinct groups having modal lengths of 68, 125 and 300 mm.

Polynemus paradiseus formed the most important species among threadfins in the catches, particularly from the middle and upper zones of the Hooghly and from Matlah, whereas *Polydactylus indicus* and *Elutheronema tetradactylum* were caught mainly from the lower zone. The fishery of *P. paradiseus* continued to be poor this year also. Mature and maturing individuals of the I and II year classes, of which the former was dominant, were represented in the catches during the earlier part of the year (March–April). The smaller size-group ('0' group with modal length of 3·5 cm.) fishes entered the fishery in the months of May and June. Only immature '0' group individuals of *E. tetradactylum* and *P. indicus* were represented in the catches sampled in the estuary. Large-sized mature individuals were caught in good numbers in the lower Sunderbans during the winter months.

Lates calcarifer which is the most important perch of brackishwater areas was caught in greater abundance from the Matlah and Malanadi estuaries. It was rarely found in the catches of the Hooghly though

abundant in the enclosed brackishwater waters fed by this estuary. The unsuitability of the gear employed appears to be the reason for the scarcity of this species in the catches from the main estuary. Experimental fishing with more effective gear is proposed to be carried out for this species with the Estuarine Research and Exploratory Fishing Vessel recently obtained. The commercial catches from the Hooghly and Matlah consisted mainly of two and three year size-groups, whereas in Mahanadi all the year groups were represented in the catches.

Maturing and mature *Sillago panijius* were caught during this year also in the winter months from the lower reaches of the Hooghly and Matlah estuaries. Juveniles with a modal length of about 4·0 cm. occurred in the catches from the rest of the estuary throughout the year.

Cat-fishes represented by about 20 different species formed a very important group contributing to the fishery throughout the estuarine system. *Mystus gulio* was represented in the middle zone during June–September and in the lower zone during the winter months. There was a decline in the catches of the species during the year as compared to the previous year. The features that characterised the year's fishery for the species were a marked numerical decline in the advanced '0' group fishes (modal length 77 mm.) which resulted from previous year's spawning; a similar rarity of the I year group (modal length 120 mm.) which in previous years constituted the main spawning group; very low recruitment to the fishery of the smaller size-groups in the post-spawning months (October–December) and absence of II and III year classes (from the fishery) which also in previous years contributed to the spawning stock. The species fed actively during all the months of the year on prawns, megalopa larvæ, insects and fæcal matter. *Pangasius pangasius*, the general trend of the fishery for which was more or less identical to that of the previous year, was represented in the catches of the middle and upper zones of the estuary almost throughout the year. '0' to IV year classes comprised the fishery, of which '0' group predominated. '0' year classes formed the new recruits entering the fishery in the upper and middle zones of the estuary during August–December. The II and III year groups, which usually enter the fishery of the middle zone during summer months were comparatively scarce this year. During winter months in the lower Sunderbans, II, III and IV year groups (modal lengths 195, 230 and 250 mm. respectively) contributed to the fishery and of these, the II year class was dominant.

Osteogeneosus militaris was represented in small numbers in the catches from the lower Sunderbans during winter months by advanced '0' group fishes (modal length 95 mm.). During summer months I and II year classes

(modal lengths 125 and 230 mm. respectively) constituted the fishery in the middle zone, of which I year group was dominant. The noteworthy features in the year's fishery were: a predominance of I year class, which in previous years were absent in the middle zone; a numerical decline of the II and III year classes which in previous years constituted the main spawning stock; comparatively low recruitment of '0' group individuals in the upper reaches of the middle zone instead of in the lower reaches as in previous years. The smaller size-groups of the species (50–100 mm.) fed on copepods and small prawns, whereas the adults subsisted on fish and prawns. The feeding activity appeared to be low during monsoon and high during winter months. *Tachysurus jella* afforded a good fishery in the lower Sunderbans during winter months. In the middle zone of the estuary '0', I and II year classes entered the fishery during March–August and of these the '0' group was dominant.

Harpodon nehereus formed an important constituent of the fishery in Matlah during all the seasons except winter. Appreciable numbers of the fish were caught in the lower Sunderbans in the Hooghly estuary during winter months. The catches consisted mainly of juveniles (72 mm. modal length). Mature specimens ranging from 132 to 279 mm. were also available in the lower zone of the Hooghly. Smaller fishes, prawns and megalopa larvæ formed the main food of the species.

Trichiurus savala, *T. haumela* and *T. muticus* were the three species of ribbon fishes in the catches, the first being the most abundant. The fishery of all these species was confined to the lower zone of the Hooghly estuary and Matlah, where they were caught in large numbers during September–March. The size of *T. savala* in the catches ranged from 16·1–42·0 cm., of which 75% of the specimens examined were immature and rest mature. Most of the mature specimens had gonads in the III stage of maturity. No oozing or spent specimens were obtained. *T. haumela* ranging in size between 18·1 and 41·0 cm. were represented in the catches in lesser quantities. *T. muticus* ranging in size from 14·0 to 34·0 cm. were caught in very small numbers. Prawns and small fishes formed the food of the species.

Pama pama was the most common species of jew fish in the catches of the Hooghly estuary. The species was absent in the catches from Matlah. The '0' age-group ranging from 10 to 70 mm. was predominant in the upper and middle zones during the months, October–March. Larger size-groups having a modal length of 25·0 cm. were caught in large numbers in lower Sunderbans during winter months. Maturing fish over 15·0 cm. in length were obtained in the catches during March–August and oozing and spent

fish in June and July. Fishes, prawns, megalopa larvæ, copepods and cladocerans constituted the food of the species. *Sciæna coitor*, *S. balengeri*, *S. ossea*, *S. vogleri*, *S. biauritus* and *Otolithus maculatus* were the other species of jew fishes that were caught, mainly in the lower zone of the Hooghly and Matlah during the winter months.

Gobiids, represented by *Glossogobius giuris*, *Apocryptes bato* and *Odontoblyopus rubicundus*, were the only group among the miscellaneous fishes that contributed appreciably to the fishery. These fishes were found mostly in the upper zone of the estuary throughout the year, where the juveniles of all these species formed a considerable part of the bag-net catches.

Study of the samples of prawn catches of previous years completed during the period shows that both in the Hooghly and Matlah estuaries, *Palæmon mirabilis*, *Leander styliferus*, *Metapenæus brevicornis* and *Parapenæopsis sculptilis* formed appreciable proportion of the catches. In the lower stretches the majority of the prawns consisted of *Leander styliferus* and *Metapenæus brevicornis*, both of which together forming about half the total catch from the entire estuarine region during the winter months. One interesting feature noticed is the scarcity of *Penæus semisulcatus* in the catches from the estuaries even though it is one of the most important estuarine prawns of the area. It is found that the majority of the prawns of this species brought to the assembling centres and markets are caught from the embanked brackishwater areas, where they enter as juveniles. It appears most likely that unsuitability of the fishing gear is responsible for the scarcity of this prawn in the catches. Exploratory and experimental fishing is therefore proposed to be carried to determine whether there are unfished resources of this prawn in the estuaries.

Observations carried out throughout the year indicate that *Palæmon carcinus* migrates down the estuary and breeds in the neighbourhood of Uluberia during the period March–June. Study of the commercial catches show that during this period mature and berried individuals occur in the area. Experimental fishing has to be carried out to delimit the breeding grounds and assess the extent of fishing intensity brought to bear on the stock.

17. *Hydrobiological observations*

In the main Hooghly estuary, the surface temperature of water ranged from 21·0 to 33·7° C. during the year, while the temperature in Rupnarain, Matlah and Mahanadi varied between 20·5–33·1° C. and 20·8–33·5° C.

respectively. In the Hooghly the salinity of water in the region above Diamond Harbour was in traces during August and September. On the basis of salinity data, the entire stretch between Fraserganj and Medgachi in Hooghly could be divided into three zones. An upper stretch (area above Khusigoli which had only traces of salinity throughout the year), a middle stretch (comprising the area between Diamond Harbour and Khusigoli which has a salinity range from traces to 25·7‰) and a lower stretch (the area below Diamond Harbour which has a salinity range between 2·0 and 34·2‰).

Qualitative and quantitative analyses of plankton from Hooghly, Rupnarain and Matlah were continued. Compared to the previous year there was a further decline in plankton production in the Hooghly estuary, whereas in Matlah the production remained steady. This appears to bear relation with the poor fisheries of the estuaries during the last two years. Production of plankton in Rupnarain improved slightly till June and thereafter declined. Plankton production in the upper zone and lower zone was higher than in the middle zone. Freshwater forms predominated in the upper zone, whereas in the lower zone marine forms dominated. In the middle zone both freshwater and marine forms were present.

Among the important phytoplankters in the upper reaches of the Hooghly estuary were *Coscinodiscus*, *Melosira*, *Spirogyra* and *Oscillatoria*. Copepods rotifers, and nauplii predominated in the zooplankton. In the lower reaches Diatoms, mainly *Coscinodiscus*, *Chætoceros* and *Thalassiothrix* predominated in the phytoplankton whereas larvæ of various organisms were dominant in the zooplankton.

18. *Studies on the productive potential of brackishwater bheris*

Studies on the distribution and cycle of abundance of benthic algæ were continued in selected brackishwater bheris in Sunderbans. Study of correlation between algal production and the temperature, salinity and nutrients, both in the soil and water phases was done. The bheris selected for observations were of three categories as far as algal production was concerned (*i.e.*, high, low and medium productivity). The water phase was examined for temperature, salinity, alkalinity, phosphate, nitrogen, potassium, calcium and magnesium and the soil phase was tested for nitrogen, potassium, phosphorus and sulphide. It was concluded on the basis of observations that for good growth of algæ in the bheris, salinity should be above 10‰ and nitrogen, phosphorus and potassium should not be in limiting concentrations. Further, in a good bheri N, P, K was observed to be above 17·7 mg./100 gm., 3·8 mg./100 gm. and 55·3 mg./100 gm. (of soil) respectively.

Studies on the periodicity and seasonal changes of algæ in the bheris showed that blue-green algæ dominated during post-monsoon and early winter months, while green algæ dominated during late winter and early summer months.

19. *Studies on the maturity, breeding and early development of estuarine Palæmonid prawns*

Regular examination of samples collected from various parts of the Hooghly estuary showed that *Palæmon rudis*, *P. mirabilis* and *Leander fluminicola* breed almost throughout the year. *Leander styliferus* and *L. tenuipes* breed only in the more saline lower stretches of the river, though the embryos do not actually hatch out there. *P. carcinus* congregates in the neighbourhood of Fuleshwar from the latter half of March–June when the catches from the area consist mainly of berried females. *P. malcolmsonii* and *P. scabriculus* are more abundantly found in the upper stretches near Khasbati and Medgachi, where during monsoon months and early winter, berried females occur in appreciable numbers. The period of incubation varies from 15 to 22 days in different species. *P. lamareii* eggs are comparatively large and the larvæ hatch out in fairly advanced stage with all appendages already formed. It undergoes three rapid moults to reach the stage when it resembles adults. The stage I and stage II larvæ of all the other species are very similar in appearance but for slight differences in the colour of the chromatophores on the 3rd abdominal segment. Observations on the maturation of *P. carcinus* show that the ovaries begin to mature by early March. From April to early part of June fully mature and ovigerous individuals are found. The pattern of ova maturation indicates that a single female spawns more than once in the season.

20. *Rapid survey of Pulicat and Kerala backwaters*

Pulicat lake is a shallow stretch of backwaters, approximately 178 sq. miles in area connected to the sea by three main openings at its southern tip and several smaller inlets in the northern half. About 3,000 fishermen work in various parts of the lake and sixteen different types of gear are operated making a total of 3,891 nets, but of these only 'Badivalai' (shore seine), (boat seine) and 'Koduvavalai' (gill net) are important.

From the collections made in March 1959 it is found that salinity in the lake varies in different localities from 12·30‰ (off Venadu) to 37·12‰ (off lake mouth at Pulicat). pH varied between 6·9 (at Irakam) and 8·0 (at Annamalaicheri).

40 different species of fish, 3 prawns and 2 crabs were observed to be caught by the commercial fishermen during the survey. Mullets and prawns constitute the major portion of the catches from the lake. It is estimated that in and around Pulicat village only (an area of approximately 40 sq. miles), 7937·87 metric tons of fish and 907·18 metric tons each of crabs and prawns are landed yearly. The total annual production of the lake is estimated to be about 18,14,360 kg.

A preliminary survey of the Kerala backwaters was initiated in the month of March 1959 for studying their fishery potential. A survey of the largest piece of backwaters, *viz.*, the Vembanad lake and connected waters, extending from Cranganore in the north to Alleppey in the south, a distance of about 60 miles and covering an area of roughly 100 sq. miles, was carried out during the year. The backwaters are in most places shallow, with depths at fishing grounds varying from 1 to 7¾ metres. The bottom is mostly muddy with an admixture of fine sand in some places.

The northern sector of the lake is much more saline than the southern portion because of its two connections with the sea and shows a salinity range of 23·31–33·55‰, while the waters south of Vaikom show a general decline in salinity (18·44–10·49‰). During the rainy season the water remains fresh for about 4 months up to Thannirmukkam in the southern sector.

Fishing is done all over the lake throughout the year. The fishing is controlled by the Government by a system of leasing and licensing. Among the most numerous and conspicuous nets are the Chinese dip nets and the stake nets, the licensing of which brings in a revenue of about Rs. 1,10,000 to the State.

In the northern sector above Arukutty, the main fishery seems to be that of prawns and mullets. At Azhikode large-sized mullets are caught in the dip nets. In the lower stretches, the fishery is dominated by the Bhetki, the Milk-fish and the Pearlspot, large- and medium-sized *Sciænids*, *Engraulids* and cat-fishes. The survey also revealed the existence of an occasional Hilsa fishery in the backwaters. It is estimated that a total of about 10,160 metric tons of prawns are caught annually in the lake.

21. *Investigations on the Hilsa fisheries of India*

As during the previous year, Hilsa fisheries were extremely poor during this year also. The migration of Hilsa up the river in the Hooghly during

the monsoon season was unusually delayed and this is attributed to the late and scanty rainfall in the area. The winter fishery was also extremely poor. However, in December there was a sudden revival of the winter fishery for Hilsa in the Sunderbans area and in the coastal areas of Midnapore. Nearabout Frasergunj alone about 11–13 metric tons of Hilsa were caught per day. This fishery, lasted only for about a week and came to a close as abruptly as it had started and was of added significance in view of the fact that the winter Hilsa fishery was a complete failure in the area during the preceding two years. Environmental studies conducted showed that coinciding with the Hilsa fishery, there was a marked increase in phytoplankton, especially the Diatom *Coscinodiscus*. The bloom lasted for about 10 days only. This observation has given added support to the inference arrived at from last year's studies, that probably the quantity of plankton in the Sunderbans area is an important factor that determines the success or failure of the Hilsa fishery.

In the Godavari and Krishna Rivers as also the Ganga, the fishery was extremely poor. However, it is reported that Bramhaputra afforded very lucrative fishery during the year. Sampling surveys to estimate the total catch and catch-per-unit-of-effort of Hilsa from the Rivers Godavari and Padma were conducted by the survey staff of the Hilsa Research Programme. An inventory of the Hilsa fishing units of the Krishna River was completed and a suitable sampling programme was devised to estimate total catches and catch-per-unit-of-effort from the river. Arrangements were finalised to obtain regularly the required catch data from other areas where comprehensive fishery investigations are now under way. Training was given to two officers deputed by the Fisheries Departments of Andhra and Assam in sampling survey methods for the collection of Hilsa statistics, with a view to collect the required data through the State Fisheries Departments in these two States.

The Hilsa catches from the Hooghly estuary during the period April–December 1958 was estimated to be 5,31,698 lb. (2,41,192,12 kg.). During the same period the catches from Lalgola amounted to 18,095 md. (6,56,617 kg.). The catches from the Godavari were extremely poor and amounted to only 17,062 kg. The catch per unit effort figures of the Hilsa fishing units operated in the Hooghly are reported elsewhere. The data for Padma are as follows:

Name of fishing unit	Hilsa catch-per-unit-of-effort in kg.	Percentage of Hilsa in relation to the other species caught in the nets
		%
Sanglo jal ..	1·85	100
Chandi jal ..	5·35	89
Kona jal ..	5·50	72
Kharke jal ..	0·56	100
Bauli jal ..	1·12	100
Chota jagatber jal ..	4·01	19

In the Godavari, Hilsa were caught in small quantities in all the 4 centres of observation. The Rangoon net was the main net operated at these centres during the quarter and the entire catch of this net consisted of Hilsa.

The four-year age-group predominated in the catches from the Hooghly, Padma and Godavari. In Padma, however, a fresh year group of two-year old fish entered the fishery in October 1958 and gained prominence over the older age-groups by December 1958.

The analysis of the morphometric data collected so far to delimit the Hilsa populations is nearing completion. The clusters of morphometric characters obtained during last year by the use of distance functions do not appear to signify either any genetic relationships or similarity in environmental conditions. The analysis of variance and covariance of non-meristic data shows that the populations of Hilsa of Ganga, Padma, Chilka, Godavari, Cauvery and the Saurashtra coast can be distinguished from the Hilsa of the Hooghly by the regression of head length or total length alone, though there are other singificantly different characters also. Similarly the population of Bramhaputra, Krishna and Narbada can be distinguished by the regression of body height alone. On the basis of total number of vertebræ, the Hilsa of Cauvery and of Saurashtra coast can be recognised from the rest. The average number of vertebræ for Cauvery samples is 44·5 and for Saurashtra 45·5; whereas it is less than 44·5 in samples from all other areas. The populations from Krishna River and Ganga can be distinguished from the others by the average number of trunk vertebræ which are 12·1

and 12·48 respectively. Populations of Chilka, Bramhaputra and Narbada can be distinguished by the average number of caudal vertebræ without hæmal spines, which are 11·24, 11·52 and 11·8 respectively. The stock of Padma can be distinguished from the others by the low average number of vertebræ with duplicate neural spines (20·5).

The fishermen and the fish traders generally differentiate Hilsa from different river systems by their taste which seems to be mostly based on fat content of the body. With a view to determine whether there are any significant differences in the fat contents of fish from different river systems, analyses of samples were carried out. Mature male and female fish in the VI stage of maturity collected during the breeding season only were utilised for the study. A minimum of 8 samples of male and female fish were analysed from each river system. The data obtained so far are given below, which show significant differences in fat contents of fish from different environments.

Origin of sample	Average percentage fat content		
	Female	Male	Total
Krishna River ..	11·70	17·50	14·48
Godavari River ..	9·70	13·60	10·70
Saurashtra coast ..	15·46	23·10	16·73
Narbada River ..	5·40	5·40	5·40
Mahanadi River ..	18·40	21·05	19·28
Padma River ..	14·07	14·70	14·40

To enable large-scale tagging of Hilsa, an inexpensive nylon streamer tag was designed and hand-fabricated with mostly locally available material. The tag which consists of a rectangular Vinyl Plastic strip, 35 × 12 mm. with the necessary explanatory legend written by hand with Vinyl Stamping Black Ink and a braided nylon streamer, costs only about a Rupee per hundred. After a series of preliminary experiments a suitable method of tagging Hilsa was evolved. The fish, collected immediately after capture from the fisherman's net, is placed in a specially prepared fish cradle lined with plastic foam lining to prevent any injury to the fish, immersed in a tub of

water. The tag is tied behind the dorsal fin by piercing the dorsal musculature by means of a surgeon's needle. This type of tagging did not injure the fish in any appreciable manner and the examination of recovered fish has confirmed this. A total of 760 fish were tagged and released in the Hooghly, Padma and Ganga Rivers during the year. So far about 7·76% of the tagged fish have been recovered. The recovery is very satisfactory in the Hooghly area where it has been possible to carry out fairly intensive propaganda. The results of the experiment obtained so far seem to indicate that the direction of migration of mature or maturing Hilsa is not always up-river as generally believed. A number of tagged fish have been recovered from downstream fishing grounds also. One fish marked near Chinsurah in the Hooghly, travelled downstream (a distance of 70 miles) and then ascended the Rupnarain a distance of about six miles. One Hilsa tagged in Lalgola in the Padma had migrated up-river a distance of about 260 miles in about two and a half months' time.

Survey to assess the abundance of young Hilsa in the Hooghly was continued. Comparative experiments conducted for the purpose of evolving a standard method of operation of bag nets for working out an index of abundance have shown that the figures of catch per high tide, obtained by the operation of a bin jal with the upper margin of the net above the surface of water, would be a suitable criterion for studying abundance in different years, seasons or localities. The average catch per high tide during the year in Barrackpore, where the experiments were conducted, was 38 fish. In low tide the average was only 9 fish. It is proposed to expand such surveys to other areas also to assess the abundance of young fish and of fresh recruits to the fishery.

Chilka Lake Investigations

22. *Fisheries of the Chilka lake*

A total of 38,37,915 kg. of fish has been estimated to have been obtained from the Chilka lake during 1958 against 44,11,249 kg. during 1957. Of this, prawns constituted 30·42%, mullets 20·97%, clupeids 16·39%, cat-fishes 10·46%, sciænids 6·98%, threadfins 5·74%, perches 5·00% and the rest 4·04%. *Mugil cephalus* (14·37%) and *Liza troschelli* (4·16%) formed the more important fishery of the mullet group. Among the prawns, *Penæus indicus* formed 21·65% and *P. semisulcatus* 6·76%. *Mystus gulio* was the most important among cat-fishes contributing 6·49% of the total production and *Tachysurus arius*, *Osteogeneiosus militaris* and *Plotosus canius* together making up 3·47%. *Hilsa* and *Nematalosa* contributed 7·35% and 5·00% respectively. *Pseudosciæna albida*, *Eleuthèronema tetradactylum* and *Lates*

calcarifer formed 6·27%, 5·74% and 3·53% respectively of the total catches. A month-wise analysis of production shows that in the year 1958, October was the leanest month of production (3·58%) and December the biggest (11·31%). The enclosure trap fisheries called Jano, producing large quantities of mullets, were operated in the latter. During April–August the production varied from 8·74 to 11·0% of the total catches.

23. *Biological observations on commercial fisheries*

Mugil cephalus formed 68·4% of the total production among mullets, followed by *Liza troschelli*. Observations in 1958 confirmed those of 1957 and the opinion of earlier workers that the species undertakes regular breeding migration into the sea largely during the months October–December. Relatively large-sized mature specimens migrate away from the sea early in the season and progressively smaller ones are left to migrate later as the season advances. The seaward migrating males are interpreted to be mostly about 1 year old and the females two and more. Large-scale inward migration occurs in fingerlings. A few fingerlings (40–71 mm.) were recorded entering the lake in January 1959 and during 1958, bulk of the advanced fingerlings entered in May and June. A few large-sized individuals of *M. cephalus*, showing spent recovering ovaries enter the lake along with the fingerlings. In June 1958, ten such large females were found in a haul estimated to have about 1,320 advanced fingerlings. A regular seaward breeding migration of *Liza troschelli* has also been confirmed during the year under report. Bulk migration of this species occurred in January 1958 and also in December–January 1958–59. The majority of seaward migrating *L. torschelli* are interpreted to be one year old and females one and two years. In May 1958, a few fingerlings, 70–78 mm. in length and in June 1958 another lot 65–80 mm. in length, were observed close to the lake mouth. In March 1959, a large number of fingerlings of the size range 96–243 mm. entered the lake from the sea, the mode being at 163 mm. class.

Penæus indicus formed 71·2% and *P. semisulcatus* 22·2% among prawns. Size frequency data on 7,323 specimens of *P. semisulcatus* collected in the main body of the lake and outer channel are on record. In September 1958, post-larvæ of this prawn measuring 9–15 mm. were collected in the sea close to the lake mouth. Some specimens of slightly larger sizes have been collected in the outer channel from August 1958 onwards and still larger ones in the main body of the lake. In April 1958 tens of maunds of *P. semisulcatus* were caught in the outer channel where there were insignificant catches in the earlier months. In the case of *P. indicus* also it was possible to catch post-larvæ measuring 8–13 mm. from the sea close to the lake mouth. It

has been confirmed that both these species of prawns depend on sea for the completion of their life-cycles.

Hilsa ilisha formed 44·9% and *Nematalosa nasus* 30·6% of the production among Clupeids in the year 1958. Year-round observations on *Nematalosa nasus* have shown that the species ripens when one year old and breeds in the lake during the period May–July. New recruits (zero group) enter the commercial fishery in August forming a very conspicuous mode centred at 67·8 mm. class. Breeding largely occurs in the Southern Sector of the lake. Observations made in 1958–59 have confirmed those of the previous year that one-year-old individuals grow to about 180 mm. total length and two years old to about 250 mm. total length. The maximum size at maturity is 131 mm. and the average size at first maturity is 171 mm. Lake mouth observations have shown that large-sized individuals from the sea of the size range 112–342 mm. add to the stock of Chilka *Namatalosa* from November-June, largest number having been recorded during April. The available data show that the zero year class enter the commercial fishery in September at 62·5 mm. class and form a very conspicuous mode at 133·5 mm. class in November–December. Yet another peak at about 312·5 mm. class represents specimens about 1¼ year old. There is evidence to show that stocks of Hilsa of the size range 213·5–488·5 mm. from the Bay of Bengal add to those of the Chilka during the period January–August. Young Hilsa 22–24 mm. and spent individuals were recorded in the outer channel in March 1959. Fingerlings of Hilsa were also encountered in the Northern Sector of the lake in March–April 1959. These observations show a double breeding of Hilsa, once in January and next in July–August–September. These observations need further confirmation.

Threadfins formed 5·74% of the total production in the year 1958 and the dominant species is *Eleutheronema tetradactylum*. The fish breeds in the lake twice in the course of the year (June–July and January–February). Its fingerlings are available in overwhelming abundance in the lake practically throughout the year but only negligible numbers are caught in the outer channel. The June–July brood enters the commercial fishery in September and by December forms a mode at 112·5 mm. class and by July of the following year at 262·5 mm. class. The winter brood forms a prominent peak at 137·5 mm. class in the next July and attains a modal length of 233·5 mm. by December. Because of double breeding the length-frequency data are very complicated and difficult to interpret beyond one-year-old stages of either brood. The minimum size at maturity of the female was recorded as 347 mm.

Of a large number of species of perches recorded from the lake, commercially important species are *Lates calcarifer* (70·7%), *Gerres setifer*, (23·2%), *Sparus sarba* and *S. datnia* (both 1·4%). *Gerres setifer* breeds in the lake during the period May–September largely in the Southern Sector. New recruits (zero group) of the species form a very conspicuous mode at 53·3 mm. class in August. About a-year-old individuals averagely grow to a size of 112·5 mm. Minimum size at maturity was found to be 86 mm. Both the species of *Sparus* breed close to the lake mouth and sea in the months November–January. The minimum size at maturity of *S. sarba* female was found to be 213 mm. and the average 251·7 mm. New recruits (zero group) form a prominent mode at 82·5–98·5 mm. class in June. Mature individuals in December appear to be two-year olds. *Mystus gulio* formed 6·5% of the total fish production of the lake in 1958 and within the group it constituted 62·2%. *Osteogeneiosus militaris*, *Arius* sp. and *Plotosus canius* together formed 3·79% of the total production. Sciænids formed 6·88% of the total production in 1958. *Pseudosciæna albida* was the most dominant species which constituted about 90% of the production of sciænids. July and August were the maximum months of production of *P. albida*. The species is available in the lake throughout the year and the new recruits enter the commercial fishery in August–September. Ripe gonads are encountered in April–June.

Observations on temperature, turbidity, pH, salinity, total alkalinity, dissolved oxygen, PO_4, and SiO_2 were made in different sectors of the lake throughout the year.

Fish Pathology Investigations

24. *Studies on fish mortality in jute-retting tanks*

Investigations on the mortality of fish in jute-retting tanks were taken up in four experimental tanks at Nilganj. After a preliminary survey, the hydrological and biotic features of the tanks were studied and about 14,000 carp fingerlings were introduced. Plankton collections and observations on the condition of the fingerlings were made once every week. Chemical analyses of water samples were carried out at the Jute Agricultural Research Institute.

Different charges of jute were given in the tanks by the Institute. Mortality of fish first occurred in tank No. 4, then in tank No. 3 and finally in tank No. 2. It was found that fish in tank No. 4 died mainly due to lack of dissolved oxygen, caused by heavy jute charges. In tank No. 3, factors other than oxygen depletion were also responsible for the death of fish.

This has to be confirmed by aquaria experiments during the next jute season. Fishes in tank No. 1 were quite healthy in spite of three jute charges and they were netted in March 1959 and a total carp population of about 750 was estimated. The fishes had grown to satisfactory sizes and it is presumed that they survived due to lesser charges of jute and also because the charges were applied one after the other. From the results obtained it is possible to arrive at a maximum safe limit of jute charges for each mass of water. The results obtained have to be confirmed by another series of experiments during the next season.

25. *Studies on isopod infections*

Investigations on incidence of isopod parasites on estuarine fishes were taken up and regular observations were made at Diamond Harbour and Canning during the Winter Season. Data on infections on *Setipinna phasa*, *Harpodon nehereus*, *Trichiurus* sp. and cat-fishes were collected. It was observed that the parasites were few in number till middle of January and then moderate till end of February. There was a period of very heavy infection on *Setipinna* and *Harpodon* during the first week of February.

26. *Investigations on fish mortality in tanks*

The causes of mortality of fishes in three tanks in the suburbs of Calcutta were studied. The fish in a tank at Paikapara died due to lack of dissolved oxygen caused by abnormal consumption of oxygen by the bottom soil. This was further confirmed by the low density of bottom fauna. Fish in a Jheel at Barrackpore were found to have died due to lack of sufficient dissolved oxygen caused by large influxes of sewage and other polluted waters. In a tank at Chinapara Dhapa, an epidemic of fish mortality was reported and three types of pathological manifestations were observed. Many of the Catlas, Rohus and Mrigals were found infected with *Argulus* sp. and a good percentage of Catlas suffered from severe eye diseases (Exophthalmus and cataract). A few Catlas suffered from Dropsy also. Several collections were made and the specimens are being used for further studies.

CENTRAL INLAND FISHERIES
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