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GOVERNMENT OF INDIA
ANNUAL REPORT OF THE CENTRAL INLAND FISHERIES RESEARCH INSTITUTE, BARRACKPORE, FOR THE YEAR ENDING 31ST MARCH 1962

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General

There was an all-round progress in the research activities of various research projects of the Institute during the year under report.

The construction of a Stores building with a workshop and garages at an estimated cost of about Rs. 1,31,000, was completed during the year. The construction of the aquarium sanctioned earlier is nearing completion.

The following Officers were appointed during the year:—

1. Shri J. C. Malhotra .. Research Officer
2. Shri A. Sen Gupta .. Assistant Research Officer
3. Smt. T. Rajyalakshmi .. Assistant Research Officer

Dr. M. P. Motwani, Research Officer, was relieved of his duties at Allahabad on the afternoon of 4th September 1961 on his deputation to the Uttar Pradesh Government as Fisheries Biologist. Shri Thomas Joseph, Administrative Officer, was transferred to the Central Institute of Fisheries Technology, Ernakulam, and Shri J. S. Rajan was appointed as Administrative Officer on a stop-gap basis.

Dr. G. N. Mukherjee, Pool Officer of the Council of Scientific and Industrial Research, joined the Allahabad Substation during the year.

Training

The 14th Session of the Inland Fisheries Training Course commenced on 1st June 1961. A total of 42 candidates—17 deputees from the States—1 each from Tripura and Manipur, 2 each from Gujarat, Madhya Pradesh and N.E.F.A., 4 from Mysore and 5 from Punjab; 14 Stipendiaries—9 from Bihar, 4 from Tripura, and 1 from Assam; 2 Colombo Plan Scholars—1 each from Viet Nam and Thailand; and 9 private candidates—3 from Madras 2 each from Uttar Pradesh, West Bengal and 1 each from Madhya Pradesh, and Kashmir are undergoing training at this Research Institute.

A Seminar for Fisheries Extension Officers and nominees of State Governments was held at the Cuttack Substation. Detailed discussions, including field demonstrations, were held on the various aspects of fish culture. At the conclusion of the Seminar, consignments of common carp spawn, fry and fingerlings, were supplied to the officers to enable them to raise stocks in their respective areas.

Twenty Fishery Officers from different States of India were given practical training in various aspects of induced breeding of Indian carps by injection of pituitary hormones. Ten Junior Officers of the Maharashtra Department of Fisheries attended special demonstrations of various aspects of fish culture, both under laboratory and field conditions. Two Asssitant Directors of the Department of Fisheries, Andhra Pradesh, were also given demonstrations and brief training in techniques of fish breeding and general aspects of fish culture. A brief training in survey work was imparted at the Riverine and Lacustrine Substation, Allahabad, to 14 Fisheries Development Supervisors of Uttar Pradesh Government. At the request of Fisheries Adviser, Punjab, a Research Assistant of the State Fisheries Department was given facilities for acquainting himself with the work done at this Institute. The Fisheries Officer, Damodar Valley Corporation, was given a week's training in the methods of *Cyprinus* breeding and induced spawning of Indian carps.

Meetings

The Director attended the All-India Gear Conference and the Fisheries Research Committee Meeting held at Veraval, the Conference of the Development Committee of Fisheries of the Tungabhadra Board held at Hyderabad, the meeting of the Central Board of Fisheries held at Bombay, and the meeting held at New Delhi for discussing the III Five-Year Plan Programmes of the Central Inland Fisheries Research Institute.

Miscellaneous

A consignment of 2,000 Grass Carp fry was obtained through the Director of Agriculture and Forestry Department, Hong Kong. Although there was some mortality in transit and conditioning, the remaining fry are being used for experimental studies at Cuttack.

Facilities were afforded to the Information Officer (Features), Press Information Bureau and Photographer for including the Central Inland Fisheries Research Institute in their coverage of projects in the eastern region

of the country. About sixty delegates attending the Science Congress Session at Cuttack visited the laboratories and the experimental fish farm of our Cuttack Substation and the various aspects of work of the Substation were explained and demonstrated to them.

Necessary facilities were given to Dr. H. Miyamoto, F.A.O. Gear Technologist and Shri G. K. Kuriyan, Assistant Director (Gear), Central Institute of Fisheries Technology, Cochin, in connection with their survey of inland fisheries gear.

The purchase of a Dodge Station Wagon, a Willy's Jeep and a Cabin Launch were sanctioned during the year under report.

The Director along with the Fisheries Development Adviser, visited the Damodar Valley Corporation reservoirs in connection with water pollution studies and inspection of work of the Fisheries Unit of the Damodar Valley Corporation.

Visitors

Dr. N. K. Panikkar, Fisheries Development Adviser, Shri F. C. Gera, Deputy Secretary, Shri K. Gopinatha Pillai, Deputy Fisheries Development Adviser, Mr. Le Van Tuyet, Consulate-General of the Republic of Viet Nam, Dr. C. H. Fernando, Lecturer in Zoology, University of Singapore, Dr. Robert R. Rofen, Research Director, George Vandarbilt Foundation at Standford University, U.S.A., Dr. D. V. Bal, Director, Central Institute of Fisheries Education, Bombay, Shri H. K. Ghazi, Director of Fisheries, Madras, Shri Mahatab Singh, Under Secretary, Government of India, Dr. A. Comfort (Nuffield Fellow, Biology of Ageing), Department of Zoology, University College, London, Dr. T. Ramachandra Rao, Director, Virus Research Institute, Poona, Dr. C. R. Rao of the Indian Statistical Institute, Shri N. M. Malkani, Superintending Engineer, Central Public Works Department, Shri H. M. Channabasappa, Home Minister, Government of Mysore, Dr. H. Srinivasa Rao, Retired Chief Research Officer of this Institute, Dr. G. N. Subba Rao, Assistant Regional Fisheries Officer, F.A.O. of the United Nations, Mr. J. A. Tubb, Regional Fisheries Officer, F.A.O., and Secretary, Indo-Pacific Fisheries Council, Dr. A. N. Bose, Director, Central Institute of Fisheries Technology, Cochin, Shri S. N. Bhuyan, Deputy Director of Fisheries, Assam, Dr. M. R. Khan, Fisheries Technologist, F.A.O., and Shri C. P. Verma, Fisheries Development Officer, Bihar, visited this Institute during the year under report.

SCHEME I: INVESTIGATIONS ON CULTURE FISHERIES

1. *Investigations on Pond Culture Techniques*

With the year round breeding of Common Carp, it has now become possible to utilise the nursery ponds throughout the year for raising several crops of fry. If properly managed, after raising two or even three crops of 15 days' old fry of major Indian carps during July–August, the pond may be cleared for stocking Common Carp spawn which can be produced as and when required in a farm, with a good stock of breeders in healthy condition.

Raising repeated crops of fry will markedly deplete natural fertility of the pond and it is therefore necessary to manure the pond after every crop of fry is taken and also to feed the fry artificially. Culture of Common Carp, therefore, helps in appreciably increasing production from nursery ponds, which formerly were either left fallow after September–October or contained only a few left-over fingerlings during October–March.

When carp fry of different sizes are stocked simultaneously in the same pond, the smaller ones are largely preyed upon by the larger ones. Because of this, it is essential to completely clear the nursery after every crop is harvested. Repeated netting will not result in satisfactory clearing and it is therefore necessary to poison the pond after the crop is harvested. If manured immediately after poisoning with derris power, the pond will be ready for next stocking within 10 days.

Survival figures in nurseries for various species as recorded in 1961–62 are given below:—

Species	No. of ponds stocked	Total No. stocked	No. harvested	Average % survival*	Approximate No. escaped during floods
1	2	3	4	5	6
Catla	7	5,60,000	1,97,332	40	30,000
Rohu	5	6,30,000	1,65,788	32	30,000
Mrigal	2	3,40,000	1,35,200	41	5,000
Cyprinus	3	5,57,000	3,09,950	60	20,000
Cyprinus	2	2,57,000	All surviving fry escaped during floods.		
Cyprinus	6	3,00,000	2,01,580	67	..

* This includes those indicated in Col. 6.

Plankton.—Studies on the seasonal fluctuation of plankton in a perennial stocking pond showed the maximum content of 1,680 units of zooplankton per litre in January and the minimum of 910 units per litre in March. Rotifers and cladocerans contributed the bulk of zooplankton at the surface, while rotifers and copepods dominated at the middle and bottom layers. Studies on diurnal variation in the quality of plankton showed that at the surface zooplankton was maximum between 18·00 and 22·00 hours and at the bottom from 6·00–18·00 hours.

The analysis of nannoplankton samples collected for about two years from different ponds at Killa has indicated that the average volume of nannoplankton was 0·408 cc / 45 litres in ponds having zooplankton as dominant group; 29·38 cc / 45 litres in ponds having algal blooms; and 3·83 cc/ 45 litres in ponds having mixture of zoo- and phytoplankton.

Investigations on the rate of reproduction and seasonal variations of the common species of copepods occurring in the fish ponds at Cuttack have indicated that *Heliodiaptomus viduus* breeds throughout the year in the nursery, rearing and stocking ponds, although large-scale breeding takes place in November–December during winter and June in summer. *Neodiaptomus strigilipes* is common throughout the year but mass breeding takes place in the middle of January and continues up to the first week of May. The second cycle is confined only to September. *Mesocyclops strenuus* was breeding in large scale during May–June in summer and July–August in monsoon. There is no winter cycle in the case of this species. The study has revealed that in 90% of the plankton samples collected during 1961–62, *Cyclops* was in bloom when the diaptomids were less and *vice versa.*

2. *Investigations on Induced Breeding of Fish*

As in previous years, experiments on induced breeding were taken up at Cuttack and Assam. Pituitary glands for experimental work were collected from Gwalior with the kind co-operation of the State Department, from Calcutta fish market and from the Killa farm. Records of length, weight, sex, stage of maturity, etc., of the fishes were kept whenever possible and the glands were individually preserved for facilitating standardisation of doses.

In an attempt to induce early spawning of carps by lowering water temperature, a pair of Calbasu could be successfully spawned in May. The prevailing water temperature was 31° C. This was reduced and maintained at 27–28·5° C. The fishes spawned after 3 injections, but only a few eggs hatched out.

Experiments on standardisation of doses of injections have shown that 7–11 mg of homoplastic pituitary gland administered per kg body-weight of females and 2–3 mg per kg body-weight of males gives successful results.

During the 1961 carp-breeding season a total quantity of 95·8 lakhs of major carp spawn could be produced, as shown below:—

Catla	..	16·4 lakhs
Rohu	..	72·6 ,,
Mrigal	..	3·65 ,,
Calbasu	..	3·15 ,,

An experiment conducted to study the effect of catfish pituitary gland in inducing spawning of carps indicated that pituitary hormones collected from fishes belonging to distantly related families are also effective in inducing breeding of carps.

Study on the maturity of gonads in carps has indicated that, in general, the carps normally attain maturity up to I–II stage only during November to February. From March onwards the progress is more rapid and many fishes reached III–IV stages of maturity by April. During May and June the fishes attained IV–VI stages.

Experiments on inducing spawning of Chilka mullets, *Mugil cephalus* and *Liza troschellii* gave very encouraging results. Ovulution took place on several occasions after pituitary gland injections and development of eggs proceeded several times and on one occasion a *M. cephalus* egg hatched out in 48 hours after fertilisation. The characteristics of the ovarian and fertilised eggs of both the species have been studied.

The failure of successful spawning of mullets in lake water is in all probability believed to be due to the lower salinity of lake water. It was observed that *M. cephalus* sperms died immediately when brought in contact with lake water. *L. troschellii* sperms, however, were active for about one minute. On the contrary sperms of both the species were found to be active for about 10 minutes when put in sea-water.

It was recorded that in Rohu the fecundity ranged from 1·24 to 23·8 lakhs of eggs, the respective weights of the specimens being 1·9 and 5·6 kg. While studying the fecundity of Rohu, measurements of ovarian eggs of the samples were taken. The average range of size of eggs in 15 specimens studied so far varied from 0·85 to 1·15 mm.

With a view to study the effect of fish pituitary hormones on spermiation in male toads, 10, 20 and 30 mg of Mrigal pituitary glands were injected to male toads weighing 53–57 gm. Positive results were obtained with all the three doses. In another experiment lower doses were administered, but there was no response.

In spite of unfavourable monsoon conditions, induced breeding experiments conducted at Assam resulted in the production of 3·74 lakhs of spawn of Rohu, Mrigal, Calbasu and Sarana.

3. *Investigations on Exotic Fish Culture*

The total quantity of Common Carp (*Cyprinus carpio*) spawn produced by occasional experimental breeding during the year exceeded 70 lakhs. Supplies made to various States and agencies during the year were as follows:—

Party supplied	Spawn (4 days old)	Fry (2–3 cm)	Fingerling (5–8 cm)
1	2	3	4
Directorate of Fisheries, Orissa ..	44,71,200	1,21,600	4,056
Directorate of Fisheries, Kerala ..	..	1,60,000	..
Directorate of Fisheries, Andhra Pradesh	..	1,29,050	..
Directorate of Fisheries, Uttar Pradesh ..	..	1,500	..
Directorate of Fisheries, Madhya Pradesh	..	6,000	..
Directorate of Fisheries, Himachal Pradesh	..	5,000	..
Department of Fisheries, Pondicherry ..	..	2,000	..
Department of Fisheries, Andamans ..	..	300	..
Fisheries Officer, D.V.C. ..	..	23,500	..
Fisheries Officer, Tungabhadra Board ..	..	1,700	..
Departmental use at Barrackpore ..	..	5,000	..
Other parties ..	..	500	200
Assistant Fisheries Extension Officer, Calcutta	45,000	15,600	..
Assistant Fisheries Extension Officer, Raipur	..	3,000	..

1	2	3	4
Assistant Fisheries Extension Officer, Allahabad	..	1,000	..
Assistant Fisheries Extension Officer, Karnal	..	1,000	..
Assistant Fisheries Extension Officer, Gauhati	..	1,000	..
Assistant Fisheries Extension Officer, Patna	..	500	..
Assistant Fisheries Extension Officer, Bhopal	..	500	..
Assistant Fisheries Extension Officer, Bangalore	..	500	..
Assistant Fisheries Extension Officer, Mandapam	..	2,400	..
Assistant Fisheries Extension Officer, Hyderabad	30,000	2,000	..
Total ..	45,46,200	4,73,200	4,256

At Assam, about 60,000 spawn was supplied to the State Fisheries Department.

Ordinarily male and female breeders are segregated and kept in separate ponds. This is essential to prevent wild spawning. Segregation of sex is not essential to induce spawning. Ripe males and females taken from one and the same pond and kept in a hapa, with weeds in the same pond water also breed satisfactorily. This happens when there is a heavy population of fish in the pond and even during April–May, when ordinarily stagnation conditions with dense algal blooms prevail in the water. It would appear from these observations that bringing the sexes together in a relatively limited space where material for depositing eggs are provided, may be the main factor inducing them to spawn.

For successful spawning, adequate quantity of weeds should be provided. Ordinarily, when a female weighing 3·6–4·5 kg is kept in a hapa for breeding, approximately 6·8 kg of weeds may be introduced. For

mass breeding in a cistern, 12·19 m.×3·05 m.×0·91 m., 5–6 females weighing in all about 18 kg would need approximately 18 kg of weeds, if 3–4 females only spawn.

With regular but moderate artificial feeding with mustard oilcake, breeders could be kept in good condition. Such fish have been observed to breed three times during the course of three months.

As soon as spawning is over, the weeds with eggs should be kept in fresh water for hatching. From the difference in weight of the spawned females, the approximate number of eggs laid is calculated. The average number of eggs per gram weight of the ovaries ranges from 600 to 1000. In a hatching hapa, 1·829×0·914 ×0·914 metres and having approximately 1 kg of weeds, 50,000 to 1 lakh eggs may be kept for hatching during February and early March. When the water temperature rises, the quantity of weeds and number of eggs per hapa should be reduced. Under favourable conditions 80–90% hatching is obtained. Delay in distributing the weeds after spawning will result in poor hatching results.

In nursery ponds at Killa, survival of fry up to 0·025–0·037 metres size, ranged from 30 to 58%. Survival of fry was extremely poor in Puri farm, when the nurseries were cleared only by repeated netting and yet contained minnows and unwanted fish. When these ponds were cleared of unwanted fish by rotenone poisoning, the survival was quite satisfactory, averaging about 56% with the maximum at 84%.

Given the same conditions as for the Scale Carps, three specimens of Mirror Carp spawned at Cuttack during the year. About 25,000 spawn obtained from one fish, were stocked in a nursery pond and on rearing, about 8,000 fry and fingerlings were obtained.

For the first time at Cuttack, Mirror Carps were found to have spawned (wild spawning) in stocking ponds. Several specimens, partially spent and oozing eggs, could be caught. At the Assam Unit, 2 specimens bred, yielding about 91,000 spawn. These have been stocked in nurseries.

Observations on the natural production of *Tilapia* in a 0·4 ha stocking pond in the Killa Farm were terminated after 46 months' continuous study. The production during the period was 41,233 specimens weighing 2,932 kg., giving an average monthly yield of about 64 kg. The total harvest from the pond, including some carps and miscellaneous fish removed during the period, was 3,347 kg which gives an overall average monthly production of 73 kg. During the period of observation, the pond

was neither manured nor the fish artificially fed. Periodic harvesting was done, at weekly and monthly intervals. For a natural pond the above rate of production may be considered as very satisfactory.

In order to find out the production of *Tilapia* under better cultural conditions, the pond was poisoned with rotenone and cleared early in June 1961. 1,000 *Tilapia* weighing about 30 kg were stocked in July 1961. During the subsequent 9 months the pond was manured as follows:

Cow dung	..	1,800 kg
N.P.K. fertiliser (6 : 8 : 4)	..	34 kg
Mustard oilcake (as artificial food)		793 kg

Harvest from the pond during the same period was:

Tilapia	68667 Nos.	..	1,123 kg
Other fish	..	..	160 kg

The average monthly production works out to 142·8 kg which is about double the natural production obtained from the same pond earlier.

Studies on the Grass Carp (*Ctenopharyngodon*) and Silver Carp (*Hypophthalmichthys*) were continued at Cuttack. Two-year old Silver Carps were fully ripe in the ponds by June-July. Induced breeding was attempted by injecting pituitary gland extracts of Silver Carps and Rohu. Though fertilised eggs could not be obtained, the general response was similar to that in Indian carps. The injected males became freely oozing. A few of the injected females could be stripped easily and in some cases ovulation took place in the breeding hapa.

The maximum weight attained by Silver Carp, now 33 months old, is 18·4 kg.

In order to compare the growth of Silver Carp with that of Catla, adult fish of equal weight were stocked together in the same pond in equal numbers, the stocking rate ranging from 25–40 fish weighing about 284 kg per hectare. The ponds (each 0·08 hectare) were manured with 22·68 kg of mustard oilcake and 453·59 kg of cowdung every month.

The Silver Carp showed decidedly faster growth than Catla. During the subsequent winter months, December–February, the growth was very poor in both the species.

In a similar experiment, Grass Carp and Catla were stocked at the rate of about 35–40 fish of each species weighing 300–360 kg per hectare and aquatic weeds *Lemna* and *Hydrilla* were periodically introduced as food. In this case also, during winter months, both species registered loss of weight. Grass Carp showed much faster growth than Catla of the same size.

A second consignment of Grass Carp fingerlings was obtained in December 1961 and a series of observations on the early growth of this species have been initiated. Stocked at the rate of 1,000 per acre and fed daily with *Hydrilla*, *Vallisneria* and *Najas*, the growth was observed to be slightly better with *Hydrilla* than with the other two.

In another experiment where identical fingerlings of Grass carp and Common carp were stocked separately and in combination at 500–1,000 per acre of each species and the fish were fed daily with *Hydrilla*, mixed with a little of soaked oilcake, the growth was fast in both the species, but better in Common Carp.

4. *Investigations on Brackish-Water Fish Farming*

A programme of survey to evaluate the problems of and practices adopted in brackish-water fish culture in West Bengal was taken up and completed during the year under report. The data obtained are being analysed.

5. *Investigations on Weed Control*

A rapid sample survey of 72 bodies of waters covering 20 districts of Andhra Pradesh indicated that the waters in the State are of three categories, *viz.*, short seasonal, long seasonal and perennial. Weeds in the short seasonal and the long seasonal waters are not serious problems, compared to those in the perennial bundh type of tanks, reservoirs and irrigation wells. Weed infestation is maximum (50–90%) in Godavari, Krishna, Nagonda and Nellore Districts, moderate (10–50%) in Srikakulam, Medak, Khammam, Karim Nagar, Kurnool and Chittor and least (Below 10%) in the remaining nine districts. Even the deep lift irrigation wells have infestations of *Hydrilla* and *Najas*. The bundh type of tanks and coastal swamps have a number of marginal, emergent and floating weeds, in addition to submerged ones.

Since ammonia at 20 p.p.m. proved deficient for the clearance of predators and weed fishes, several laboratory and field trials were carried out to study its use as a fish poison compared with rotenone, which has at present to be imported. In these experiments ammonia (above 15 p.p.m.) was

found to compare favourably with rotenone in its fish killing effect but the cost was more. The toxicity of ammonia remained longer in the water than in the case of rotenone, leading to low survival of stocked fry.

A new multi-point applicator, about six feet long, has been modelled for delivering ammonia gas quickly and it has given encouraging results in initial field trials.

The 2, 4-D compound "Taficide-80", which was previously found effective against water hyacinth at 5·6 kg / ha, has been found useful for the control of the emergent weeds *Nymphaea*, *Eurgale* and *Nelumbium* also, all the plants being killed in about four weeks. The effective dose against *Nelumbium* was 11·2 kg / ha, and for the others 5·6 kg / ha. Because of the waxy leaf surface, a second application was frequently necessary for *Nymphaea*.

Several laboratory and yard experiments carried out with different formulations of Simazine WP. 50, indicated that the wettable powder at 3–5 p.p.m., gives 90–100% control of *Hydrilla* and *Najas* within about 3 months, whereas *Vallisneria* is affected only by the granular formulation which acts through the soil. This probably shows difference in the mode of absorption of the two plants. At 112 kg / ha, Simazine appears to sterilise the soil against all vegetation. When sprayed as an emulsion at 5·6 kg / ha, the chemical kills water hyacinth and *Pistia* in about 2–3 weeks. At 1 p.p.m. it controlled algal blooms in aquaria without killing fish.

In the swamp at Kausalya Ganga, *Najas indicus* showed maximum vegetative growth during May–July and least in February. There was grave competition from *Hydrilla* and water hyacinth during the remaining months. Flowering and fruiting started in October, with peaks in December and March respectively. *Najas graminea*, which was studied in a pond at Cuttack, produced flowers and fruits from September to January. Apart from the age of the plant and bright sunshine, the sudden approach of unfavourable conditions like drying up of the water area appeared to hasten the intensity of flowering and fruiting. *Ceratophyllum*, which was studied in two Cuttack ponds, showed maximum vegetative growth from January to March and August to December, with flowering and fruiting from October to December.

Field observations in a number of localities at Cuttack and nearby areas showed that some plants like *Najas*, *Lagarosiphon*, *Ceratophyllum*, *Utricularia*, *Pistia*, *Jussiaea*, *Ipomoea* and *Neptunia* flower from September to March, whereas others like *Ottelia*, *Trapa*, *Limnanthemum*, *Nymphaea*, *Euryale*, *Eichhornia* and *Limnophila* flower almost throughout the year, though not continuously. Plants like *Hydrilla*, *Azolla*, *Lemna*, *Splrodela* and *Wolffia* either flower for limited periods or only rarely.

Seeds of *Ottelia* kept in the laboratory remained healthy after a period of 24 months. They will be put to germination tests during the rainy season. Attempts at growing *Hydrilla*, *Najas* and *Lagarosiphon* in some weedless ponds at Kausalya Ganga during August–February failed, probably on account of high water level and the steep banks of the ponds.

6. *Investigations on Soil Chemistry*

Studies on correlation between soil condition and fish production in selected tanks in nine different fish farms in Orissa and Madhya Pradesh showed that generally the growth rate of fish bears a direct correlation with available soil phosphorus. For high phosphorus levels (7·9–11·7 mg/100 gm) in Raipur, Bilaspur, Damoh and Sambalpur fish farms, the growth per annum of Catla, Rohu and Mrigal were 625–1,020 gm, 520–677 gm, 345–510 gm respectively, while in fish farms at Balasore, Angul and Chowduar with low available phosphorus (1·2–1·7 mg./100 gm), the respective growths were 204–208 gm, 133–153 gm and 96–105 gm.

Studies on the response of alkaline soils with different levels of available phosphorus to treatment with a single phosphatic fertiliser was taken up in three different fish farms, *viz.*, Sambalpur, Berhampur and Balasore. A comparative study after application of double superphosphate (32% P_2O_5) at 50 kg / ha, showed that soil reaction continued to be slightly alkaline and available phosphorus showed a slight increase, post-treatment figures being 13·4, 6·4, 2·8 against the pre-treatment figures of 12·0, 6·0 and 2·7. Increase in available nitrogen, however, was more marked, post-treatment figures being 60, 57 and 44 (mg./100 gm.), as against the pre-treatment figures of 37, 40 and 38 for Sambalpur, Berhampur and Balasore respectively. An increase in growth for Catla and decrease for Rohu were recorded in all the farms.

Studies on the response of low nutrient acid soils to treatment with increasing doses in mixed fertiliser 6–8–4 N–P–K was taken up in twenty-four Lingipur ponds, the total dose applied being 100, 200, 300, 400 and 500 kg/ha, distributed in three equal instalments at an interval of three months. Chemical examination of water quality and estimation of plankton concentration (c.c./45 litres) showed that waters continued to be slightly alkaline with fair D.O. and low alkalinity. There was no marked increase in nitrate nitrogen while increase in dissolved phosphorus was relatively more marked. Plankton concentration showed an increase in all the treated ponds. During the first two months a steady increase was noted up to a dose of 300 kg / ha, and then a decline. During the next three months there was steady increase upto the maximum dose of 500 kg / ha, and then a decline.

A preliminary survey of bottom biota in selected fish farms in Orissa, *viz.*, Puri, Pipli, Kausalya Ganga, Barang, Lakshmisagar and Cuttack showed that common forms in all farms were chironomid larvae. In Puri and Pipli, mollusca were predominating, while in Kausalya Ganga, *Tubifex* and soil nematodes formed the bulk of the samples. In Barang, main forms were caddis larvae and soil nematodes, while in Lakshmisagar, Killa and Chaudwar, the predominating organisms were chironomid larvae and soil nematodes.

Scheme II: Investigations on Capture Fisheries

7. *Investigations on the Fisheries of the Ganga River System*

The total yield of fish during the period April 1961 to March 1962 at seven selected centres on the Ganga and two on Jumna were 495·1 and 275·7 metric tonnes respectively. The following table shows the landings and the percentages of important fishes from Ganga and Jumna separately.

Species or group	River Ganga		River Jumna	
	Landings (m. tonnes)	Percentage in total	Landings (m. tonnes)	Percentage in total
C. mrigala ..	32·4	6·9	79·9	27·7
L. rohita ..	17·7	3·8	25·7	8·9
L. calbasu ..	3·1	0·7	15·7	5·4
Catla catla ..	17·5	3·7	21·0	7·3
(Major carps) ..	70·7	15·1	142·3	49·3
W. attu ..	53·5	11·4	21·1	7·3
Mystus aor ..	32·1	6·8	33·3	11·5
M. seenghala ..	19·6	4·2	17·2	6·0
P. pangasius ..	25·3	5·4	5·9	2·0
C. garua ..	28·6	6·1	5·6	1·9
E. vacha ..	10·0	2·1	3·8	1·3
R. rita ..	8·0	1·7	5·7	2·0
(Catfishes) ..	177·1	37·7	92·6	32·0
H. ilisha ..	52·7	11·2	21·1	7·3
S. phasa ..	17·2	3·7	3·5	1·2
(Clupeoids) ..	69·9	14·9	24·6	8·5
Prawns ..	20·8	4·42	1·3	0·45
Rays ..	3·1	0·66	0·3	0·11
Tortoises ..	9·2	1·96	..	..
Miscellaneous ..	104·5	22·23	16·24	5·61

From October 1961 a method was adopted whereby the numbers of fish of different size-groups landed at seven observation centres on Ganga and two on Jumna were computed from the data on landings. The size-groups formed provisionally are artificial (except for *Cirrhina mrigala*), but will be integrated into age-groups relevant to each species, when age determination studies are completed.

Major Carps: Cirrhina mrigala

Age group	River Ganga		River Jumna	
	Oct.–Dec. 1961	Jan.–Mar. 1962	Oct.–Dec. 1961	Jan.–Mar. 1962
I	8,246	1,742	16,066	2,991
II	8,390	3,731	10,037	3,948
III	1,953	1,055	2,979	1,745
IV	121	176	834	630
V	60	104	162	157
VI and above	17	116	69	104
Total ..	18,787	6,924	30,147	9,575

It may be possible to estimate total mortality rates and population size from the numbers of different age-groups after a year's data in this respect are collected.

Size-frequency studies conducted on *Catla catla* revealed that the commercial fishery largely comprises 8-year classes, the mean length of year classes 1–8 being 285, 455, 655, 810, 890, 955 and 1035 mm respectively. The formulae correlating length with weight for *Catla catla* for males and females were found to be:

Males: $\text{Log } W = -5{\cdot}5202 + 3{\cdot}2697 \log L$

Females: $\text{Log } W = -4{\cdot}7686 + 3{\cdot}0031 \log L$

Eggs of specimens ranging from 301 to 3,118 gm. were found to vary in number from 2,31,831 to 29,63,125. Sex ratio was 1 : 1. The food of juvenile Catla was found to be 63·8% crustacea, 10·2% algae and 11·0% insects

and that of adults, 57·1% crustacea, 24·0% algae, 8·2% higher aquatic plants and 6·0% insects.

Size-composition and year class strength studies in respect of *Mystus* (*O*) *aor* were initiated in October 1961 and the following table furnishes the number of specimens of different size-groups landed at the centres in Ganga.

Size-group	Oct.–Dec. 1961	Jan.–March 1962
I	19,893	2,301
II	20,138	4,678
III	3,312	2,584
IV	415	1,244
V	62	371
VI	72	318

Pectoral spines of *M.* (*O*) *aor* were studied to see if they can indicate age and growth. When studied in conjunction with length-frequency distribution method, there emerged a fairly close agreement between length of different age-groups deciphered by either method as shown by the following table:

Age-groups	Length from length-frequency distribution methods mm.	Lengths as deciphered from spine radius mm.
I	440	426
II	640	622
III	800	766
IV	880	849
V	..	913
VI	..	957

During the year under report, 605 fingerlings of major carps (*C. mrigala* 253, *L. rohita* 197, *C. catla* 153 and *L. calbasu* 2) were tagged and released in the Jumna and Ganga at Allahabad. So far, recoveries of 24 tagged fish have been reported. These are *C. mrigala* 2, *L. rohita* 14, *C. catla* 8, and *L. calbasu* nil. A total of 1,104 fingerlings (Mrigal 845, Rohu 172, Catla 63 and Calbasu 24) were tagged and released in the Jumna at Agra.

The study of physico-chemical factors, *viz.*, temperature (air and water), pH, turbidity, D.O., Cl, hardness, NO_3, PO_4, Si_2, CO_3, HCO_3, and free CO_2 were continued. The data obtained revealed that during summer months Jumna water was more alkaline, transparent and hard, while Ganga water maintained greater turbidity (150 p.p.m.). Fluctuations in pH were negligible in both the waters. Ganga water appeared to be slightly richer in nutrients like nitrates, phosphates and silicates. D.O., in Ganga was higher than in Jumna. With the onset of monsoon, there was a gradual decline in pH, alkalinity, hardness, D.O. and chlorides while essential inorganic salts showed a considerable rise along with turbidity. After the monsoon there was a steady rise in almost all the chemical constituents in both the rivers.

8. *Gandak River Basin Survey*

A stretch of 115 miles of the river Gandak from its Nepal border, as far down as Govindganj (close to Bettiah), was surveyed during the year to ascertain if fishways are to be provided within the barrage at Bhaisalotan. Physico-chemical factors were studied at six separate centres. More nutrients are found to be added to the river as it flows downwards, as shown by total alkalinity (84–144 p.p.m.) and oxygen consumption values (2·6–16·8 p.p.m.). Nitrate and phosphate values are apt to fluctuate depending upon several factors, but the values on the whole were consistently lower than the main Ganga and the Jumna at Allahabad. Temperature (in November) varied between 19·5° and 22·9° C., with a tendency to rise lower down, as can be expected in any river taking snow melt waters from the Himalayas. Temperature gradients, however, are expected to be very high at Bhaisalotan and 50–70 miles below during warmer months, which coupled with the wide bed of the river (8–12 miles across) and numerous streams and spill channels, affect the distribution of fish from lower to the upper regions of the river. The identity of 24 species of diatoms, 16 of Chlorophyceae, 9 desmids, 9 Myxophyceae, 9 Protozoa, 18 rotifers and copepods has been determined.

A total of 113 species of fishes were recorded, of which *Labeo rohita*, *Cirrhina mrigala* and *Catla catla*, occur within the lower half of the stretch

(50–60 miles below Bhaisalotan) only as 'stray' or 'rare' numbers. Migratory species like *Hilsa*, *Pangasius*, etc., are absent close to Bhiasalotan for 50–60 miles below. The main fishes of commercial value close to Bhaisalotan were submontane forms, *Labeo dyotheilus*, *L. dero*, Kutli Mahseer (*Lissocheilus hexagondepis*), Tor Mahseer (*Tor tor* and *Tor mosal*), *Puntius chagunio*, *Bagarius bagarius*, several *Mystus* spp. (*M. aor* and *M. seenghala* occurred consistently), *Glyptothorax* and *Clupisoma* spp. Main sandy stream holds smaller forms *Aspidoparia morar* and several *Barilius* spp., etc., in abundance.

The following are the main findings of the survey:

(i) There is no commercial species of the lower Gangetic forms—major carps or catfishes or *Hilsa ilisha*—close to Bhaisalotan requiring artificial protection to enable them to move up or down in search of food, shelter or spawning grounds.

(ii) The river shows three regions, *viz.*, (*a*) upper sub-montane, a rapid water stretch where fish life is torrential in nature, adapted to colder temperatures and clearer waters, (*b*) a middle region with an unstable fluctuating fish fauna of both mountainous and middle Gangetic forms, and (*c*) a lower region showing a Gangetic fauna.

(iii) Spawning grounds of well-known major carps are situated well below the 100 miles limit from Bhaisalotan. The species that are available close to Bhaisalotan can continue to thrive above or below Bhaisalotan as before, even after the construction of the barrage.

(iv) The canals and other watersheets (including the abandoned Tribeni Canal) can be used for culturing not only major carps (whose young have to be imported from lower reaches) but also the Mahseers, three species of which are known to occur.

9. *Investigations on the Fisheries of the Krishna-Godavari River System*

Collection of statistical data on the capture fishery of river Godavari over a stretch of about 25 miles was continued. The total of 184·805 metric tonnes of fish, landed at Rajahmundry, showed a fall of about 70 metric tonnes from last year's total fish catches. This was mainly due to lean Hilsa season. The total of 40·926 metric tonnes of major carps catch constituting 22·14% of the total fish landings included *L. fimbriatus* 8·84%, *C. mrigala* 10·55%, and *C. catla*, *L. rohita* and *L. calbasu*. 34·403 metric tonnes of catfish were landed, which included *M. seenghala* 5·4%, *Silonia* sp. 2·97%, *W. attu* 2·73%, *P. pangasius* 2·04%, *B. bagarius* 0·99% and *C. garua* 3·34%.

Among the other economically important species, *Spratelloides*, *P. coitor*, *P. kolus*, *P. sarana*, *Cirrhina* sp., *Lates calcarifer* and *Mugil* spp. contributed substantially to the total production. Freshwater prawns (35 metric tonnes) formed 18·95% of the total fish catches.

Spawn collection and sample rearing carried out in river Krishna near Vijayawada for the 1961 fish breeding season indicated the first appearance of spawn along with the floods during the first week of June. Species compositions and their relative abundance revealed on rearing the spawn are given below:

Species	% among major carps	% in total collection
L. fimbriatus ..	84·22	30·37
C. catla ..	14·15	5·10
C. mrigala ..	0·86	0·31
L. rohita ..	0·61	0·22
L. calbasu ..	0·16	0·06

Other economically important species occurring in larger numbers are *L. bata* 13·9%, *C. reba* 12·96%, *L. procellus* 10·1%, *L. pangusia* 4·9%, and *L. kontius*, *L. boga*, *P. sarana*, *S. nukta*, *Garra* and others.

In order to locate new collection centres in the river Godavari, test collections of fish seed were carried out below the anicut at Kapileswarapuram, Kotipalli and Yanam along the right bank of the river for a period of six days. The quantity of seed obtained indicated that Yanam and Kotipally were very good collection centres, with about 1,00,000 fry per hour per net at Kotipally and 25,000 fry per hour per net at Yanam. These heavy collections at places almost near the river mouth was very significant since the chances of their survival below, under saline conditions, are rather meagre.

A total of 35·116 metric tonnes of prawns were landed at Rajahmundry from March 1961 to February 1962. Food studies of *Metapenaeus malcolmsonii* showed that small specimens subsist on diatoms, which constituted well over 33·0% of the stomach contents. Other important items recorded were dipteran larvae, insect parts, crustacean fragments, plants parts and

small fish scales. On the other hand, stomach contents of bigger specimens included considerably larger amounts of debris, mud and sand grains.

Breeding was recorded in specimens ranging from 140·0 to 169·0 mm and the pooled data for two seasons indicate that among the breeding females more than 56·8% were constituted by specimens ranging from 60·0–84·0 mm in 1960 and 68·7% in 1961.

Observations on the breeding habits of *M. malcolmsonii* have confirmed that they normally breed in freshwaters of Godavari in the stretch of the river even beyond 800 km. upstream from Rajahmundry and the breeder do not show a concentrated migratory movement to the estuarine areas for purposes of breeding.

Study on the migratory movement of young prawns over the anicut at Dowleswaram has indicated that this constitutes the main source of recruitment to the heavy prawn fishery existing above the anicut. It is possible to tap this source as a prawn seed collection centre on commercial basis for purpose of stocking inland waters.

10. *Investigations on the Fisheries of the Narbada and Tapti Rivers*

Observations on fish landings were limited to a 30 miles stretch of Narbada River by covering the fisheries of two important landing centres at Hoshangabad, from April 1961 to March 1962 and Shahganj from April 1961 to July 1961 and November 1961 to March 1962.

The estimated annual fish landings from this stretch of the river were found to be 34·2 tonnes in 1961–62. Over 15 tonnes of fish (44·3% of total fishery), valued at Rs. 16,480, was exported from Hoshangabad and Shahganj centres to Itarsi, Simla, Khandwa and Bhopal.

The species composition of the commercial catches at Hoshangabad, Shahganj and collectively at both centres during the year is shown below:—

	Hoshangabad	Shahganj	Both centres
Tor tor ..	25·3	22·1	23·7
Labeo fimbriatus ..	16·7	24·1	20·4
Labeo calbasu ..	4·4	4·3	4·35
Labeo bata ..	2·6	3·0	2·8
Cirrhina mrigala ..	2·1	0·9	1·5

	Hoshangabad	Shahgang	Both centres
Catla catla ..	0·2	..	0·1
Other carps ..	5·2	1·5	3·35
Rita pavimentata ..	6·7	14·4	10·55
Mystus seenghala ..	10·1	8·8	9·45
Wallago attu ..	10·9	6·2	8·55
Mystus aor ..	4·7	3·9	4·3
Clupisoma garua ..	2·0	2·0	2·0
Other catfishes ..	0·6	0·9	0·75
Ophicephalus marulius ..	4·5	4·7	4·6
Mastacembelus armatus ..	1·0	3·0	2·0
Miscellaneous ..	3·0	0·2	1·6

Observations on size-composition of important fisheries of this stretch of the river were also made. For this purpose, the entire size range of various species was arbitrarily divided into four size-groups and the percentage by weight was determined. The number of specimens was estimated in each size-group for important species like *Tor tor*, *Labeo fimbriatus*, *Rita pavimentata*, *Mystus seenghala* and *Wallago attu*. The results of these observations, which indicate the trend of catch curve and mortality rate, are given below:

Species	Size-group	Length range mm.	% by weight	Estimated number
Tor tor	I	up to 215	5·4	1,632
	II	216–420	58·6	7,748
	III	421–625	27·9	701
	IV	626 and above	8·1	214
Labeo fimbriatus	I	up to 165	2·6	265
	II	166–320	37·9	4,554
	III	321–470	46·1	3,429
	IV	471 and above	13·4	616
Rita pavimentata	I	up to 115	2·0	562
	II	116–215	60·1	5,757
	III	216–320	34·4	1,118
	IV	321 and above	3·5	36

Species	Size-growth	Length range mm.	% by weight	Estimated number
Mystus seenghala	I	up to 265	1·0	249
	II	266–470	22·2	596
	III	471–650	43·8	483
	IV	651 and above	33·0	267
Wallago attu	I	up to 265	0·8	173
	II	266–470	27·3	747
	III	471–650	42·0	676
	IV	651 and above	29·9	299

With a view to determine the fluctuations in the relative abundance of fish in Narbada River, observations on the catch-per-unit of effort, mainly in respect of net and long line operations were made in Hoshangabad area from October 1961 to March 1962 and in Shahganj area from April 1961 to July 1961 and November 1961 to March 1962. The observations in respect of cast net and long line operations from the two areas are given below:

	Catch per gear per hour kg
CAST NET	
Hoshangabad Area (six months)	
October–December 1961 ..	0·468
January–March 1962 ..	0·362
Average ..	0·415
Shahganj Area (nine months)	
April–June 1961 ..	0·385
November–December 1961	0·345
January–March 1962 ..	0·319
Average ..	0·35
LONG LINE	
Hoshangabad Area (six months)	
October–December 1961 ..	0·292
January–March 1962 ..	0·109
Average ..	0·2
Shahganj Area (nine months)	
April–June 1961 ..	0·165
July 1961 ..	0·103
November–December 1961	0·158
January–March 1962 ..	0·143
Average ..	0·142

Over 5 tonnes of *Tor tor* are estimated to have been landed at Hoshangabad and Shahganj centres during nine months from April 1961 to July 1961 and November 1961 to March 1962. The average monthly catches is estimated to be 630 kg in 1961–62 as against 530 kg in 1960–61 and 650 kg in 1959–60. The fishery of this species made up 38·5% in carp fishery and 24·2% in total catches at two centres during the period under report. 216–420 mm size-group was the most dominant (58·6%) in the fishery of this species. The catch-per-unit of effort of this fish from cast net operations at Shahganj during 9 months was found to be 0·112 kg per-net-per-man-hour and this species made up 29·4% in cast net fishery.

336 specimens of this species were examined for detailed biological study during this year. The feeding intensity was found to be poor from July to October (av. G.S.I.: 1·715), which period coincided with its breeding season. The feeding intensity increased progressively from November (G.S.I.: 2·94) to February (G.S.I.: 5·43) and thereafter declined up to July (G.S.I.: 1·278). The trend of feeding intensity during the year is similar to that of 1960–61.

The percentage composition of the diet of *Tor tor* was studied by eye estimation and occurrence methods. The diet consisted of macrovegetation (38·3%), filamentous algae (12·0%), insects (10·9%), and molluscs (7·3%).

The maturity of the fish was studied by gross examination of the gonads, gonado-somatic index and ova-diameter measurements of specimens measuring over 280 mm, which is the size at first maturity. The observations indicated that the species commences breeding in July-August and has a prolonged season up to January-February, with peak breeding from July to September. Availability of post-larvae of size range 9–12 mm from August to February fully supports these observations.

With a view to locate new and productive carp seed collection centres and spawning grounds of commercially important species of fish in Narbada and Tapti Rivers, investigations were undertaken to ascertain the availability of fertilised eggs, larvae and fry of commercially important species, particularly of major carps, at Moti-Koral on Narbada River from 11–7–1961 to 27–8–1961 and at Bodhan on Tapti River from 16–7–1961 to 15–9–1961. One new and very productive carp seed collection centre has been successfully established at Moti-Koral on Narbada river and another centre of comparatively lesser value has been established at Bodhan on Tapti River. Over 46,00,000 of carp spawn were collected by operating a maximum of three

nets for 253 hours on 46 days in Moti-Koral Centre and catch-per-net-per-hour was found to be 6,000. The peak period of collection was from 6–8–1961 to 8–8–1961 when 20,00,000 carp spawn were collected from three nets in 18 hours (catch-per-net-per-hour: 37,200 carp fry).

In order to determine the quality of carp seed collected, samples of the collections were stocked in four nursery tanks and the species composition of reared fry was found to be as follows:

	%		%
Major Carps	.. (53·0)	Minor Carps	.. (47·0)
Catla catla	.. 22·0	*Labeo bata*	.. 27·0
Cirrhina mrigala	.. 30·0	*Cirrhina reba*	.. 18·0
Labeo calbasu	.. 1·0	*Chela* spp.	.. 2·0

The carp seed collection ground extending over about half a mile in the vicinity of Moti-Koral was found to be most suitable for the operation of over 75 nets simultaneously. The ground is located at a distance of half a mile from Moti-Koral Railway Station and the seed can be transported conveniently to Baroda, Broach and Surat by rail and road.

About 8,25,000 carp spawn were collected at Bodhan Centre by operating a maximum of three nets for 244 hours on 45 days. The peak collections of carp seed were made on 23–7–1961, when about 4,00,000 and 2,00,000 respectively, of carp spawn were collected from three nets in 6 hours.

The samples of carp seed collected were stocked in local nursery tanks and the percentage of major carps was found to be extremely poor.

The observations relating to location of spawning grounds of *Hilsa ilisha* (Ham.) were continued at Moti-Koral. 15,000 *Hilsa* eggs were collected during 14–7–1961 to 27–8–1961. The observations made have indicated that majority of *Hilsa* eggs belonging to two different ages had drifted down from at least two spawning grounds located between Malsar (16 miles upstream of Moti-Koral) and Poicha (34 miles upstream of Moti-Koral).

The observations for the location of spawning grounds of Hilsa in Tapti River were commenced for the first time during the monsoon season of 1961 at Bodhan. Over 22,000 Hilsa eggs were collected with spawn collection nets during the period 16–7–1961 to 15–9–1961. The eggs had drifted down from a spawning ground located between Piperia (5 miles upstream of Bodhan) and Mandvi (17 miles upstream of Bodhan).

Observations were made on the occurrence and breeding of Catla in Tapti River during the course of exploratory investigations on fish seed resources during the monsoon season of 1961. With a view to determine

the quality of fish seed obtained from Tapti, several samples collected at Bodhan from 16–7–1961 to 15–9–1961 were reared in two local nursery tanks. The examination of reared samples of fish from one of the nursery tanks after three weeks, revealed the presence of 26 fingerlings (2–3 inches) of Catla which made up 1·1% in the collections. This is of significance in view of the generally accepted view that Catla does not occur in Tapti River.

11. *Investigations on the Fisheries of Estuaries*

Hooghly-Matlah System.—The total catch from the estuary registered an increase of 10·2% over the previous year, which was mainly due to the catches of Hilsa at the mouth of the estuary (near the Contai Coast). The catch-per-unit of effort in the estuary itself was, however, lower this year (58·25 kg.) than during the previous year (198·32 kg). A decline in total landings by 34·1% over the previous year was recorded from the Rupnarain. Estimated zone-wise landings and catch-per-unit of effort are given below:—

Zone-wise and gear-wise catch (metric tons) and C.P.U.E. (kg.)
Hooghly-Matlah Estuary
1961–62

Zone	Zone I		Zone II		Zone III		Zone IV		Zone V	
Gear	Catch	C.P.U.E.	Catch	C.P.U.E.	Catch	C.P.U.E.	Catch	C.P.U.E.	Catch	C.P.U.E.
Bag net ..	54·3	4·06	46·2	2·09	996·3 +574·6	58·65*	346·8	6·25	72·9	14·84
Purse net ..	38·4	0·46	3·9	0·14	0·1	—	—	—	—	—
Hook and Lines	21·4	1·65	46·6	0·96	68·7	—	—	—	—	—
Lift net ..	131·2	2·89	3·9	0·31	0·4	—	—	—	1·8	4·79
Trawl net ..	60·8	2·57	1·3	7·28	—	—	—	—	—	—
Drift net ..	30·3	1·43	7·6	2·43	481·8 +152·3* 0·4	—	20·9	1·16	—	—
Cast net ..	5·7	2·10	—	—	10·7	—	—	—	—	—
Seine net ..	1·1	2·04	—	—	110·8	—	—	—	3·6	3·46
Traps ..	10·8	1·35	—	—	—	—	—	—	—	—
Set gill nets ..	6·2	1·25	—	—	32·5	—	—	—	—	—
Set barrier ..	—	—	—	—	217·3	—	—	—	3·1	5·56
Tangle net ..	—	—	—	—	502·0	—	—	—	—	—
Unknown ..	—	—	—	—	242·2	—	—	—	—	—

* Obtained from lower Sunderbans (Winter fishery) catches only.
— Negligible quantity.
\+ Frazergunge camp data.

Clupeoids formed the dominant group in the catches during the year and accounted for nearly 30·2% of the total landings. *Hilsa ilisha*, *Setipinna phasa* and *Setipinna taty* were the more important species of the group that were represented in the catches. *S. phasa* contributed to 1·9% of the total catches. During the first half of the year, its fishery was, as usual, largely confined to the upper and middle stretches of the Hooghly and the Rupnarain estuary, but during the third quarter of the year, though the fishery was poor, it had spread into the lower zone and during the last quarter it was almost wholly confined to the lower zone and the adjoining lower Sunderban areas. At Canning, it continued to be almost non-existent. This contributed to a fairly steady year-round fishery along the Ichamati. Juveniles (modal length 8·5 cm.) and just-maturing forms (modal length 14·5 cm.) belonging possibly to the '0'-year and 1-year groups, dominated the Hooghly-Rupnarain catches. Older age-groups (20–32 cm.) were mainly encountered in the lower Sunderban areas. The Ichamati landings consisted of comparatively larger size-groups, most of them being within the size range of 9·0–17·0 cm, with 10·5 cm as the modal length. In general, bigger size-groups were encountered in the landings at Hasnabad than in those at Itindaghat and Kalinagor.

S. taty contributed to 1·3% of the total catch. Its fishery was mainly confined to the lower zone of the Hooghly and other lower Sunderban areas and to a lesser extent to Canning on the Matlah, with a comparable fishery in the Rupnarain estuary during the first half of the year. While the catches from the Hooghly and Rupnarain consisted mainly of maturing and mature forms (modal size 11·5 cm), those from Canning were dominated by immature and just-maturing forms (modal sizes 5·5, 8·5 and 12·5 cm). Along the Ichamati, the individuals landed ranged in size from 5·0 to 17·9 cm, with a modal length of 10·5 cm.

Harpodon nehereus which accounted for nearly 24% of the total landing was represented mainly by big size-groups having modal lengths of 65·5, 115·5, 165·5, 215·5 and 265·5 mm., respectively. Excepting the '0'- and 1-year groups, which were represented during all the months of the year, the rest of the size-groups contributed to the fishery only during the winter months of October to February. Females in the III/IV stage of gonadial maturity (modal length 265 mm) were available in the catches only during February.

Catfishes which formed 4·7% of the total catches were represented by *Pangasius pangasius*, *Tachysurus jella* and *Osteogeniosus militaris*. Four size-groups (0 to III) of *P. pangasius* were represented in the catches in the

different zones. Bigger age-groups were represented in the lower zone of the estuary during October to February. Early recruits of the '0'-year group, having a modal size of 33·0 and 32·5 mm, entered the fishery during July and November respectively. This group dominated the fishery during August to November. During all the other months of the year the I group constituted the bulk of the catches. *Osteogeneiosus militaris* was represented by the '0'-year group (modal length 70 mm) during November and December in the lower Sunderbans. Maturing and mature adults of the II and III year group (modal lengths 166, 268 and 348 mm) formed the fishery in the lower and middle zones of the estuary during January to May. *Tachysurus jella* was represented in the catches from the lower Sunderbans during August to January by individuals ranging from 600–900 mm. Smaller size-groups (I and II year classes) contributed to the catches from the Rupnarain and middle zone of the Hooghly during the same months.

Sciaenids contributed to nearly 4% of the total landings and were represented in the catches mainly by *Pama pama* and *Sciaenoides biauritus*. *Pama pama* occurred in the catches from all the zones of the estuary during different months of the year. Three age-groups 0 to II (modal lengths 25, 125 and 205 mm) contributed to the catches from the upper and middle zones of the Hooghly and Rupnarain during February to May. Durying the other months of the year II and III groups (modal sizes 205 and 345 mm) contributed to the fishery in the lower zone of the Hooghly and lower Sunderbans area. *S. biauritus* ranging from 41 to 1,380 mm contributed to the fishery from the lower Sunderbans during the winter months.

Eleutheronema tetradactylum ranging from 21 to 530 mm in total length and belonging to five length groups, having modal lengths of 55, 105, 195, 325 and 430 mm, were represented in the commercial catches. The bigger fish were mostly available during the winter months December to February in the catches from lower Sunderbans. The younger fish were common during August and September in the catches from the Matlah and Ichamati. The fish was conspicuous by its absence in the catches from the upper zone of the Hooghly and the Rupnarain.

Polynemus paradiseus ranging from 21 to 324 mm in total length was present in the commercial catches in four age-groups, having modal lengths of 50, 200 and 260 mm, respectively. While immature fish ranging between 21 mm and 70 mm were common in the catches from the Rupnarain and the upper zone of the Hooghly during December to January and June to July respectively, maturing and spent fish ranging between 100 and

324 mm, with modal length of 140, 200 and 260 mm were common in the catches from the lower zone of the Hooghly, the Matlah and Ichamati during the winter months, November to February. Thereafter, fish in an advanced stage of maturity were available in the catches from the Rupnarain and the upper and the middle zones of the Hooghly during the months April to July, indicating migration to these areas for spawning.

Sillago panijus ranging between 40 and 420 mm, comprising seven length groups, contributed to the fishery in the estuary. The modal lengths of the various groups were 55·5, 95·5, 125·5, 185·5, 255·5, 315·5 and 375·5 mm, representing 0 to 6th year groups respectively. Of these, the third group was most predominant throughout the year. The fishes were landed mostly during January and February. *Lates calcarifer* was represented in the catches from the lower Sunderbans mostly during the winter months by individuals ranging in length from 50 to 950 mm, consisting of seven different size-groups.

Trichiurus savala ranging between 60 and 175 mm, in vent length and belonging to four length groups with modal lengths of 50, 80, 110 and 160 mm, respectively, was represented in the commercial catches from the regions close to the mouth of the system. The fish was most common in the catches from the lower zone during the winter months of November to February. It was available mostly in the bag nets (Been jal). Stray juveniles ranging between 41 and 105 mm in length were represented in the commercial catches from the Matlah and the middle zone of the Hooghly and Ichamati.

Trichiurus haumela ranging between 45 and 165 mm in vent length and belonging to two length groups, with modal lengths of 70 and 125 mm, was present in the commercial catches. Of the two size-groups, the latter was more common. It was mostly caught by the bag nets from regions close to the mouth of the estuary during the winter months of November to February. It was represented by stray individuals ranging between 45 and 125 mm in vent length, in the catches from the Ichamati, the Rupnarain and the middle zone of the Hooghly.

The data pertaining to five commercially important species of prawns collected over the past three years were analysed during the year for age and size composition, sex ratio, etc. Three age-groups (0, 1 and 2-year groups) seem to contribute to the fishery of *Metapenaeus brevicornis*. Growth in females is faster than in males during the second year. Thus, one-year-old males and females measure about 45·8 and 47·4 mm respectively and at the age of 2, they measure 80·5 and 89·0 mm respectively. There appear to

be two spawning periods, one in March-April and the other during June-July. 0-year individuals measuring 24·5 to 26·4 mm begin to appear in the catches during the months July and October-November.

I and II year groups constitute the fishery in the lower reaches of upper zone and upper reaches of middle zone, the I year group forming the dominant group during all months except August–October. In the lower middle zone and lower zone, 0–III year groups contribute to the fishery, with the former appearing only from July to December. In the Rupnarain 0, I and II year groups only contribute to the fishery, whereas, in Matlah, III year group also is present mainly during winter months. Spawning occurs only at sea and juveniles migrate up the estuary later.

Palaemon carcinus occurred in very small numbers only during the year under report. The presence of juveniles measuring 44–73 mm. at Medgachi probably indicates a migration from breeding grounds (lower middle zone) to upper reaches for feeding and growth.

The catches of *P. malcolmsonii* were confined to the period January to February, when the length range was 31 to 90 mm and later during the June–July, when the length range was 34 to 115 mm Among these latter catches, 95% of the females in the length range of 85 mm to 115 mm were all egg-bearing or maturing. Mature males measured between 67 and 75 mm.

The probability plot analysis of the data for the three years showed 3 normally distributed size-groups in females (36·5, 56·0 and 43·5 mm) and 4 in males (40·0, 58·0, 90·5 and 118·5 mm). The 0-year class with modal sizes (sex indistinguishable) of 28·5 to 33·5 mm occurred during October–December only. The percentage occurrence of females is higher than that of males. All size classes were distributed mainly in the upper zone.

Length-frequency data on *P. mirabilis* analysed by probability plot method showed that there are 3 normally distributed size-groups (20·5, 29·3 and 33·5 mm) among males, and 3 in females (20·3, 34·2 and 46·4 mm). Monthly progression of modes in the length frequency distribution indicated an approximate growth of 2–3 mm per month, with a slightly faster growth in females. Thus, it may probably be inferred that 0 and 1-year groups contribute to the fishery. The last, however, forms a minor percentages. All the size-groups contributed to the fishery in the upper and middle zones of the Hooghly and Rupnarain, during all the months. However, in the lower zone of the Hooghly, the mature females were present only during

January and March and from September–December all size-groups were present. The species was completely absent in Matlah.

Four normally distributed size classes of *Leander styliferus* were seen in males, *viz.*, 33·0, 43·5, 56·0 and 70·0 mm, and 6 in females 32·8, 43·7, 55·0, 67·6, 77·6 and 88·0 mm. Progressio of modal sizes showed a growth rate of 3–4 mm per month, both in males and females. And, taking into consideration, the prolonged breeding period of the species (7–8 months) it is likely that two consecutive size classes represent each year class except the 0-year group. Hence it appears that males are represented by 0, I and a few II year groups in the catches and females by III year group also. All size-groups are distributed in the lower middle zone and lower zone of the Hooghly, Matlah and Rupnarain estuaries. Maturing females occurred during March-April in the Rupnarain, June and September in the Matlah; and January, February, June and October–December in the Hooghly.

Hydrobiological observations.—Studies on the trends of fluctuations in salinity and temperature in various zones of the estuary indicated that they are essentially similar to those observed during the previous year. April to June constituted a high salinity period and August to October and December to February low and medium salinity periods, respectively. In the upper zone of the Hooghly, salinity was in 'traces' throughout the year, whereas in the middle and lower zones it fluctuated between traces to 9·23‰ and 1·56 to to 26·82‰ respectively. In Rupnarain and Matlah, salinity fluctuated between traces to 6·52‰ and 10·55–28·04‰ respectively. Temperatures in the Hooghly during the year ranged between 20·90 and 31·51° C. In Rupnarain and Matlah surface temperatures ranged between 21·67 and 31·37° C. and 21·45–29·6° C. respectively.

As noticed during the previous year, mainly freshwater planktonic forms were present in the upper zone of the Hooghly, while in its middle zone and in Rupnarain both fresh-water and brackish-water forms were present. In the lower zone of the Hooghly and at Canning on the Matlah the plankton was dominated by marine forms.

Diatoms were the most important phytoplankton group. Among the zooplankters, copepods and cladocera were the most dominant. Rotifers were mainly present in the fresh-water zone. Nauplii, trochophores, lamellibranch, veligers and cyphonautes were also present in good quantities, particularly in the lower zone of the Hooghly and in the Matlah.

In the Upper zone, the dominant diatom forms were *Coscinodiscus*, *Melosira*, *Synedra* and *Surirella* and among the algae *Spirogyra*, *Pediastrum*, *Eudorina* and *Microcystis*. *Coscinodiscus*, *Melosira*, *Synedra* and a few

Biddulphia spp., among the diatoms and *Microcystis*, *Pediastrum* and *Spirogyra* among the algae, were the main forms encountered in the middle zone. In the lower zone of the Hooghly and also at Port Canning, mainly marine diatoms such as *Biddulphia*, *Chaetoceros*, *Lithodesmium*, *Coscinodiscus*, *Triceratium*, *Thalassiothrix* and *Rhizosolenia* were present. Algae were found only in limited quantities. *Trichodesmium* sp. was present in lesser numbers than during the previous year. Some dinoflagellates like *Ceratium* spp., *Peridinium* sp. and *Noctiluca* sp. were also present. Lower zone of the Hooghly and Port Canning were the richest in quantity, as well as variety, of both diatoms and zooplankters.

Larval and young fish survey.—Studies on the distribution and abundance of larvae of commercially important species were continued. Larvae of *H. ilisha* were available, mainly, during July to November in Zones I, II and IV. Yolked larvae of the species were abundant only in Zone I in the stretch of the river between Konnagar and Ghasighata. This confirms earlier observations that the fish spawns in the upper stretch of the estuary and that August and October constitute peak periods of spawning. Post-larvae and juveniles of Hilsa were collected only from the lower reaches of Zone II.

Larvae of *S. phasa* were available all the year round, generally from Zones I and IV. Availability of yolked larvae in abundance, during the months November and February, indicate that this period constitutes the peak spawning time.

The distribution of eggs and larvae of the species leads to the conclusion that like Hilsa, *S. phasa* also spawns in the fresh-water zone of the Hooghly and in Rupnarain. Yolked larvae of *P. paradiseus* were abundant only during the months July and August in Rupnarain and Zone I of the Hooghly. Post-larvae and juveniles of *E. tetradactylum* were available throughout the year in Zones II, III, IV and V. *Pama pama* appears to breed all round the year with spawning peaks during February–March, July–August and October-November, as evidenced by the occurrence of the yolked larvae of the species. Rupnarain appeared to be the principal spawning ground of this species.

Mahanadi estuarine system.—Sample survey of dry fish markets and total enumeration of fresh fish exported were carried out successfully for estimating the total marketable surplus. There was regular fresh fish export from Kujang almost throughout the year, except during May and June. The same started in November from Machgaon in the South and Jamboo in the North and continued till February. The export business at Machgaon was mainly concerned with the large Hilsa catches obtained in the Devi River

during the above period. Fresh fish export was the heaviest during the last quarter, mainly due to large Hilsa catches and formed about 50% of the total annual export.

Species-wise total catch figures, as estimated from the dry fish market disposal and fresh fish export figures, are given below:—

Species-wise market disposals and exports (in kg.)
Mahanadi Estuary
1961–62

Name of fish	Market disposals*	Fresh fish export	Total	%
Mullets (unidentified) ..	..	1,395	1,395	0·2
M. cephalus ..	45,880	12,281	58,161	10·3
M. cunnesius ..	19,052	1,436	20,488	3·6
M. parsia ..	38,832	5,398	44,320	7·8
M. tade ..	1,590	6	1,596	0·3
M. troschellii ..	3,975	2,518	6,493	1·1
Prawns ..	63,055	16,292	79,347	14·0
P. indicus ..	18,888	6,337	25,225	4·5
E. tetradactylum ..	5,300	1,229	6,529	1·2
Sciaenids ..	10,068	4,747	14,815	2·6
L. calcarifer ..	14,145	11,621	25,766	4·6
Thrissocles spp. ..	6,570	2,793	9,363	1·7
Nematalosa sp. ..	10,400	120	10,520	1·9
Ilisha spp. ..	2,342	4,165	6,507	1·2
Anchoviella spp. ..	618	195	813	0·1
Sardinella spp. ..	16,652	..	16,652	2·9
H. ilisha ..	48,218	136,060	184,278	32·6
Mystus spp. ..	4,958	635	5,593	1·0
Arius spp. ..	4,838	1,397	6,235	1·1
O. militaris ..	10	28	38	..
P. pangasius ..	25	2,664	2,689	0·5
Miscellaneous ..	24,712	13,706	38,418	6·8
Total ..	340,128	225,023	565,151	100·0

* Figures are in terms of fresh fish.

(During the period August–November, data were collected only from two major 'hats' and the figures for that period as given above are only estimates.)

Gear-wise catch-per-unit effort in Mahanadi

Nets	Catch per unit (kg.)
Salua ..	20·10
Suta ..	6·75
Kukut ..	14·98
Mala ..	22·16
Saru ..	11·76
Torania ..	7·04
Hilsa nets ..	24·84

Hilsa constituted the most dominant fishery during the year, contributing to 32·6% of the total landings. It was caught mainly during the winter months November–February and during March, with very heavy catches during December and January.

Several species of mullets contributed to the second biggest fishery in the estuary, forming 23·3% of the total landings. *Mugil cephalus*, *M. parsia* and *M. cunnesius* and to a lesser extent, *M. troschellii* were the main species. *M. cephalus* was the most dominant mullet. It was caught mainly from the Jatadharmohan and Hukitola regions and the individuals varied in size from 15·0 to 60·0 cm, with most of them within the size range of 30–40 cm. Mature and spent forms were encountered during November–December, which formed the breeding season of the species. *M. troschellii*, with a size range of 20·0–60·0 cm, contributed to a significant fishery from October onwards. Majority were within the size range of 30·0–40·0 cm, November–January formed the breeding season of this species. *M. parsia* (5·0–24·9 cm.) and *M. cunnesius* (10·0–23·9 cm) contributed to two other commercially important fisheries almost throughout the year.

Lates calcarifer contributed to a major fishery, specially during the early winter months. They varied in size from 13·0 to 11·0 cm, with most of them within the size range of 17·0–35·0 cm the modal length being 31·5 cm. The polynemids, *Polydactylus indicus* and *E. tetradactylum* formed

a significant portion of the total catches (4·5% and 1·2% respectively) *P. indicus*, which was landed in larger numbers from July to October, ranged in size from 10·0 to 85·0 cm, with the majority within the size range of 30·0–50·0 cm. *E. tetradactylum* showed a size range of 10·0–76·0 cm and those measuring 15·0–30·0 cm, with a modal length of 20·5 cm dominated the catches.

Among others contributing to commercial fisheries may be mentioned some clupeoids (*Thrissocles* spp., *Nematolosa* sp., *Ilisha* spp. and *Sardinella* spp.), Sciaenids (*Sciaena miles*, *Sciaenoides biauritus*, *P. pama*, etc.) and catfishes (*Mystus* spp. and *Airus* spp.). Small-sized prawns, mainly penaeids, contributed to 14·0% of the total catches.

Larvae and juveniles of several commercially important fishes and also of others were encountered, mainly in the lower stretches at Hukitola, Paradip-lower Mahanadi region and at Jatadharmohan. Mullet postlarvae were the most common and were found distributed over Zones I, VI and VIII. Postlarvae of *M. cephalus* (12·0–13·0 mm) were encountered from January to April in Zones I and VIII and of *M. parsia* and *M. corsula* (24·0 mm) during January in Zones VII and VI respectively. Postlarvae of *Thrissocles mystax* (13·0–25·0 mm.) were seen during April-May in Zones I and VIII and during November in Zone VI while those of *T. kammalensis* were encountered in Zones I and VIII during November. Post-larvae of *E. tetradactylum* (7·0–9·0 mm) were seen during April and May in Zone I.

12. *Exploratory Fishing in Sunderbans*

During the year under report 10 voyages to Sunderbans estuarine waters were made using the exploratory fishing vessel M. V. "Sunderbans". The nets and gear operated this year were trawl net, gill net, beenjal and hook and line. A locally designed mid-water trawl was also used during the last quarter of the year.

A total of 156 hauls were made during the year, each haul being of one hour duration. Of these, 108 were made in Zone I (comprising of Muriganga and Saptamukhi estuaries) and 48 in Zone II (Thakuran and Matlah estuaries). Trawling yielded 3357·342 kg of fish, of which 1560·182 kg were caught in Zone I and 1797·160 kg in Zone II. The total landings averaged 21·52 kg per haul. The average catch per haul in Zone I was 14·45 kg and for Zone II was 37·44 kg. The catch per haul (in kg) during different months is given below:—

Months	April	May	July	Oct.	Nov.	Dec.	Jan.	Feb.	March
Zone I ..	9·7	9·3	16·95	2·64	25·3	..	15·27	21·2	11·9
Zone II ..	3·7	4·07	..	..	40·16	86·07	51·73	25·14	..

The fishes which predominated in the catches were *Harpodon nehereus*, *Pama pama*, *Arius sona*, *Setipinna taty*, *S. phasa*, *Coilia ramcarati*, *Pangasius pangasius* and *Coilia dussumieri*. Of the prawns, *Parapenaeopsis sculptilis* appeared regularly in both the Zones. Appreciably large catches of *Leander tenuipes* were obtained in Matlah and Thakuran estuaries in November and December 1961. In the former month it formed 53% and in the later 66% of the total landings.

A new trawling ground has been located in the Matlah estuary along the right bank north of Holiday Island. The water depth ranged between 9 and 12 fathoms, and the ground is even in the area. Good catches, comprised mainly of *Polydactylus indicus* and *Arius sona*, were observed in this area.

Gill net was operated 7 times and 58·430 kg of fish were caught, giving an average of 9·347 kg of fish per operation. The catches comprised of *Arius sona*, *Chorinemus sanctipetri*, *Hilsa toli*, *Eleutheronema tetradactylum* and *Setipinna phasa*.

During seven operations of hook and line using 400 hooks, an average of 37·174 kg of fish were caught per operation. The fishes caught included *Trygon bleekeri*, *Arius sona* and *Pristis cuspidatus*.

Behundijal gave on an average 38·00 kg of fish per operation. Catches consisted mainly of *Acetes* sp., *Anchoviella* sp. and Ribbon fish.

The Sciaenid catches were composed of *Pama pama*, *Sciaenoides biauritus* and *Sciaena glaucus*, *Pama pama* was available throughout the year. The fishes ranged from 30·329 mm with a single mode at 155 mm. *Sciaena glaucus* appeared in the catches from April to September. The fishes belonged to 0-year group with modal length at 85 mm. The fingerlings of *Sciaenoides microdon* were common in the catches during February-March.

The most common clupeoids were *Setipinna taty*, *Setipinna phasa* and *Coilia ramcarati*. Other species were *Ilisha elongata* and *Coilia dussumieri*. *S. taty* showed the presence of two size-groups. The modal points were

at 95 mm and 155 mm. It is likely that they represent two age groups. The latter group dominated the catches.

Catfishes consisting of three species *Arius*, *Pangasius pangasius* and *Osteogeneiosus militaris* were common in the catches of Saptamukhi estuary during the period July–November. *Pangasius* catches showed two clear modes at 175 and 255 mm, representing most probably two different age-groups. Larger fishes of the species were available in September and ranged from 320 to 449 mm. *Osteogeneiosus militaris* catches comprised of fishes from 50 to 179 mm with modal point at 105 mm. A larger size-group with a modal point at 315 mm was evident in the catches of July 1961.

Parapenaeopsis sculptilis was the only species of prawn which appeared consistently in the catches. Two modes were distinguishable at 95 and 120 mm. Of the occasionally occurring species, *Leander tenuipes* had a very limited season during November–December, when it appeared in the catches in great abundance, forming the major percentage of the catch. The other species were *Penaeus indicus*, *Leander styliferus* and *Metapenaeus brevicornis*, but they did not contribute significantly to the catches.

Studies on the biology and population of fishes from Sunderbans were initiated during the year. The fishes taken up for detailed studies were *Coilia ramcarati*, *Coilia dussumieri*, *Setipinna taty*, *S. phasa* and *Silago panijus*. *C. ramcarati* is the commonest of the species of the genus inhabiting the estuarine system. 74 specimens drawn from various localities have been examined in detail. The size varied from 96 to 212 mm in total length. It is seen that the species feeds mainly on prawns, *Acetes* sp. forming the bulk. Copepods and Cladocerans are also consumed by the species. From November the sex-organs of this species show a gradual progression towards maturity. In December–January, practically all specimens are found in advanced stages of maturity. Therefore, the spawning seems to take place during the winter months.

About 100 specimens of *Coilia dussumieri* ranging in size from 103 to 161 mm in total length have been examined. From November to January the period for which samples have been studied, mature and spent specimens were found in the catches. This indicates the spawning period of the fish.

The samples of *Setipinna phasa* and *S. taty*, drawn from the catches of November–March, have been studied. The gonads show a gradual progression in maturity from November onwards. The specimens in November had ovary in early maturing stages. In March, however, maturity of the gonad was observed in fish from lower reaches. The major item of food was *Acetes* sp.

13. *Investigations on Hilsa Fisheries*

A late monsoon fishery and a sporadic winter fishery were the characteristics of the Hilsa fisheries in the Ganga-Padma-Hooghly River System during the year. The monsoon fishery commenced in June with localised small-scale fishing in Zones I, II and III. The fishery, however, did not get established and because of heavy floods, declined soon after, reviving again to a limited extent in September–October. The winter fishery commenced in the coastal waters of Bengal towards the end of November, yielding large catches of Hilsa on the Digha coast. This fishery continued up to the end of February on a lesser scale, but the Hilsa shoals failed to ascend the Hooghly as in the previous years.

The estimated total catches of Hilsa in the Hooghly during the year was 1028·7 tonnes.

In the Padma, the monsoon fishery for Hilsa commenced in June and appreciable quantities of Hilsa were landed in June and July, but the fishery declined rapidly and almost ceased in August and September, due to the heavy floods in the river. In November and December the catches were good; but the total winter fishery was also below normal. A total of 1185·33 tonnes of Hilsa were caught and landed from the Padma in the neighbourhood of Lalgola during the year.

In the Ganga the Hilsa fishery during the year was comparatively poor, an estimated total of about 70·0 tonnes of the fish being the landings during the nine months April 1961 to December 1961. In the Jamuna the Hilsa fishery was negligible.

The bulk of the commercial catches of Hilsa in the Hooghly during the monsoon fishery comprised of fish of age 2 + and 3 + years, though other age-groups, *viz.*, 1 +, 4 + and 5 +, were also represented in the catches. The coastal fishery for Hilsa (Digha coast) during the winter months was composed mainly of the 1 +, 2 + and 3 + age-groups, the 2 + group being the most numerous. The fishery in the Padma and in the lower Ganga (Rajmahal area) was contributed mainly by the 2 + and 3 + groups both during the monsoon and winter. In the Godavari, the monsoon fishery appears to have been dependent mainly on the 3 + and 4 + age-groups, though larger fish up to a length of 60·0 cm. were also present in the catches. The winter fishery in the Godavari, as usual, comprised of smaller sized fish, the most dominant age class being the 2 + group.

Analyses of the gut contents of 347 Hilsa (150 young and 197 adults) obtained from Godavari during winter and monsoon seasons show that

the main items of food of Hilsa of all sizes are decayed plant matter (39·60%), crustaceans (18·88%) and diatoms (15·43%). Algae (2·84%) and molluscan larvae (2·97%) were also found in considerable quantities in a good number of specimens collected during the winter season. Protozoans (1·00%) and rotifers (0·57%) were scarcely represented in few specimens and in others they were totally absent. The presence of sand grains (18·29%) in appreciable quantities in the stomachs of a large number of specimens shows that the fish at times feeds near the bottom. No appreciable difference has been observed in the composition of food of young and adult Hilsa. The fish appears to feed on all planktonic organisms depending on their availability and abundance and hence no selectivity in feeding has been noticed. An interesting feature is that during the breeding season (July–November) most of the fish examined had their stomachs empty, the only food seen in the stomachs of the other specimens being decayed plant matter mixed with sand grains in very negligible quantities.

The availability of maturing (V), mature (VI) and spent (VII) Hilsa at Centres like Kotipalli, Bodasukuru, and Rajole on the lower stretches of Godavari shows that the region just below the anicut at Dowlaiswaram is not the only breeding place for Hilsa, and that the breeding might extend to the downstream stretches also. The fish breeds throughout the monsoon season as evidenced by the availability of specimens in the final stages of maturity during all the months from July to December, at all the above centres. In December and January most of the specimens were spent and recovering. In the beginning of the monsoon season the catch at Dowlaiswaram comprised mostly of males (above 75%) which are in V, VI and partly spent stages, but as the season advanced the ratio of males and females rose gradually. Females in the second stage of maturity were present in the samples collected during the later part of March and April and these would probably be the first to attain maturity in the earlier part of the monsoon season (V and VI stage females were present in the samples of July and August). Females in second stage were available at Dowlaiswaram during September also. These may be the late spawners shedding their eggs in the later part of December. IV Stage ovaries were found in specimens of October and fully mature ovaries in those of December.

When the river is in full spate with the water rising high (up to 18 ft.) above the crest level of the anicuts, the Hilsa migrates to the upper stretches of the river and the presence of young Hilsa measuring 43 mm and upwards in the catches of shore seines in the river above the anicuts indicates that the fish breeds above the anicuts as well.

During the monsoon season 800 adult Hilsa were tagged of which 500 were released in the neighbourhood of Rajmahal (above Farakka) and 300 in the neighbourhood of Dhulian-Lalgola (below Farakka). Of these 4·1% have been recovered so far, all of them from points downstream of their release. Three of these fish, two released near Dhulian and one released near Rajmahal, have been recaptured at the mouth of the estuary in East Pakistan. There were three similar recoveries last year from East Pakistan estuaries. These recoveries indicate that at least part of the Hilsa stocks in the Padma and the lower portion of the Ganga find their way to the sea through the estuaries that lie in East Pakistan. There has been so far only one instance of a fish released in the Padma (near Dubra) being recaptured in the Hooghly and none of the tagged fish released in the Hooghly (3720 fish have been tagged and released) have been recaptured in the Padma or the Ganga. This indicates that there is very little intermingling of the Hooghly Hilsa with that in the Padma-Ganga.

Hilsa with fully mature and partially spent gonads were obtained in considerable numbers in the catches in the stretch of the river from Rajmohal down to Lalgola during the monsoon fishery season. Larvae and post-larvae of the fish ranging in size from 2 mm (yolked) to 20 mm were also obtained in the tow net collections in the Rajmohal and Lalgola areas during this period. These observations point to the conclusion that Hilsa may be spawning in this entire stretch of the river. Developing eggs of Hilsa have not been obtained in the collections so far, but the presence of yolked larvae of size 2 to 5 mm shows that the actual spawning areas are not far from the collection centre. Thus, it is to be surmised that Hilsa breeds both above and below the site of the proposed Farakka barrage.

14. *Investigations on Water Pollution*

Laboratory studies have indicated that by the use of Aluminium Sulphate as a coagulant, in doses ranging from 0·5 to 2·0%, it is possible to reduce values of chemical oxygen demand, smell, colour, etc., of the pollutants. Investigations to ascertain the suitability of other coagulants, such as lime, ferrous sulphate, ferric chloride, etc., as possible curatives of the noxious effects of pollutants from paper mills, are in progress.

15. *Investigations on the Fisheries of Fresh-water Lakes*

Tungabhadra Reservoir.—During the year under report 20·73 metric tonnes of fishes were estimated to have been sold in Hospet fish market. Carps formed the predominant group which accounted for 59·57%, followed by catfishes (37·29%), murrels (2·55%) and others (0·60%). By order of

predominance (by weight) *Barbus kolus* contributed to 24·33% of the total fish landed and among the catfishes *Silonia silondia* contributed to 17·97%. The significant percentages of other carps were *Labeo fimbriatus* 12·58%, *L. potail* 5·81%, *L. calbasu* 4·44% and *Barbus dobsoni* 5·70%. Catfishes other than *Silonia silondia*, were *Mystus seenghala* (7·69%) and *M. aor* (4·07%). *Labeo rohita* and *Catla catla* were recorded for the first time in the Hospet fish market.

Experimental fishing in the reservoir was conducted on 145 days. The total number of net days in the year was 487, and the catch-per-net-per-day was 4·70 kg. The fish catches per day in nets of different meshes were:—

1½″ Uduvalai	1½″ Rangoon net	2″ R.N.	2½″ R.N.	3″ R.N.	3½″ R.N.	4″ R.N.
kg	kg	kg	kg	kg	kg	kg
1·156	2·364	1·892	0·298	0·284	0·039	0·063

The 1½″ Uduvalai (bottom-set gill net) was operated only during the last quarter. Among the reservoir catches obtained in the Departmental nets also, carps predominated, forming 66·92%, with the catfishes coming next forming 33·08%. *Barbus kolus* predominated contributing to 44·51%, followed by *Silonia silondia* with 24·30%, *Labeo fimbriatus* 6·40%; *Labeo calbasu* 4·9%, *Barbus pinnauratus* 4·3%; *Rohtee vigorsii* 4·0%, *Mystus aor* and *Mystus seenghala* 3·0% each, *B. dobsoni* 2·7% and *Eutropiichthys vacha* 2·0%. *Cirrhina mrigala* was recorded during this year in the reservoir catches.

During the year under report 626 specimens of *Barbus kolus*, varying in total length from 94 to 445 mm and in weight from 9 to 1,200 g were studied. The largest number of *Barbus kolus* were in the size-group of 291–300 mm. The sex ratio was 1 (M): 1·1 (F). The diameters of 3,855 eggs at random from the mature ovaries of 28 *Barbus kolus* were measured and plotted. They showed 2 modes indicating that the ova are shed in two successive batches. For *Barbus kolus* the ratio of total weight of fish to gutted weight was found out for mature and immature fishes. From the results obtained it is clear that feeding activity is less in mature fishes. Similar studies were made for *B. pinnauratus*. The relationship between total length and head and body girths of *Barbus pinnauratus* was found to be represented by the regression equation:

$$Y = 1 \cdot 44 X + 63 \cdot 7,$$

where Y is the total length of fish and X the head girth, and $Y = 1 \cdot 17 X' + 72 \cdot 69$ for body girth, where X′ is body girth.

195 specimens of *Rohtee vigorsii* caught from 1½″ gill nets were studied in detail. The fecundity of 40 fishes were worked out and was found to range from 15,320 to 68,680. A correlation coefficient of + 0·99 was found between the weight of fish and fecundity. The relationship between the body weight and the gutted weight was worked out and it was found that there was no significant change in the values during the different months of the year. A linear relationship was noticed between the total length of *Rohtee vigorsii* and the head and body girths and the regression equations were:—

$$Y = 1 \cdot 71 X + 6 \cdot 10 \quad \text{for head girth}$$

and

$$Y = 1 \cdot 39 X' + 3 \cdot 76 \quad \text{for body girth}$$

where Y is the total length of the fish and X and X′ are head and body girths respectively.

Among the siluroid fish catches, *Silonia silondia* formed 83·9%, *Mystus seenghala* 11·8%, *Eutropiichthys vacha* 2·6%, *Mystus aor* 2·4% by weight. The sex ratios of the different species were *S. silondia* 1 (M): 1·96 (F); *M. seenghala* 1 (M): 2·75 (F) and *M. aor* 1 (M): 1·75 (F).

The analyses of the plankton samples of the Tungabhadra reservoir revealed a slight predominance of phytoplankton over zooplankton. The predominance of the phytoplankton was contributed by the blue-green aglae, which showed an enormous increase in June 1961 unlike the previous years and contributed to 58·5% of the phytoplankton. The order of predominance was blue-green algae, green algae, and diatoms. Among the zooplankters, copepods predominated forming 62·4%. The order of predominance was copepods, Rotifera and Cladocera.

The surface temperatures varied between 23° C. and 30·6° C. and the bottom temperatures between 22·6° C. and 29° ·2° C. Thermocline was not observed during any part of the year. pH varied between 7·53 and 8·58 in surface and was almost uniform at all depths, except at bottom (20 metres) in the months February–May when there was a steep fall. Surface distribution of dissolved oxygen showed a double oscillation during the period, one maximum in July (7·85 mg/l) and the other in January (7·85 mg/l) and two minima, one in April (6·95 mg/l) and the other in November (7·10 mg/l). Bicarbonates varied between 35·2 mg/l and 76·5 mg/l,

Carbonates were present during the months of April–June in 1961 and January–March in 1962. The concentrations varied from 4 mg/l to nil. Free carbon dioxide was found at 16 metres and bottom (20 metres) during the months April and May 1961 and February and March 1962. During the other months free carbon dioxide was found at all depths. The distribution of phosphates showed two peaks, one in June 1961 (0·072 mg/l) and the other in March 1962 (0·064 mg/l). Nitrate distribution followed the same pattern as that of phosphates. Concentration of silicates varied between 5·90 mg/l and 8·62 mg/l during the period. It showed a gradual decrease from April 1961 to August 1961 and an upward trend from September 1961 to March 1962.

16. *Investigations on Fisheries of Brackish-water Lakes*

Chilka Lake.—The estimated annual fish production for the Chilka Lake for the period April 1961 to March 1962 was 2881·450 metric tonnes. Of this prawns (28·54%), Mullets (12·56%), Catfishes (13·30%), Clupeoids (11·78%) and Threadfins (10·31%) constituted 76·49% of the total and the rest were shared by Beloniformes (2·87%), Perches (6·21%), Sciaenids (5·28%) and miscellaneous fishes (9·06%).

Mugil cephalus formed 269·47 metric tonnes, *i.e.*, 9·53% in the total annual yield. The size-groups between 250 and 375 mm provided the chief fishery constituting more than 70% of the catch.

Liza trozchellii contributed 35·77 metric tonnes, *i.e.*, 1·26% in the annual fishery yield. December and January were peak months of fishery for this species accounting for a little over 23 metric tonnes. A little over 58% of the catch falls into size-group 240–360 mm (zero-year class).

Hilsa ilisha contributed 107·03 metric tonnes to the annual yield, *i.e.*, 3·78% of the total fishery. The yield was significant in January (22·04 metric tonnes) and May (16·55 metric tonnes). The fishery was poor in July, August and September with an average yield of 0·23%. Little over 67% of the catch of Hilsa are in the size range 200–300 mm.

Nematalosa nasus formed 72·16 metric tonnes, *i.e.*, 2·55% in the total yield. The fishery was significant between February and May contributing 59·03 metric tonnes. The size-group 120–165 mm (zero-year class) dominated the fishery forming little over 67% of the catch.

The threadfin fishery represented by *Eleutheronema tetradactylum* formed 291·58 metric tonnes, *i.e.*, 10·31% in the total fishery. The maximum yield was in August (46·02 metric tonnes) and lowest in May (5·08 metric

tonnes). The size-group 200–300 mm (zero-year class) dominated the fishery forming little over 55% of the catch.

Among catfishes, *Mystus gulio* contributed 292·48 metric tonnes, *i.e.*, 10·34% in the total yield. The fishery of this species was uniformly good during all months with a maximum in June (44·60 metric tonnes) and minimum (6·22 metric tonnes) in October. Over 75% of the fishery was contributed by the size-group 120–165 mm (zero-year class).

Plotosus canius contributed 53·28 metric tonnes, *i.e.*, 1·88% in the total annual yield. Maximum catches were noted in August (13·05 metric tonnes) and June (0·11 metric tonnes). Among other catfishes *Tachysurus arius* contributed 22·53 metric tonnes (0·80% in the total) and *Osteogeneiosus militaris* 12·94 metric tonnes (0·46% in the total).

Among perches *Lates calcarifer* contributed 43·50 metric tonnes, *i.e.*, 1·54% in the total. The fishery was maximum in January (11·35 metric tonnes). Over 19% of the catch was composed of specimens in the size-group 275–400 mm and over 30% from size-group 600–750 mm.

Perches in all contributed 178·58 metric tonnes, *i.e.*, 6·31% in the total annual yield. Of this 41·01% came in January and February. Perch fishery was poor in June, forming only 1·17% in the catches.

Pseudosciaena coibor contributed to 147·90 metric tonnes, *i.e.*, 523% in the total annual yield. The fishery was highest in June (25·10 metric tonnes), but lowest in September (0·11 metric tonnes). Little over 60% of the catch came from the size-group 250–375 mm (zero and I year classes).

Beloniformes was represented by *Tylosurus strongylurus* and *Hemiramphus gaimardia*. They contributed 8105 metric tonnes, *i.e.*, 2·87% in the total yield. Little over 61% of the fishery was during July and August. March was the leanest month, contributing only 2·64%.

Among prawns, *Penaeus indicus* contributed 564·16 metric tonnes, thus contributing the maximum to the fishery of the lake more than any single species either among the fishes or prawns. The percentage contribution in the total yield was 19·95%.

Penaeus semisulcatus was next in importance, contributing 188·44 metric tonnes, *i.e.*, 6·66% in the total yield. The period between April and July contributed to significant catches, *viz.*, 56·05, 38·29 and 21·85 metric tonnes in April, May, June and July respectively.

The outer channel fishery at Arkhakuda contributed 53·422 metric tonnes. Out of the total yearly yield *P. indicus* formed 25667·18 kg *P. semi-*

sulcatus 9697·78 kg, *N. nasus* 9737·00 kg, *Hilsa ilisha* 728·00 kg, *T. arius* 492·66 kg, *L. troscheli* 424·35 kg, *Mugil cephalus* 4769·28 kg, *E. tetradactylum* 428·72 kg, *L. calcarifer* 1170·60 kg, *S. sarba* 122·00 kg and *P. coibar* 6·00 kg.

During the period under report the water temperature ranged between 29·5° C. (in May, June and August) and 20·3° C. (in December) as against the air temperature of 29·3° C. in May and 16·9° C. in December. The pH values ranged between 8·7 and 8·2. The range of water transparency was considerably less in Kaluparaghat 18–33 cm (except October to January when the value was 41–70 cm) but quite high in Rambha (50–143 cm) except in June (28 cm). The impact of monsoon and consequent rain and larger discharge of water reduced the salinity to 2·16–3·98‰ during August–December. The period March–June showed higher values of salinity between 17·06 and 19·48‰. The level of dissolved oxygen remained between 4·9 and 7·5 p.p.m., the lowest in February and highest in October. The alkalinity ranged between 57·7 p.p.m. (August) and 129 p.p.m. (March), showing lower values during monsoon period but higher values in the post-monsoon period. The values of nitrate-nitrogen were 0·067–0·025 and phosphate 0·060–0·027 p.p.m. The value of silica ranged from 1·4 p.p.m. (in February) to 4·5 p.p.m. (in September and October). The maximum was observed during the peak flood period of September and October.

Plankton biomass as an index of productivity, points out that the northern sector is considerably more productive (0·02 ml/l.) than other sectors. Arkhakuda and Satpara show 0·10 ml/l each. The other sectors show lesser values: Lake mouth 0·008 ml/l, Central Sector 0·006 ml/l and Southern Sector 0·004 ml/l.

Studies on bottom zoo- and phytobenthos were initiated in September. As a pilot survey carried out between September and November showed diverse bottom fauna and flora, detailed studies for the entire lake was undertaken. The first series of investigations have been completed and the results indicate that the yield for Southern Sector was 23·1 g per sq metre and for the Central Sector 10·3 g per sq metre.

Consequent to the detailed studies of phyto and zooplankton and phyto- and zoobenthos of the lake, corresponding studies on the mode of utilisation of the organisms by fishes of the lake was taken up periodically by studying the food of fishes from different sectors of the lake. Significant results have been obtained for 44 species of fishes.

The weeds form an important habitatal element of the lake and little is known of their role in the biological complexity of the area. Preliminary observations indicate that aquatic vegetation is more dense on the eastern shore than on the west. *Potamogeton pectinatus* is the dominant element among the weeds on the east shore, while *Gracilaria confervoides* is dominant on the west.

Naias is very prominent in the eastern region. *Halophila ovata*, *Enteromorpha* and *Ceramium* are among other important elements that form the submerged weed population. The middle zone of the lake (200–400 cm depth) is practically devoid of submerged weeds.

Scheme III. Ancillary Projects

17. *Investigations on Fish Pathology*

The etiological agent of the new eye disease of *Catla catla* has been found to be most probably a variant of *Aeromonas liquefaciens*. There have been no indications to show that a virus is associated with this disease. The first symptoms noticed, *viz.*, vascularisation of the cornea and opacity of the tissue, are likely to be due to avitaminosis. The etiological agent was isolated in pure cultures. The bacterium shows considerable variation in form and the colonies grow well in temperatures between 18 and 24° C. are found to be killed in 15 minutes at 30° C., 8 minutes at 35° C., 5 minutes at 40° C. and 2 minutes at 45° C. The organism is gram-negative in staining reaction, motile and flagellated. It stains readily with aniline dyes. The colonies are smooth, spreading, greyish and translucent. The cells vary in size, but appear as short rods, 1·2–2·1 μ long and 0·3–0·7 μ broad.

The etiological agent of Dropsy disease of Indian carps has also been recognised as a bacterium and has been tentatively identified as *Aeromonas*. Cultures prepared from the affected tissues of the artificially infected fish showed the presence of bacteria identical to the inoculated ones.

Dip treatment for 1 minute in a 1 : 2000 copper sulphate solution was found to be the best control method against a type of ulcer disease of fish recorded in a Bheri near Barrackpore. By applying this method it was possible to save many of the affected fish.

Study of parasites of *Hilsa ilisha* from different areas was continued. Percentages of infection in specimens from 2 zones of Hooghly were as follows:—

	Hemi-urides	Fello-destomes	Acanthe-sentis	Cestode cysts	Cestode larvae	Tetra-rhynchids	Copepod parasites
Zone I (upstream of Konnagar)	35	73·2	19	57·5	92·3	7·7	38·5
Zone II (Konnagar to Diamond-Harbour)	43	64·3	Nil	21	57	29	7

To find out the suitability of "Algistat" (an algicide) for use in fish ponds a series of experiments were conducted and it was found that the product is toxic to fish fingerlings at a dose of 0·5 p.p.m. Blue-green algae died within the range of 0·35–0·65 p.p.m., whereas Chlorophyceae were destroyed at levels between 0·5 and 1·0 p.p.m.

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