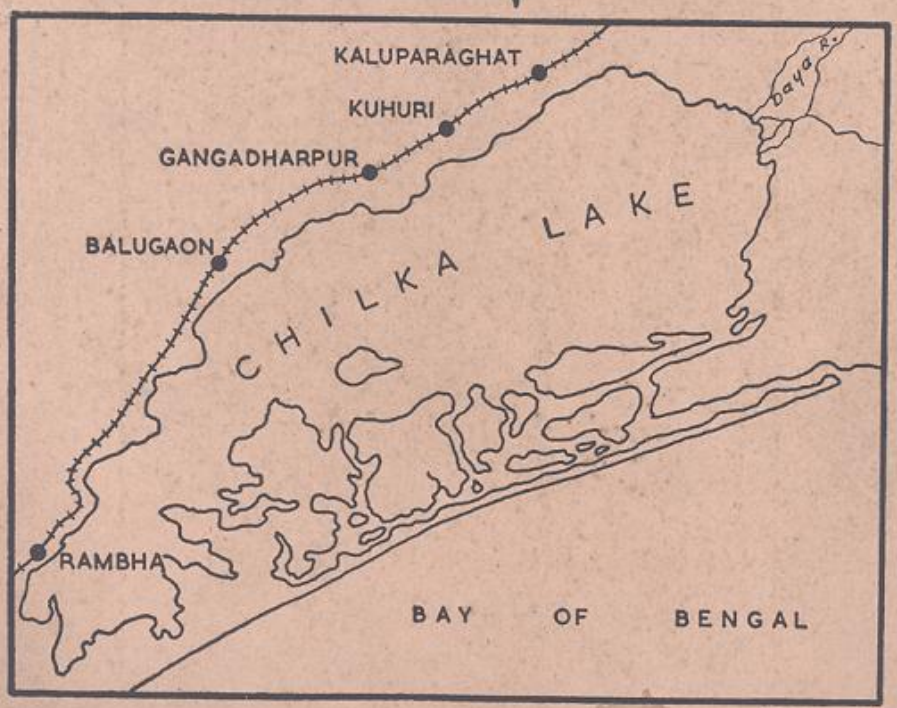
FINAL REPORT
ON THE FISHERIES OF THE CHILKA LAKE
(1957 - 65)



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GOVERNMENT OF INDIA
CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
BARRACKPORE, WEST BENGAL,
INDIA

FINAL REPORT
ON
THE FISHERIES OF THE CHILKA LAKE

(1957-1965)

By

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I N D I A

C O N T E N T S

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1. INTRODUCTION

The Chilka lake is an important source of fish in Orissa, the fluctuations in fish yield of which from time to time, over the years, have caused a suspicion in the minds of fishing industry and administrators whether the fishery resources of the lake are heading towards a depletion. This is, indeed, the starting point of the present investigations by the Chilka Investigation Unit of Central Inland Fisheries Research Institute, Barrackpore, covering a period of about ten years from 1956-1965. The investigations had necessarily to be broad-ranged so that they covered, in their ambit, not only the immediate problem of depletion of fish stocks but also various other biological aspects that would assist in drawing up a long range plan leading to the development of the fisheries of the lake and their conservation. The investigational and methodological details, in the final present report, are kept to the barest minimum, in fact confined only to the extent they assist in full appreciation of the results and findings of the Chilka Investigation Unit. It is hoped that this would help the fishing industry and administrators to get to brass tacks without getting lost in the mire of details.

2. MORPHOLOGICAL AND HYDROLOGICAL FEATURES OF THE LAKE

The Chilka Lake, situated between latitutes 19°28' and 19°54'N and longitudes 85°65' and 85°35'E, is a pear-shaped brackishwater lagoon confluent with the Bay of Bengal and sprawls Puri and Ganjam Districts of the state of Orissa. The lake, shallowed over the years by the silt carrying rivers on the north, chiefly by river Daya, is characterised by loose mud and silty substrata. It has a water spread of 906 sq km in summer and 1165 sq km in flood season. The depth is uneven, the northern part being the shallowest and the southern comparatively deeper. The summer depth is in the range of 0.94-2.63 metres and the depth, in flood season, in the range of 1.78-3.70 metres. The lake has a natural channel of sandy substrata which connects it with the sea after running parallel to the latter for 24.1 km. The lake mouth in the year 1965 was at a distance of 8 km from Arkhakuda, a fishing village on the outer channel, and was only 90 and 130 metres wide just before and at the confluence point respectively, both at low tide.

The salinity of the lake shows extreme annual cyclic changes in the range 0.13-36.02‰. The Northern and Central Sectors go nearly fresh in the flood season and so too the Outer Channel. The salinity starts rising from November-December and reaches its highest values in April-June period. The Southern Sector shows comparatively less fluctuations in salinity where the difference between maximum and minimum over the years studied is about 9.5‰. Both, the river discharge in flood season as well as seawater influx in summer, seem to affect this zone the least. The opening of Palur canal in August, 1964, appears to have had only marginal effect upon salinity in Southern Sector as well as the lake as a whole.

The overall average salinity of the entire lake (including the Outer Channel) has been falling since 1957-58. It was 22.31‰ in 1957-58 and dropped to 13.20‰ in 1960-61. The downward trend continued into 1961-64 period with values fluctuating in the range of 9.14-11.83‰. While the higher figure in 1957-58 may be attributed to drought in 1957, the general downward trend in salinity is unmistakable. It is very likely that the inflow of river discharge into the lake in recent years must have been much higher due to construction of embankments on river Daya preventing spill water over the banks in flood season. A much slower process albeit, the ever-extending Outer Channel with periodic shifting of lake mouth north eastward is another factor that may reduce the lakeward tidal inflow and contribute to the lowered overall salinity.

Among physico-chemical features of the lake the following may be mentioned as their ranges of the respective characters : water temperature, 17.5-32.0 C; dissolved oxygen, 2.6-15.6 ppm; pH, 6.8-9.7; total alkalinity, 25.8-157 ppm; phosphate, trace to 0.18 ppm; nitrate, trace to 0.19 ppm; silica, 0.1-6.0 ppm and iron, trace to 0.52 ppm. Higher values of phosphates, nitrates, silica and iron occurred in monsoon months while that of total alkalinity in summer months.

3. PLANKTON AND BOTTOM BIOTA

The average plankton biomass, as determined for the entire lake during the period 1958-64, was in the range of 0.03-0.27 cc/litre. Two peaks of net plankton production occur, the first around April-August and the second during October-November, the former being the more dominant. The two minima fall in the months of February and August-September. The April-August peak is chiefly contributed by phytoplankton, and that of October-November by zooplankton. The copepods are the chief element among zooplankton and diatoms among phytoplankton. There are 20 species of copepods which are permanent inhabitants of the lake of which 13 are brackishwater species and 7 marine forms. Among the brackishwater copepods mention may be made of following : Pseudodiaptomus annandalei, P. hickmani, P. bingami, Acartia chilkensis, A. southwelli, A. sewelli, Stenhelia inopinata, Laophonte sp, Nitocra spinipes var orientalis, Paracalanus crassirortris, Cyclopina intermedia, Acartiella major and A. minor. The marine copepods are : Isias tropica, Labidocera pavo, Acartia centrura, Oithona brevicornis, O. nana, Paratagestes sphaericus var. similis and Saphirella sp. In flood season fresh water copepods enter the lake and the genera Diaptomus, Cyclops and Mesocyclops may be mentioned under this category. Among diatoms mention may be made of Chaetoceros, Thalassiothrix, Asterionella, Rhizosolenia, Coscinodiscus, Bacteriastrum, Tabellaria and Nitzschia. Some of the diatoms noticed in Central Sector are not autochthonous but physically pushed into the Sector by tidal and wind action. It is perhaps one of the reasons why there are certain common diatoms between the Outer Channel and Central Sector. Dinoflagellates, the third important element in plankton, occur significantly in summer months in the Outer Channel with phytoplankton but not in succession as is commonly supposed. They are represented by Ceratium and Peridinium.

In order to understand the benthic constituents of the lake, its bottom biota with special reference to its sectoral and seasonal abundance and role in the food chain of the fishes was studied. The bottom biomass was exceptionally rich (Grade I) with an annual average of 18.28 gm/sq m in Central Sector, 'average rich' (Grade II) with 13.81 gm/sq m in Outer Channel, 'average rich' with an annual average of 11.10 gm/sq m in Northern Sector and 'average rich' with an annual average of 11.09 gm/sq m in the Southern Sector. Foraminifera, nematodes, polychaetes, copepods, ostracods, isopods, amphipods, gastropods and lamellibranchs among zoobenthos and algae and diatoms among phytobenthos formed the components of bottom biota with some sectoral variations.

4. ALGAE AND LARGER AQUATIC PLANTS

The lake favours the luxuriant growth of algae. Among algae, the red algae represented by Gracilaria lichenoides and G. confervoides are of commercial interest as they form the basic material of agar agar. They are distributed all along the western shore of Central and Southern Sectors of the lake, near Gurubai, Sidua Nadi and in the shallow regions of Morai and Kampan Jano on the eastern side, and around Kalijai and Barakuda island and Samal island. An estimate of the abundance of Gracilaria indicated that it formed 8-25 gm/sq m in the Southern Sector and 8-29 gm/sq m in Central Sector. The green algae is well represented by Spirogyra, Enteromorpha and Chaetomorpha, while bluegreen by Lyngbya.

The larger aquatic plants, represented by submerged phanerogamic vegetation, occupy an important place in the eco-complex of the lake and their role, in an indirect form, namely detritus, has an important place in the food of fishes. The western shores generally favour denser growth of larger aquatic plants, they intrude upto 13 km (i.e. upto Tua nali) in the Northern Sector and about 2 km or so in the narrow Southern Sector. The islands like Nalban, Kankarkuda, Samal, Barakuda and Chiraigua also favour satisfactory growth. The annual average yield was estimated at 518-565 gm/sq m in respect of Potamogeton pectinatus, 77-104 gm/sq m for Najas falcioulata and 34-47 gm/sq m for Halophila ovata.

5. FISHING GEAR OF THE LAKE

Detailed investigations of the gear of Chilka Lake revealed considerable terminological and nomenclatural synonyms and antonyms and required to be clarified. The studies indicated 15 well-defined gears classifiable under three major heads, viz. (1) Drag net (with and without bag), (2) Gill net (with and without foot rope) and (3) Cast net (with and without strings). That as many as 54 names exist to denote the above 15 gears may give an idea of the extent of nomenclatural confusion. The names of standard gears are (i) bekti jal, bhida jal, hilsa jal and patua jal - all drag nets with bag, (ii) borogo jal, khadi jal, muni jal and small units of patua jal - all drag nets without bag, (iii) dosti jal, menjia jal, ora jal and sahal jal - all gill nets with foot rope, (iv) noli jal - gill net without foot rope (drift net), (v) khepa jal - cast net with strings, and (vi) khepa jal - cast net without strings. Either hemp or cotton usually form the webbing material in drag nets and gill nets, depending upon the species which the net is made to catch.

5.1 Mode of fishing

The fisheries of the Chilka Lake are exploited by (i) net fishing (ii) large impoundments constructed with split bamboos in shallow regions, known locally as janos, and (iii) traps. The second and third modes of fishing are seasonal while net fishing goes on throughout the year with varying intensity.

5.1.1 Net fishing

The net fishing contributes about 50-66% of annual production of Chilka Lake. Investigations reveal that patua jal followed by khadi jal and menjia jal are the most effective gears in the lake catching 40.6%, 23.7% and 11.4% of catches taken by net fishing. Amongst the rest, borogo jal, bhida jal and noli jal closely follow, in sequence stated, taking 6.6, 5.6 and 5.5% of the catches.

Patua, khadi, bhida and menjia jals catch all fish in general without showing any marked species preference. Noli jal is more selective in respect of mullets and balangi. Bekti, borogo, hilsa and sahal jals are more selective in respect of fish after which they are named. Khepa jal is very effective for balangi, kabla and sahal in addition to other fishes.

The percentage of different economic species in the total all net catch is borogo, 9.8%; kabla, 7.5%; sahal, 6.9%; balangi, 5.3%; hilsa, 4.4%; kantia, 4.6% and kantla chinguri, 3.6%. Miscellaneous fishes (49.8%) occupy an important place in net fishing.

Net fishing intensity greatly varies during the course of the year and some experimental observations indicate the following : 8.9% in January; 12.4% in February; 9.3% in March; 8.2% in April; 8.9% in May; 7.7% in June; 7.5% in July; 13.0% in August; 10.5% in September; 3.8% in October; 4.9% in November and 4.6% in December.

5.1.2 Jano fisheries

A total of 112 janos are exclusively leased out fisheries in the Chilka Lake. Between 13 and 22% of the catches of the lake are accounted by this mode of fishing. Though it takes a wide variety of fishes, M. cephalus and L. macrolepis are the important among jano catches accounting in certain years well over 80% of the catch. Among others, mention may be made of M. gulio, L. calcarifer, G. setifer, E. tetradactylum and among penaeids, P. semisulcatus.

5.1.3 Prawn trap fisheries

A total of 67 prawn fisheries, like janos, are exclusively leased out fisheries. Trap fisheries account between 19 and 32% of total fish production of the lake. Among species components, P. indicus constitutes 62-74% of the trap catch; P. semisulcatus, 8-33%; M. monoceros, 3-26% and M. dobsoni 0.1-8%.

5.2 Catch per unit of effort

The catch per unit of effort is a conventional study in fisher investigations, which provides a useful index of fish abundance and which, in turn, is used in deriving certain population parameters. Detailed observations were made on bekti jal, bhida jal, hilsa jal, borogo jal, khadi jal, muni jal, patua jal, menjia jal, sahal jal, noli jal and khepa jal. In all these nets, studies revealed a wide array of meshes which were seriated for each net in 5 mm class intervals. The study of catch per unit of effort for each of these mesh intervals for each net would have been a colossal task in terms of available staff and was, therefore, not undertaken. However some observations made on certain gears per mesh interval may be mentioned. These, however, failed to throw any light on fish abundance.

Gear	Mesh	Catch per man hour in kilograms
Khadi jal	11-15 mm	0.221-0.435
	16-20 mm	0.437-0.609
	21-25 mm	0.229-0.415
Menjia jal	31-35 mm	0.207-0.428
Patua jal	6-55 mm	0.593-0.790

A pooled catch per man hour per net head is present below :

Net head	Catch per man hour in kilograms
Drag net	0.359-0.642
Gill net	0.250-0.663
Drift net	0.436-0.531

Topograpically restricted operations in certain cases, too many species taken in different gears, net length unrelated to man power employed and mesh variability, together with the migratory movements of the stocks, greatly vitiated the results of catch per unit of effort from rigid theoretical considerations. They are at best useful economic indices. Two jals, namely bekti jal and bhida jal were however further examined because among the jals these two, at least, fulfilled certain theoretical conditions including 'sweep of fishing grounds' and 'unit concept'. The analyses was based on catch (in kg)/105' of jal length/7 hours in case of bhida jal and catch (in kg)/234' of jal length/7 hour for bekti jal. The bag mesh in both cases were considered critical, 20 mm in the case of bhida jal and 40 mm for bekti jal, both being meshes commonly employed. The estimated total nominal effort in the case of bhida jal is 106215 units and estimated catchability 0.00000123. In the case of bekti jal the estimated total nominal effort was 415735 units and estimated catchability 0.00000209. As the total mortality is fairly high, it is assumed that natural mortality is marginal and is omitted in the present calculations.

For fishery administrators interested in conservation/ development measures, a knowledge of mesh variability in gears which causes size selectivity in fishes would be useful and they are given as under:

Name of the net	Mesh range (mm)	Number of 5 mm classes
Bhekti jal	61-115	13
Bhida jal	16-125	15
Khadi jal	6- 65	10
Borogo jal	21- 45	4
Hilsa jal	26- 65	5
Patua jal	6- 55	1
Menjia jal	26- 45	4
Sahal jal	46- 60	3
Noli jal	16-125	21
Khepa jal	166- 65	10
Muni jal	6- 25	4

6. TAGGING OPERATIONS IN CHILKA LAKE

Tagging experiments were attempted on commercial fishes in 1957 and 1959 using Peterson type of tag and celluloid streamer tag respectively. The celluloid streamer tag was found extremely effective and least harmful to fish. In all six species were tagged. The numbers tagged were 998 in 1957 and 6712 in 1959.

Rate of exploitation which forms one of main aims of tagging operation however could not be realised due to only partial reporting of recovered tagged fish. The recovered percentage upto 31st December 1961 of the fish tagged in winter months of 1959 was : 8.6% in the case of M. cephalus, 6.3% in L. macrolepis, 7.9% in E. tetradactylum, 6.3% in L. calcarifer, 2.02% in S. sarba and nil in P. coibor. No tagged fish were reported after 31st December 1961. Since the extent of recovered fish unreported is unknown no attempt is made here to discuss further regarding fishing mortality.

Among the useful biological information obtained from tagging experiments mention may be made of the following in the case of Mugil cephalus :

i) The average rate of growth was 8.5 mm per month during the period November 1959 to April 1960 as against an average estimated growth rate of 12.5 mm per month between first and second year classes.

ii) Directional movements of tagged specimens show, in most cases, a convergence of fish to certain areas (where janos are located) for feeding and, in certain others, dispersion to remote areas of the lake suggesting homogeneity of stocks which is an important prerequisite in the derivation of certain population parameters.

iii) Maturing M. cephalus undertakes seaward breeding migration mostly during the period October to December. Females attain maturity at the end of second year of life and the males at the end of first. After the exit of maturing or mature specimens into the sea, largely first year females stay behind in the lake.

7. FISHERY AND BIOLOGY OF COMMERCIAL FISHES

Under this head the fishery and biology of 16 commercial fishes are briefly discussed. Certain aspects on population have been taken up under "Recommendations on the development of the fisheries of Chilka Lake".

7.1 Mugil cephalus Linnaeus or 'koinga' or 'kabla'

The fishery of kabla during 1957-66 period fluctuated in the range of 181-893 tonnes, with the average annual yield during the period at 476 tonnes.

The chief gears that capture this fish are janos, khadi, khepa and noli jals, the last three respectively accounting 17.3%, 20.7% and 45.5% in their total landings.

The fish in the size range 201-350 mm formed 62-92% and the size range 351-500 mm formed 3-33% in the catch of janos. Khadi jal and patua jal account for a large portion of small size kabla up to 200 mm in April-September period. The size range 200-500 mm are taken by ncli, menjia, hilsa and bhida jals and the size range 501-625 mm by patua and noli jals.

The fishery is sustained by three year classes of which the third is only of nominal interest. The fish reaches approximately 201-350 mm in the I year, 351-500 mm in the II year and 501-625 mm in the III year.

Kabla performs seaward migration in October-January period for breeding. Females mature in II year and males in I and they both participate in the seaward migration, the first year females, however, stay behind in the lake. Migrating female and male show reduction in average sizes as the season progresses : from 538 to 493 mm in the case of females and from 396 to 357 in the case of males. Regular lakeward influx of fry of 22-24 mm have been observed at the lake mouth during November-February. Influx of fingerlings has been noted in spring and subsequent months. Some very large kabla also appear to move into the lake after breeding during June-August.

Mullet eggs were found dominantly in the gut contents of Ambassis gymnocephalus. As these fish tend to form shoals they may cause considerable mortality to developing eggs.

For other details of biology, reference to chapter 'Tagging operations in Chilka Lake' may be made.

7.2 Liza macrolepis (Smith) or 'Dangla'

Dangla occupies the second place next to kabla in the mullet yield. The average annual yield during the period 1957-65 was 114 tonnes but showed wide fluctuations in the range of 27-299 tonnes.

Among gears that take this fish, janos, khadi jal and noli jal are important, the last two taking 3.6% and 5.9% respectively. In the jano catches, dangla of the size range 151-260 mm form 45.1-96.93% of the size range 261-420 mm, 1.02%-50.8%; and, of the size 390-490 mm, 1.92-16.39%. Khadi and patua jals take small sized fish up to 150 mm in large numbers in July-September. All sizes above 150 mm occur in noli jal. Bhida and hilsa jals catch large fish during April-June.

The fish reaches 170-260 mm in I year, 310-350 mm in the II year, 410-450 mm in the III year, 490 mm in IV year and 550 mm in the V year. Only the first three year classes contribute substantially to the fisheries.

Males appear to reach maturity in the II year though a certain percentage of mature individuals was noted in the I year of their life. Females mature in III year. Peak seaward migration of this species occurs in December-January. Completely spent large-sized specimens of dangla are not uncommonly encountered in the Outer Channel area during January-March. The breeding is close to the lake mouth where thousands of developing eggs of this species have been taken in tow net collections. Huge waves of lakeward moving 10-12 mm long fry of dangla have been noted in the lake mouth in January.

Algae appear to form a favoured food of this species.

7.3 Eleutheronema tetradactylum (Shaw) or 'Sahal'

The average annual yield over the period 1957-65 was 236 tonnes and the fishery fluctuated in the range 122-364 tonnes, the former in 1964 and the latter in 1959.

Patua, khadi, bhida, menjia and noli jals are the principal gears which account in their total catch 6.7%, 6.1%, 15.0%, 9.0% and 6.1% respectively. Janos and khepa jal also take the fish variously.

Sahal is believed to breed in the Northern Sector near the mouth of river Daya during Januaty-June with two peaks of breeding

in March and June. The occurrence of eggs, pro-larvae and post-larvae of sahal in this sector also appears to confirm the above. The size at maturity is 243 mm in males and 285 mm among females. The March brood attains a length of 300 mm, 475 mm and 600 mm in the first three years and the June brood 263 mm, 430 mm and 570 mm at the same ages.

The food of sahal consists of prawns (49.5%), fishes (26.1%), mysids (9.8%), stomatopods 2.9%, isopods (2.1%), amphipods (1.3%) and miscellaneous matter.

Spent and mature, largesized specimens of sahal are encountered both in the lake and the Outer Channel which suggests that the fish breeds in the sea as well as the lake and performs inter sea-lake movements. Of the 544 fish tagged (small size groups), 43 recoveries were made but all inside the lake.

7.4 Hilsa ilisha (Hamilton) or 'Ilish'

The average annual yield during the period 1957-65 was 142 tonnes but Hilsa fishery showed extreme fluctuations in the range of 30-293 tonnes, the former being the catch in 1965 and the latter in 1963.

The hilsa jal (a variant of bhida jal) and bhida jal together account for 89.5% of this fish in their total catch. Sahal jal takes 5.7% and menjia jal 5.6%. Patua and menjia jals take 68.3% and 38.9% of the zero year class respectively; menjia jal and noli jal, 36.0 and 22.0% of the first year class; bhida jal, hilsa jal, noli jal and menjia jal, 67.7%, 63.8%, 74.2% and 22.8% respectively of the second year class; hilsa jal and bhida jal 24.9% and 19.4% respectively of the third year class and hilsa jal 4.2% of 3 year class and above.

Zero to third year class of Hilsa have been estimated to grow 150 mm, 265 mm, 350 mm and 420 mm respectively.

Pro-larvae and post-larvae of this species were collected in large numbers between August and November in the lower and middle reaches of the Daya river. The dominant sizes that participate in breeding are 350-375 mm in the case of males and 400 mm in the case of females. Mature females measure 200-300 mm and mature males 175-300 mm. The indications are that 200-300 mm long female may not spawn. Two waves of migration, one in winter/spring and the

other in monsoon months, are perceptible. Statistical tests carried out between winter/spring and monsoon samples do not indicate any difference between these two migrants indicating their homogeneity.

Gut content study of Hilsa indicates 31.7% copepods, 32.0% organic detritus, 17.5% prosobranch and lamellibranch larvae and 9.1% mysids. In addition, diatoms, rotifers, algae and sand and mud also occurred in the diet.

7.5 Nematalosa nasus (Bloch) or 'Balangi'

The fishery of this species fluctuated in the range of 55-199 tonnes during 1957-1965 with the annual average at 141 tonnes.

Balangi is largely caught by net fishing. Menjia, patua, khadi and noli jals take 30.3%, 28.7%, 15.4% and 11.5% respectively in their total catch.

Balangi breeds in the Southern Sector of the lake in the shallow sandy areas at its eastern end. Pelagic eggs and larvae referable to this species have been collected in this sector. The breeding season extends from February-July, the peak period being June-July. Ripening adults of balangi enter the lake from the sea during January-June and this behaviour of the fish is made use of by the fishermen to capture them in large numbers at the lake mouth. The minimum size at maturity in the case of male is 124 mm and of female 116 mm. The fish attains a size of 135, 215 and 260 mm at the end of first three years. The maximum length occurred in the catch was 328 mm and the minimum 53 mm.

Balangi feeds on decayed organic matter (63.5%), copepods, conchostracans, etc. (11.9%), diatoms (4.5%) and algae (3.6%).

The fishery is chiefly sustained by three year classes. The 'fish of the year' start appearing in the catch from August.

7.6 Mystus gulio (Hamilton) or 'Kontia'

Kontia fishery fluctuated during 1957-65 in the range of 199-485 tonnes with an average annual catch during the period at 311 tonnes.

Kontia is captured in janos as well as net fishing. The shallow regions inundated either by wind or by flood waters are

bunded and the fish are caught significantly in areas of Mangala Jodi, Panidwar, Balinasi and Bushandpur. Patua jal takes 7% and khadi jal 7% in their total catch.

Kontia breeds throughout the lake during the period June-November, August being the peak breeding month. In departmental nets, juveniles in the size range of 15-53 mm occurred during July-November in the Central, Outer Channel and Northern Sectors.

The fish attains approximately 125-140 mm in the I year, 175-195 mm in II year and 225-235 mm in the III year.

Kontia feeds on amphipods (30.8%), prawns (13.1%), algae (12.6%), detritus (8%), higher plant matter (5.3%), fish (4.8%), mysids (3.8%), gastropods (3.6%), isopods (3%), insects (2.3%), copepods (1.7%), lamellibranchs (1.3%) and miscellaneous items (32.3%).

Kontia is endemic to the lake and is not known to perform any lake-sea migrations.

7.7 Tachysurus arius (Hamilton) or 'Singda'

The fishery of singda fluctuated between 13-66 tonnes during 1957-60 with an annual average catch at 44 tonnes.

It forms 1.3% of net catch in bhida jal. It also occurs variously in khadi, patua, noli, menjia, borogo, khepa and sahal jals and hook and line. It is also caught in janos in their terminal phases of operation.

Singda breeds in the Northern and Central Sectors of the lake in June-September with July as peak month. The species shows buccal incubation with male tending the developing eggs. Minimum size at maturity recorded for the females was 238 mm.

Zero to three year classes of singda attain a length of 140 mm, 250 mm, 325 mm and 400 mm respectively by December. The overall average length in the commercial catches was in the range of 264-303 mm.

Singda feeds on lamellibranchs (23.3%), prawns (18.3%), detritus (17.9%), annelids (8.5%), higher plant matter (6.4%), fish (6%), crabs (5.5%), and other miscellaneous matter (14%).

Large catches of singda are made in the lake mouth in January, February and July. The species is believed to enter the lake from the sea and add to Chilka stocks.

7.8 Osteogeniosus militaris (Linnaeus) or 'Sunga'

Sunga fishery fluctauted in the range of 12-73 tonnes in the years 1957-60 with an annual average at 42 tonnes.

The fish occurs in janos, nets and hook and line. It forms 3.1% of bhida jal, 3.1% of khadi jal, 1.2% of patua jal and 1.4% of sahal jal in their respective total catch. It also occurs in noli, menjia and hilsa jals variously.

Sunga breeds in the Northern and Central Sectors of the lake during January-June, March and April being peak months. The species shows buccal incubation with the male tending the developing eggs. The minimum size of mature female recorded was 265 mm.

Sunga appears endemic to the lake and no sea-lake migration is perceptible.

7.9 Plotosus canius (Hamilton) or 'Kamda'

The fishery of Kamda fluctuated in the range of 22-59 tonnes during the period 1957-60 with an annual average at 34 tonnes.

The fish occurs in janos, nets and hook and line. It forms 1.5% of the catches of bhida jal and 1.7% in khadi jal in their respective total catch. It also occurs variously in patua, noli, menjia and khepa jals.

The fish breeds in the Northern and Central Sectors of the lake in May-September, July being the peak month of breeding. The minimum recorded size of mature female was 400 mm. The fish appears endemic to the lake and no lake-sea or vice versa migration is noticeable.

7.10 Pseudosciaena coibor (Hamilton) or 'Borogo'

The fishery of this species fluctuated in the range of 103-294 tonnes during 1957-65, the former in 1962 and the latter in 1964. The average annual yield during the period was 198 tonnes.

Borogo is taken in janos, hook and line and nets, the last being the most important. Borogo jal accounts for 79.8% of the catch, bhida jal 8.3%, khadi jal 3.5%, patua jal 5.5%, noli jal 4.2%, menjia jal 3.9%, bekti jal 4.6%, hilsa jal 6.0%, sahal jal 6.7% and khepa jal 1.3%, all in their respective total catches.

Norther Sector of the lake, especially Tuanali near Daya, appears to form the breeding ground of this species. April-July is the breeding period with May as peak month. Developing eggs, agreeing with oozing eggs of this species, have been collected in the Northern Sector. Fry and fingerlings of borogo are available in very large numbers during July-September in Northern Sector. The minimum size at maturity is 176 mm in the male and 213 mm in the female.

The fish attains a length of 238-263 mm in its first year, 363-388 mm in second year, 463 mm in third year, 563 mm in fourth year and 638 mm in the fifth year.

The fish feeds on prawns (35%), fish (20.7%), amphipods (15.1%), isopods (8.2%), stomatopods (6.1%), detritus (4.1%), higher plant matter (2.5%), algae (2.2%) and miscellaneous items (4%).

No lake~~-~~sea or vice versa migration is perceptible in this species.

7.11 Lates calcarifer (Bloch) or 'Bekti'

The fishery of this species has shown wide fluctuation in the range of 55-749 tonnes, the former (all time low) in 1961 and the latter (all time high) in 1964. The average annual yield during 1957-65 was 204 tonnes.

The fish is captured both in janos and nets, the latter being the more important. Bhida jal takes 11.0% of this fish in its total percentage, bekti jal 59.3% and khepa jal 6.1%. It is also taken variously in khadi, patua, noli and menjia jals.

The breeding season appears to be March-July. Mature specimens in III year class are common. Certain percentage of II year class also appears to mature late in the season. Large specimens (over 625 mm total length) in ripe condition are encountered in the lake mouth area in May and June. Advanced fry were noted in lake mouth area during July-August. 'Fish of the year' occur in commercial catches in fair numbers in September-October. The fish performs

sea-lake and vice versa migration for feeding and breeding respectively. Some of the small-sized tagged specimens were recovered only from the lake. However, the number tagged was small and recoveries only a few.

The fish attains a length of 400, 550, 688 and 800 mm in the first four years of its life. The first two years, however, show variations in certain years; 265-365 mm in I year and 465-565 mm in II year.

The fish feeds on fish (51.2%), prawns (39.3%), stomatopods (7.0%) and miscellaneous matters including weeds (2.5%).

7.12 Gerres setifer (Hamilton) or 'Jagli'

The fishery of this species fluctuated in the of range of 16-8 tonnes during 1957-65 with the average annual yield at 45 tonnes.

The fish is taken in janos as well as nets. A type of scare line with hanging palm leaves is also employed to capture this fish. The fish forms 3.1% of total catch of khadi jal, 2.3% in bhida jal and 1.2% in menjia jal. The fish is also captured in patua, noli and khepa jals.

The fish breeds in the Southern Sector of the lake in the shallow sandy areas at the eastern end. The breeding season extends from May-August, the peak month of breeding being June. The minimum recorded size at maturity of males and females are 73 and 86 mm respectively. The fish attains 110 and 175 mm in the first two years In certain years a clear mode in the range 53-83 mm indicates that it pertains to the first year class.

The fish feeds on crustaceans (42%), molluscs (31%), algae (6%), decayed organic matter (13%) and miscellaneous matters (8%).

The peak landings in certain months namely April, May, September and November which are variable between years, indicate a lakeward incursion of this species in these months.

7.13 Etroplus suratensis (Bloch) or 'Kundal'

The fishery of this species fluctuated in the range of 32-222 tonnes during 1961-65 with average yield at 108 tonnes. The fish is more abundant in monsoon and winter months in commercial catches. Northern and Central Sectors sustain the fishery.

The fish occurs in janos and nets, the latter being important. Patua, khadi, noli and bhida jals take substantial catches. Juveniles are captured in large numbers by patua jal and khadi jal from April-July and September-November.

The fish breeds all the year round with two peaks, one in December-February and the other in April-May. During the breeding season the fish settles itself in the weedy areas at an average depth of 60-100 cm in the western shores of the lake and breeding grounds are located off Kaluparaghat, Ghoradawda, Nairi, Balugaon, Barkul, Jatia and Palur Canal. The fish starts maturing at lengths above 105 mm.

The fish reaches 105-125 mm in the I year, 175-185 mm in the II year, 235 mm in III year and 265 mm in the IV year. The maximum observed length of the species was 305 mm.

The fish feeds on weeds (48.03%), algae (11.93%), detritus (34.10%), gastropods (3.6%) and other miscellaneous matters comprising bivalves, insects, mysids. Sand and mud are also encountered in stomachs. Among larger aquatic plants, Potamogeton, and the algae, Spirogyra and Lyngbya are greatly favoured.

7.14 Sparus sarba (Forskal) or 'Dhala kuranti'

The fishery of this species showed extreme fluctuation in the range of 2-165 tonnes during 1957-65 with the average annual yield for the period at 91 tonnes.

The fish occurs in janos (Morai Jano chiefly) and is also taken by nets and hook and line. Towing shark carcass as well as use of black earth are some of special methods also used in the capture of fish in the lake mouth region. Bhida jal takes in its total catch 3.2% of this fish. Khadi, patua, noli, menjia and bekti jals also capture this variously.

Khuranti breeds in the sea, perhaps in the vicinity of lake mouth during November-January, the peak month of breeding being December. Mature adults occur in very large numbers in the vicinity of lake mouth and in the Outer Channel generally. A few khuranti tagged at Morai Jano were recovered close to the lake mouth indicating sea breeding. Fry and fingerlings of khuranti were observed in the lake mouth region during January-May. Sizes from 90 mm upwards start

appearing in the catch in the lake, indicating juvenile incursion into it. It is very likely that this species may get acclimatised to lake conditions. Adult incursion into lake in winter months is also a possibility in this species in addition to lake grown adults going into sea for breeding.

The fish reaches 175 mm in first year, 250 mm in second year and 325 mm in the third year.

Khuranti feeds on algae (31%), molluscs (20%), crustacea (17%), organic detritus (12%), larger aquatic plants (11%) and miscellaneous matter (11%).

7.15 Crenidens crenidens (Forskal) or 'Haribolia khuranti'

This species had only a 'record status' until 1957 but came to limelight in 1962-63 when it formed a fishery of 92 tonnes. Its abundance, however declined in subsequnet years. Some observations made in 1962-63 indicate that the fish may grow upto 165 mm in I year, and 270 mm in II year. Specimens upto 300 mm have been observed in the catch. Out of 400 specimens examined for biological studies, the sex ratio of male to females was 9:10. Mature individuals have been observed in winter months generally in the lake mouth and Outer Channel. It is taken in Morai Jano and by rod and line. The minimum size at maturity is 128 mm among females and 120 mm among the males. Breeding may be in the sea in the vicinity of lake mouth. The fishery is composed chiefly of I year group. The fish feeds on algae (35%), decapod larvae (30%), copepods (10%) and diatom (25%). In specimens sampled at Morai 100% of gut contents showed Potamogeton.

7.16 Penaeus indicus (Milne Edwards) or 'Kantla chingudi'

The fishery of P. indicus fluctuated in the range of 385-978 tonnes during 1957-65 period with average annual yield at 665 tonnes.

The chief gears which catch the species are 'boza' and 'daudi' among traps and khadi jal among nets. It is also taken by janos and patua jal. Khadi jal takes as much as 12% of this prawn in its total annual catch. The maximum catches occur in March-August period in traps chiefly concentrated on the eastern shores and especially dense in the Mugger Mukh and vicinity.

The post-larvae occur fairly throughout the year. Two peaks are likely, one around February-May and the other August-September

or even later. The main fishery of the Chilka lake in March-August seem to be contributed by the latter brood and is referred as 'primary brood' and February-May brood as 'secondary brood'.

The primary brood reaches a size of 65-95 mm in February/March. The brood leaves the lake by July or August when they reach a size of 100-115 mm and when the salinity of the lake is suddenly lowered due to floods. The seaward movement of the prawn of this brood thus appears salinity-oriented.

The secondary brood reaches a size of 75-95 mm in August/ September. They reach a maximum length of 105-120 mm by December. They are observed in the catch up to April in certain years but chiefly their 'run' is over by February. Here the bigger size groups leave first from December (unlike 'primary brood' where the earlier size groups leave first) probably seeking warmer waters i.e. towards sea. They are followed by smaller groups. The movement, in this brood, thus, appears temperature-oriented.

The primary brood reaches about 65 mm in about 5 months at the average rate of 13 mm per month and reaches 105 mm in about 9 months at the average rate of about 12 mm. Its life in the lake ranges from 5-10 months. In the case of secondary brood the rate of growth is 15 mm per month upto 75 mm. The rate of growth from 75-120 mm is 11 mm per month.

The dominant item of food is detritus, followed by plant matter, molluscs, crustacean remains, algae, diatoms and sand.

The entire Outer Channel plus the area around the head of channel seem to form suitable substrata for benthic life of the post-larvae before dispersion.

In general the chingudi catches in the post full and new moon weeks are the heaviest.

7.17 Penaeus semisulcatus (De Hann) or 'Bagda'

Bagda fishery showed fluctuation in the range of 84-485 tonnes during 1957-65 with average annual yield during the period at 246 tonnes. The peak landings generally occur between April and August but vary from year to year.

The mode of capture is the same as that for P. indicus. In addition, thatta kantha, a kind of pound trap also takes bagda significantly.

Like P. indicus, the lakeward movement of post-larvae of bagda also occurs throughout the year with likely peaks in Janua April and June-October. The participation of at least two brood is perceptible in bagda also. The June-October brood is termed 'primary' as it contributes chiefly to April-September fishery a January-April brood as secondary. The pattern, thus, appears su tantially similar to P. indicus.

The primary brood grows to a length of 135 mm in six month at the average rate of 22 mm per month. It reaches a length of 175 mm at the average monthly rate of 15 mm indicating that avera rate of growth drops considerably during the second six months. The brood lives in the lake between 6 and 12 months. By the time they are 10 months old they migrate back to sea in fairly large numbers. The rate of growth of the individuals comprising 'secon brood' is more or less the same as that of the primary. The trap in individuals (the individuals washed down southwards in the onru of flood waters and which could not find their way to sea) in southern zone stay for longer period. They reach a size of 205 mm in 14 months.

The dominant item of food is detritus, followed by molluscs plant matter and sand.

Significant catches occur on new moon day and upto 5 succee- ding days. Fourth day to seventh day from full moon also appears productive.

7.18 Metapenaeus monoceros Fabr.

The fishery fluctuated in the range of 17-237 tonnes during the period 1957-65 and the average annual yield was estimated at 84 tonnes.

The mode of capture is the same as that for P. indicus and P. semisulcatus.

During fishing season (March-September) they were found in the size range of 50-100 mm. During the period July of September (after floods have commenced), they were captured in good numbers in the Outer Channel and the migrating mode values ranged from 65- 105 mm. The common modes noticed in lake catches ranged from 60- 90 mm but in Southern Sector a higher mode at 105 mm is noticeable.

The food of this species chiefly comprised detritus, small crustaceans and molluscs.

7.19 Metapenaeus dobsoni Miers

The fishery fluctuated in the range of 3-158 tonnes during 1959-65 with average annual yield at 38 tonnes.

The mode of capture is the same as described for other prawns. During prawn season it is observed that sizes ranged from 40-100 mm generally, with a mode around 60 mm.

The species occurs in the catches in Outer Channel between January and April with a mode at 60 mm. This perhaps represents migratory movement. They again occur after floods furnishing more or less the same modal values.

The food consists of detritus and small crustaceans.

The breeding in the case of Metapenaeus spp. appears extended with peak during January-June and again in October. They are well represented in night collections in surface hauls. In the case of P. indicus and P. semisulcatus, day hauls are preferrable.

8. FISH EGGS, LARVAE AND JUVENILES

Data on fish eggs, larvae and juvenile of 35 species have been collected. Here a brief account is given only on commercial fishes and on a few others which are caught in appreciable quantities and have some worthwhile value in lolcal markets. The information furnished will help locating seed collection centres, if necessary.

Liza macrolepis : The lake mouth and inshore waters adjoining lake mouth form the breeding ground of dangla. The developing eggs, measuring 0.658-0.732 mm, with a large oil globule, verily clogged townet collections in November and December near lake mouth. Waves of shoals of fry of this species measuring 10-12 mm were observed in January in lake mouth and in Rushikulya estuary in February also.

Mugil cephalus : Like dangla, the best fry collecting ground of kabla is also lake mouth where vast shoals of fry measuring 22-24 mm have been observed from middle of October to the end of February. Some eggs referrable to this species have been collected in Outer Channel but the identity requires further confirmation.

Liza corsula : Eggs measuring 0.81-1.00 mm and post-larvae of 4.5-19 mm size occurred in July-September in Tua nali near Daya mouth and juveniles of 20-50 mm in September and December.

Eleutheronema tetradactylum : Eggs measuring 0.72-0.99 mm with a large oil globule and referrable to this species have been collected in large numbers in Tua nali off Borokudi village and near Daya mouth during December-June. Pro-larvae and post-larvae were also observed. Juveniles of 50-130 mm occurred between April and October in Departmental nets as well as in commercial patua jal. These observations do not foreclose breeding in coastal waters.

Hilsa ilisha : Pro-larvae measuring 4.5-9 mm and post-larvae in the size range of 9.5-32 mm occurred in the collections during August-November in the lower and middle reaches of Daya. Developing eggs, however, occurred only sparingly. Juveniles of the size range 31-90 mm have been observed in patua jal catch in November-January inside the lake.

Nematalosa nasus : The eggs of this species measuring 0.91-1.17 mm and larvae of the size range of 2-5.5 mm occurred in tow net in Southern Sector off Kumarpur, Chikalkhani and Samalnasi. Juveniles

of the size range 45-60 mm sparingly occurred in Departmental nets.

Anchoviella spp. : The characteristic ellipsoidal eggs of this genus as well as larvae and juveniles occurred practically throughout the year both in the main lake and Outer Channel.

Thrissocles spp. : Eggs, larvae and juveniles occurred practically during most part of the year in the main lake and Outer Channel.

Mystus gulio : Juveniles in the size range of 15-53 mm occurred during July-November in Central and Northern Sectors and Outer Channel.

Plotosus canius : Juveniles of the size range 25-53 mm occurred in Northern and Satpara Sectors.

Tylosurus strongylurus : The pro-larvae of the size range of 6-8 mm, post-larvae of 9-22 mm and juveniles of 24-70 mm occurred throughout the year in the main lake and Outer Channel.

Hemirhamphus gaimardi : The larvae of this species and juveniles of 25-65 mm occurred practically throughout the year in all parts of the lake.

Lates calcarifer : Advanced fry are encountered in the lake mouth area during July-August. Advanced fingerlings occur in commercial catches in large numbers in September-October.

Gerres spp. : Juveniles of the size range of 15-45 mm occurred in January-March and again May-June in Outer Channel and Satpara and in Central Sector in April and May.

Pseudosciaena coibor : Eggs of this species measuring 0.84-0.88 mm in diameter were collected in the month of April in Northern Sector. Fry and fingerlings of borogo are available in very large numbers during the months July-September in Northern Sector.

Triacanthus brevirostris : The juveniles of 15-55 mm occurred dominantly in Central Sector, Northern Sector and Satpara in July-December but were less common in Southern and Outer Channel Sectors.

9. UTILISATION OF FISH FOOD RESOURCES OF THE LAKE

As a corollary to the studies of plankton, bottom biota, algae, and larger aquatic plants reported upon earlier in this report, it is desirable to know their role in the food of fishes. The food of 54 species of fish was studied. That of only important fishes is mentioned below under each food head.

DETRITUS as a food item dominated in 34% of the fish examined and formed one of the items in another 24%. Namatalosa nasus, Pangasius pangasius, Mugil cephalus, M. cunnesius, M. dussumieri, Valamugil seheli and Triacanthus brevirostris may be mentioned under this head. All penaeid prawns also show detritus-dominated diet.

FISH dominated in 25% of fishes and occurred as one of the items in another 20%. Lates calcarifer, Sciaena russelli, Tachysurus falcarius, Therapon jarbua, Caranx preustus, Chorinemus lysan and C. tala may be mentioned under this category.

MOLLUSCS dominated the diet in 8% of the fishes and as one of the items in another 9%. Tachysurus arius, Plotosus canius, Caranx carangus, Leiognathus equulus and G. setifer come under this category.

PRAWN dominated in 23% of fishes and as one of the item in another 19%. Under this head may be mentioned Anchoviella commersonii Thrissocles hamiltonii, T. mystax, E. tetradactylum, Coius quadri-fasciatus, Johnius semiluctuosus, Sciaena russelli, P. coibor, Drepane punctata and Platycephalus indicus.

INSECTS dominated in 6% of the fishes and as one of the items in another 17%. Osteogeniosus militaris may be mentioned under this head.

ZOOBENTHOS as food item dominated in 8% of the fishes and as one of the items in another 20%. Tachysurus coelatus, Mystus gulio and S. russelli come under this.

ZOOPLANKTON dominated in 6% of the fishes and occurred as one of the items in another 15%. Hilsa ilisha, Thrissocles purava and Crenidens crenidens come under this.

LARGER AQUATIC PLANTS dominated in 6% of the fishes and as one of the items in another 24%. Liza corsula and Etroplus suratensis come under this head.

ALGAE dominated the diet in 2% of the fishes and as one of the items in another 15%. Liza macrolepis and Sparus sarba may be mentioned under this.

PHYTOPLANKTON occurred only in 4% of fishes but in none as a dominant item.

It is significant to note that detritus occupies a dominant place in the diet of fishes of the lake followed by fish, prawns, larger aquatic plants, zoobenthos, insects, zooplankton, algae and phytoplankton.

10. DISCUSSION ON THE SALIENT FEATURES OF THE INVESTIGATIONS

Under this head commercial fishes of the Chilka Lake are examined individually and development measures of the fishery of each discussed. The developmental measures suggested are incorporated in the recommendations on conservation of the fisheries of the lake as a whole which are given in Chapter 11. The discussion presented in this section would reveal that biologically it is necessary to prescribe different size limits for the capture of the different economic species. Many gears taking different species being common to several species, it is not practical to prescribe different size limits for each species as substantiated biologically. This fact is taken into account in framing the conservation measures given in Chapter 11 and explains the apparent contradiction in size limits advocated in Chapter 10 for those given in Chapter 11 in some cases. Opinion on overfishing or otherwise is also given though in fisheries of tropical waters the problem of overfishing has to be viewed in conjunction with many other factors whose implications are given at a later point in this section of the report.

The fishery of Mugil cephalus has been fluctuating in the range of 181-893 tonnes. An examination of the abundance of the I year class over the years suggests that recruitment has not been constant but highly varying resulting in the fluctuation of the fishery. As the fishery is chiefly sustained by I and II year classes, the failure of I year class is immediately reflected in fishery. But the occurrence of only two years classes (for all practical purposes) and that too coinciding with age at maturity, the low overall average length, viz, 290-336 mm, and high mortality ranging from 80-95%, all seriously point to a very high rate of exploitation though some allowance may have to be given to the fact that we are dealing with migratory estuarine stocks. Thus the fishery fluctuations cannot be attributed only to recruitment variability. The question arises whether even within the limitations caused by recruitment variability, a better yield than what is obtained now, is possible. Here the migratory behaviour of the fish will have to be given due weight. Thus from the biological observations it is clear that males mature in the I year, the females in II and that the mature fish migrate to sea for breeding. The exact extent of migratory diversion to other estuaries and the possible avoidance of estuaries either partially or fully of large size groups are matters on which no firm opinion can be advanced because the studies reported here were essentially confined to

Chilka lake. Going by the fishery pattern, it is suggested all the same to reduce fishing mortality on I year class (more precisely the average 7 months old) which virtually bear the brunt of the fishery year-in and year-out and are captured in large numbers in the janos. In this connection, it is suggested that the I year females in janos can be easily eliminated by application of slight pressure in the belly region (resulting in oozing of milt through vent in males only) and should be released back in the lake alive. It is very likely that this may provide a lucrative fishery in II year. Juveniles measuring 15 cm and below are taken in large numbers by khadi jal and to some extent by patua jal. This should be checked. Reduction in number of janos is suggested and, so too, the undue destruction of gravid females by khadi jal at lake mouth in winter months. The destruction of incoming fry and fingerlings in Outer Channel should also be meticulously avoided. It is likely that these measures, if carried out, may enhance kabla yield and in addition, neutralise, to some extent, recruitment variability which itself could be a symptom of overexploitation.

In Liza macrolepis the fishery showed considerable fluctuations in the range of 27-299 tonnes. Observations indicate that as in kabla this may be, in no small measure, due to variation in recruitment from year to year. The fishery is chiefly contributed by three year classes. That II and III year classes also coincide with ages of maturity in male and female respectively, the low overall average length in fishery viz. 226-325 mm and a high mortality viz. 72-97% all point to a high rate of exploitation. The inconstant recruitment, thus, cannot neutralise the above facts. A careful study of the fishery pattern suggests that it would be advantageous, from yield point of view, that emphasis in fishing be laid from 300 mm and above. A few years of experimentation (3-4 years) would give useful clues. In this connection it is pointed that the highly successful fishery of 1965 was contributed to, in no small measure, by the average 30 months age group. The size up to 300 mm are chiefly taken by janos, khadi jal and patua jal. Some restraint in the catch of this size by these jals is certainly indicated.

The fishery of E. tetradactylum also showed fluctuation in yield in the range of 122-364 tonnes. The fishery is chiefly sustained by I year class but as many as six year classes are noticed though contributing little to overall yield. Here also a high total mortality viz. 71-95% and low overall average length in catches, viz. 192-255 mm suggest a high rate of exploitation. The juveniles of less than 4 months start appearing in the commercial catches from

March onwards when the size range 65-165 mm are exploited, especially between March and July. Length frequency study of sahal suggests a possible continuous stay of juveniles up to 18 months in the lake. If the commercial exploitation of the species could start from 200 mm and above, which would coincide with the month of October, this may visibly enhance the yield. This is one aspect of the problem intended to accrue immediate advantage by shifting the time of exploitation. The other aspect of the problem is the role of the larger-sized individuals. It may be mentioned, supported by available data, that there is a possible incursion of larger-sized adults from November-April. Restrained exploitation of I year class, for at least two consecutive years, may indicate the possible impact upon II and III year classes, especially regarding their migratory behaviour. If the experimentation is favourable, shifting of exploitation to a much later stage may prove fruitful. Juveniles, 50-80 mm and upwards are taken in large numbers in patua jal and khadi jal and up to 150 mm in patua, bhida and patua jal with 'modi' bag. All this should immediately stop for better realisation of yield. The fish is chiefly carnivorous and the occurrence of large percentage of prawns in the diet of this fish merits consideration in the development of this fishery.

The fishery of Hilsa showed extreme fluctuations in the yield during the period under study in the range of 30-293 tonnes. The recruitment is also highly variable contributing to fluctuations in yield. The fishery is chiefly sustained by two year groups. This fact, together with low overall average length in catches, viz. 256-291 mm, and a high mortality viz. 72-91% all suggest a high rate of exploitation. As a measure of conservation, a lesser exploitation of 125-300 mm size group is indicated. This may enhance the yield of 325-450 mm size group and also considerably enhance the overall yield, allowing migratory loss as negligible. This is worth experimentation. The zero year class (up to 150 mm) is largely exploited by patua jal and menjia jal but this should stop.

Balangi (N. nasus) also showed fluctuations in fishery in the range of 55-199 tonnes and is marked by vagaries in recruitment. The high mortality viz. 82% and the low overall average length in the catch namely 139-170 mm suggest a rather high rate of exploitation. For a better yield, it is desirable that the I year group i.e. up to 165 mm should be less exploited than hitherto. The question arises if the delayed exploitation would not involve loss due to fish migration. The lucrative fishery of II year class in many years covered by present study does not support such an assumption in toto.

The above suggestion is worth experimentation. The capture of fish less than 104 mm taken in large quantities in khadi jal and patua jal should be immediately discouraged.

Kontia fishery (M. gulio), as exploited now, is chiefly contributed by I and II year age groups. The fishery, inspite of extremes, is much steadier with average yield during the period 1957-65 at 311 tonnes. The recruitment also is less variable, a fact reflected in the fishery. The overall average length in the catches was 123-136 mm. This coupled with a high mortality viz. 70% suggest a high rate of exploitation. The pattern of the fishery suggests that by reducing the I year catch in the size range of 91-149 mm further, with the resultant higher survival for II year class, the yield may go up considerably. The capture of juveniles of 50-100 mm in patua jal must be discouraged. The Chilka lake appears to be favourable to reproduction, growth, and abundance of this species.

The fishery of borogo (P. coibor) fluctuated in the range of 103-294 tonnes and is sustained by four year classes. This species is also subject to recruitment vagaries. The estimated mortality was in the range of 52-60% except in one year when it was 87%. Rate of present exploitation of this species cannot be considered very high. The variability in yield is directly attributable to recruitment vagaries. For augmentation of this fishery lesser exploitation of I year class is indicated. The I year class is generally taken by khadi, patua, bhida and noli jals. The destruction of juveniles in the size range of 40-80 mm by patua jal should be discouraged.

The fishery of bekti (L. calcarifer) showed extreme fluctuation in the range of 55-749 tonnes. The mortality was estimated at 58% (average between age groups) which, considering other fisheries, is not very high. The recruitment is highly variable between years or appears so due to variability in the lakeward incursion of the 'fish of the year' as well as I year age group. This is reflected in the fishery fluctuations more than any due to rate of exploitation. The pattern of the fishery over the years indicates, within limitations imposed by recruitment and other factors, that a higher yield may be expected by reducing exploitation of the size range up to 475 mm while intensifying exploitation from 475 mm and above. The jals that take smaller size groups are khadi jal and patua jal in addition to janos. Capture of the 'fish of the year' under 200 mm should be strictly avoided.

The fishery of jagli (G. setifer) is sustained by three year classes. The overall average length in the commercial catch

was 110 mm and the mortality ranged from 67-73%. These two factors suggest a fairly high rate of exploitation. The fishery pattern indicates intensive exploitation of I year class. A reduction in this may prove beneficial to the fishery besides indicating more precisely the behaviour of larger year classes in relation to migration. As a first step it is suggested that capture of fish less than 105 mm may be desisted. The size group is chiefly taken by khadi jal.

The fishery of kundal (E. suratensis) also showed extreme fluctuations in the range of 32-222 tonnes. The fishery is sustained by three year classes and the mortality is estimated at 67%. The recruitment is very uneven and fluctuates from year to year and this seems to be reflected in the fishery of the species. It is desirable to exploit less of the I year class and juveniles younger than six months old. Mass destruction of juveniles practised in summer and autumn months by patua jal and khadi jal is to be deprecated and should immediately stop. The fish has great yield potential if judiciously exploited inspite of recruitment vagaries. Potamogeton, Spirogyra and detritus, which form important items of food of this species, are available in plenty in the lake and food, thus, will not be a limiting factor for its development.

The penaeid fishery represented by P. indicus, P. semisulcatus, M. monoceros and M. dobsoni has been showing considerable fluctuations and during the period 1957-65 ranged from 548-1863 tonnes. It is difficult to study the population changes of penaeids as the fishery in estuarine nurseries (Chilka Lake) is purely made of juveniles/sub-adults. It is for this reason that catch/trap/night does not indicate the relative abundance of the whole stock and hence is unusable in deriving mortality/survival parameters.

The fishery of P. indicus and P. semisulcatus appears to be contributed by two broods, at least, of which one is monsoon/post-monsoon in origin and is designated as 'primary brood' and the other pre-monsoon and is designated as 'secondary brood'. This conclusion was independently arrived at by length frequency studies and post-larval abundance, both broadly conforming to the same pattern. It is the primary brood that appears to contribute to the summer/monsoon fishery of the lake. It is considered that a good rainfall in the July-September period may be vital for spawning and recruitment and the average salinity for these months at Arkhakuda, a place near lake mouth and sea, was taken into account in this connection.

The average salinity at lake mouth was 3.66‰ in 1964 (the lowest) and the yield in 1965 was highest with 1862 tonnes; the average salinity was high i.e. 14.2‰ in 1963 and the yield in 1964 was poorest with only 548 tonnes. The average salinity for 1965 was very high i.e. 21.00‰ and the fishery in 1966 is expected to be very poor. A good rainfall in July-September and lowered salinity, thus, appear to have some correspondence with yield in the following year. It appears from available observations that inland rainfall and resultant river discharge are also important in conjunction with coastal rainfall. In 1962 the coastal rainfall was above average but the inland rainfall failed resulting in poorer river discharge during the July-September period. This may be one of the reasons for a low yield in 1963. In addition to rainfall, river discharge and salinity, the variable mortality of juveniles through predation, behaviour of adult prawns in the sea, especially with reference to coastal movements, coastal currents and winds favouring or disfavouring post-larval incursion are all factors which individually or cumulatively can contribute to fishery fluctuations. There is nothing to suggest that the present rate of exploitation of juveniles, by itself, contributes to fluctuations in yield and to that extent no conservation measure for penaeids is warranted. It is, all the same, suggested that near-blocking of Mugger Mukh area, the gateway to Outer Channel and sea with prawn traps during season is not a healthy practice and some restraint here is certainly indicated.

10.1 <u>On the question of overfishing</u>

The question of overfishing in this discurssion is confined only to fishes. We have catch statistics available for the lake from 1930 but the prawn and fish components of the annual catches are unfortunately not available except for the periods 1948-52 and 1957-65. Let us assume that the catch statistics for the intervening period of 1953-1956 is about the same as during the preceding (1948-52) and succeeding years (1957-65). The fish yield from 1948-65 period, as per 3 year moving average method, fluctuated from 2000-3000 tonnes with no trenchant trend of production whatever, a fact which is important for the consideration of the problem of overfishing. Now we have records of fishermen population of Chilka lake for 1955. The Chilka Investigation Unit carried out a sample fishermen population census in 1965 covering 35 fishing villages. These studies indicated 54% increase in their number. This increase includes the influx of refugees besides natural population growth. By same token, we may assume that fishing effort was

much less in 1948 than it was in 1955. Inspite of definite increase in fishing effort from 1948, the fish yield has remained more or less the same for 18 years. It is, therefore, futile to expect only higher yield by increasing the fishing effort which necessarily means a decreasing catch per unit of effort. The yield before 1948, when the fishing effort was much less, might have been much higher. The available records do not corroborate this for the simple reason that the extent of drying and salt curing of fish are unaccounted in the earlier catch statistics. The above state of affairs, though studied collectively for all fisheries together, represent a higher rate of exploitation. The fisheries studied individually, as given above, also indicate in most cases a high rate of exploitation verging on overfishing as represented by occurrence of fewer year classes, low overall average length and high rate of mortality. Since the fishes of the Chilka lake, as in tropics in general, show extended breeding, high fecundity (excepting E. suratensis), early maturity and fast rate of growth, none of the above symptoms by themselves would over deplete the fishery in absolute sense. But what we need is higher yield. Here comes judicious exploitation in the picture. Even at the present rate of exploitation a higher yield can be expected by reduced juvenile destruction. Juvenile capture, besides adding little by way of yield, is unwise in the context of great fluctuation in recruitment which afflicts almost all the species supporting commercial fisheries in the lake.

The problem of depletion does not arise in the case of prawns (penaeids) as long as adult population in sea is untouched or underexploited.

10.2 Prawn culture

Some interesting observations on growth of penaeids have emerged from studies in the lake. The Southern Sector of the lake sustains giant-sized individuals. Growth in the Southern Sector reaches 185 mm in the case of P. indicus and 300 mm in that of P. semisulcatus as against the normal maximum of 105-115 mm for the former and 155-195 mm for the latter obtained in the Central and Northern Sectors of the lake. These specimens partly pushed in by flood waters and partly due to their inability to move against currents appear trapped in the Southern Sector (which was a blind end until August, 1964) and appear to register further growth perhaps leading a vegetative life. This has tremendous 'culture angle'. Bagda (P. semisulcatus) is ideal for this purpose. Bagda grows to a size of 205 mm in 14 months under lake conditions. It may be much faster in 'culture' conditions.

10.3 Fish seed resources

As more and more shallow areas of lake are likely to be converted into fish ponds the question of seed availability becomes important. Mullet fry, both of Mugil cephalus and Liza macrolepis, are available in plenty in November and December in the case of former and January in the case of latter and the best collecting ground for both being the lake mouth itself. Morning hours, during the months of seed availability of these species, when low tide has completely receded and the high tide just started, is the best time to collect mullet fry when shoals of them are easily spotted. Besides post-larvae, the juveniles of penaeids can be collected in the Outer Channel, vicinity of Satpara, Gansera etc. Etroplus suratensis is another fish whose fry and fingerlings are available in unlimited supply from April-July and September-November. They are caught in patua and khadi jals, along the western shores from Kaluparaghat to Balugaon, the maximum from Ghoradawada. During monsoon months they are captured in large numbers in Gamcha from Barkul. The juveniles of Eleutheronema tetradactylum, less than 4 months old, are available in March-April (up to July) but that it is a predatory fish will have to be given due consideration.

10.4 Suggestions for lake improvement

As much as 63.4-74.5% of the lake's production depends upon recruitment from the sea. At present, all the interchange of populations occurs through a single lake mouth which has been gradually shifting its position northeast leading to the formation of continually growing sandbar. The Survey of India Map (1929-30) shows three mouths, two of which are a little north of, and, one just opposite the Arkhakuda village. In 1965, the mouth was 8 km northeast of Arkhakuda and was 135 metre wide whereas in 1912-1930 it was estimated to be 1931 metres wide. It is feared that a long channel and a narrow mouth may impede tidal impact as well as to and fro migration of larval/juvenile/adult fish and prawn. It would be safer to stabilise the position and width of lake-mouth at a convenient point in the Outer Channel by artificial means (after a hydrographic survey) such as are adopted to safeguard some of the harbours of the east coast of India.

Mugger Mukh is an area where prawn traps are so closely laid that entrance into the lake is often practically blocked for the lakeward incursion of juvenile mullets which may have adverse effect on mullet fishery. Deconcentration of traps in this area is strongly indicated.

The Southern Sector contributes only 10-14% of the lake's total production. This sector may be considered poor in the productivity of more palatable fishes. That it is very far away from the lake mouth may be one of the reasons. The opening of Palur canal connecting the southern end with Rushikulya estuary in August 1964 is timely, especially as the latter harbours a rich mullet fry and prawn post-larvae and juveniles. This canal, however, must be further widened and deepned such that the tidal current is effective. As it is, its impact on the salinity in Southern Sector, on the basis of an year's observation may be said to be marginal. Observation over a longer period is certainly indicated before any firm opinion can be advanced on the effectiveness of the canal. Blocking of Palur canal with traps should also be discouraged for the same reason as for Mugger Mukh.

Silting up of the lake, through process of sedimentation, from river discharge over the years is a general feature for the lake but it is very pronounced in the Mugger Mukh area such that even flat bottomed country boats are unable to move in the greater part of the area. Since it is the gateway into and from the lake it is desirable that this area be deepened to, at least, 150 cm in summer by dredging and desilting. In addition to existing nalis additional deep channels may be dug to provide shelter for medium and large-sized fish. This may also prove useful for navigability.

The yield per hectare of Chilka lake is 25-42 kg as against 117 kg of the delta lake of Egypt. One of the reasons for higher productivity of Egyptian lakes is the successful yield from Tilapia (60%) while in Chilka lake E. suratensis, also a cichlid, plays a comparatively minor role. Apart from this, the Egyptain lakes are intensively stocked with mullet fry to augument the production. This part of it may be tried in the Chilka lake. If the hormone administration is successful in mullets for induced breeding and if the developing larvae could be reared to fry stage (which may be incomparably more challenging than induced breeding) the stocking of fry from this source would be an added advantage.

11 RECOMMENDATIONS ON CONSERVATION OF FISHERIES AND LAKE DEVELOPMENT

(i) Both the economically important mullets, viz. kabla and dangla, undergo seaward breeding migration through the narrow Outer Channel during the period September-January. They are in ripe condition at this time and are captured in large numbers in the Outer Channel by khepa and khadi jals. These breeders need protection. It is recommended that high tide mullet fishing should be restricted in the Outer Channel, especially in the full and new-moon weeks, when they are caught in exceptionally large numbers. Further observations correlating parent-progeny relationship should be made to ensure an abundant supply of mullet seed [vide item (V) below].

(ii) In certain years lakeward migration of fingerlings of these mullets occurs in shoals in very large numbers in April-July when they are caught in boat-loads in the narrow Outer Channel. The capture of the fingerlings of kabla and dangla should be completely banned. It is desirable to ban the destruction of mullet fry in general which are taken in Outer Channel practically all the year round.

(iii) While biologically it is necessary to prescribe different size limits for the capture of the economic species viz., kabla, dangla, sahal, borogo, bhekti, ilish, balangi, kundal, kontia and jagli, the same is not practical when the fishing nets (in the present case khadi and patua jals) and janos, taking such diverse fishes with very wide range of average maximum lengths, are one and the same. For this reason it is not practicable to suggest mesh regulation. Any mesh regulation will also interfere with capturing trash and miscellaneous fishes which form as much as 50% of the net catches. It is, therefore, recommended that economically important fishes smaller than 6 inches occurring in the catches must be salvaged and returned to the lake alive. Marketing and local consumption of these sizes must be banned as a first step in this direction.

(iv) Giant-sized specimens of bagda have been found to grow upto 300 mm in the Southern Sector of the lake where they are physically pushed by onrushing flood waters during monsoons and from where they are unable to find their way to the sea for breeding. They have reached giant sizes by leading a vegetative life. This

is a clear indication that, if cultured, they can reach much larger sizes than what is normally their average growth (say, 175 mm) in the lake. The same is true in respect of several species of chingudi as well. Culture fisheries of penaeid prawns should, therefore, be developed in the lake, a beginning for which may be made in Keshpur Fish Farm.

(v) As the shallow areas of the lake, especially the Northern Sector, are being reclaimed, as per an earlier recommendation of the Institute (Bulletin No.1, Centr. Inl. Fish. Res. Inst. July 1963), the question of seed availability assumes great importance. Forms which may be cultured together are kabla, dangla, kundal, bagda and chingudi. Fry of kabla and dangla are available in large quantities at lakemouth in winter months and that of kundal in the lake in summer and autumn months along western shores from Kaluparaghat to Balugaon. The penaeid juveniles may be collected in the Outer Channel, Satpara, Ganserra, Katapentha, etc. Sahal, which is a predator, may be cultured in separate ponds. The juveniles of sahal are available in summer off Kuhuri and adjoining areas.

(vi) Induced breeding of kabla and dangla by pituitary hormone administration should be developed so as to procure stocking material of these fishes not only for the lake but also for culture operations recommended to be developed in this region.

(vii) At present prawn traps are so heavily concentrated in the strategic Mugger Mukh area that the seaward migration of prawns and lakeward migration of mullet fingerlings are greatly hindered. The prawn traps need to be put sparsely.

(viii) The Mugger Mukh area is already so much silted up that even flat-bottomed country boats often experience difficulties in negotiating it in summer. As it is the gateway for entry into and exit from the lake, it is necessary that this area be dredged and desilted to, at least, maintain a summer depth of 150 cm.

(ix) To render tidal inflow into the lake more effective for the ingress of post-larvae/juveniles of prawns and mullets, the Palur canal, opened in August 1964, should be depened and if possible widened.

(x) The shifting of lake mouth northeastward year after year causes reduction in tidal effect in the lake. This has ominous overtones from fisheries view point and it is likely that eventually a stage may reach when self-stocking of the lake of various

fish, especially mullets and prawns, may be adversely affected. Attempts should be made to stabilize the position and width of the lake mouth by intensifying casuarina plantation.

12 SUGGESTIONS FOR FUTURE WORK .

It is suggested that the following work may be conducted on a continuing basis.

(i) Estimation of total and species-wise catch of all economic fishes and prawns and catch per unit of effort of seaward migrating adult kabla and dangla along with their lakeward migrating fry.

(ii) Length frequency of all commercial fishes and prawns. The sampled frequencies may be taken from Rambha, Kallikota, Balugaon, Gangadharpur, Kuhuri and Kaluparaghat. A minimum of 5 days sampling for each centre in a month is desirable.

(iii) A record of sectoral temperature and salinity observations at fortnightly intervals.