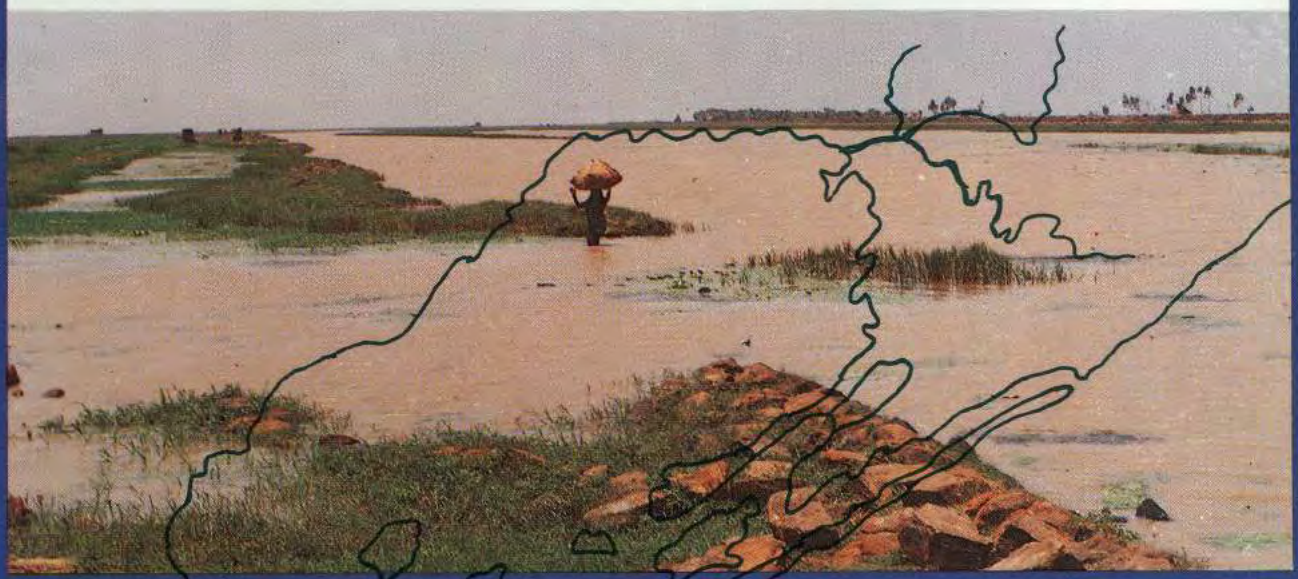
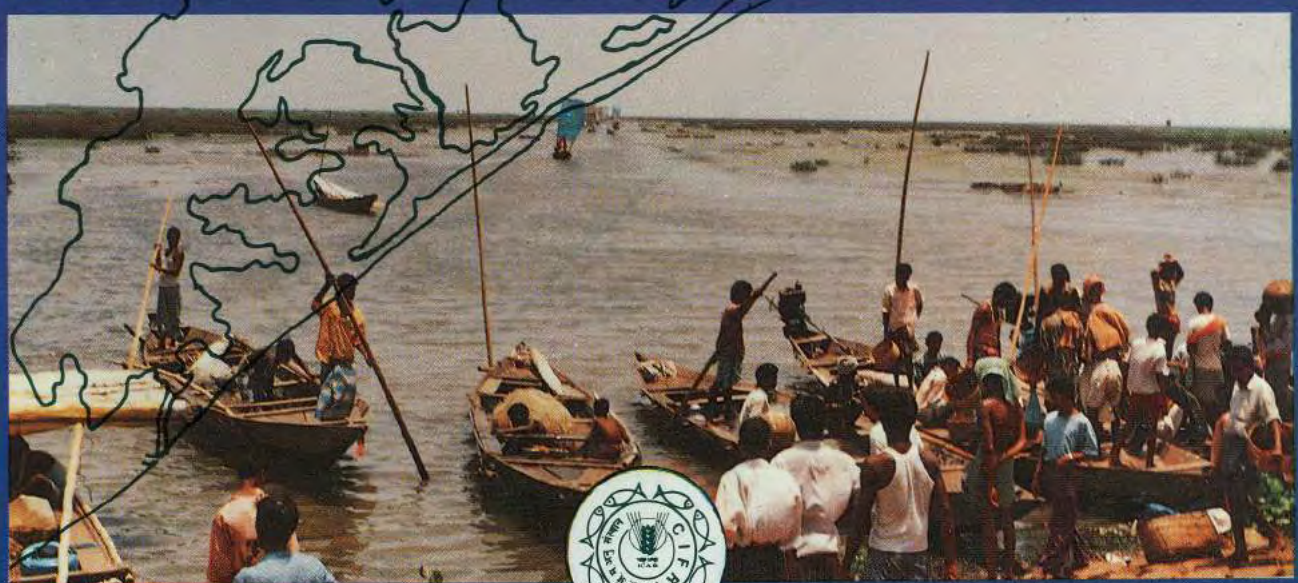
CHILKA LAKE

PRESENT AND PAST





CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE BARRACKPORE

Chilka Lake - Present and Past

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Chilka Lake - Present and Past

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FOREWORD

The lagoons in India constitute one of the richest resource of valuable fish protein and livelihood for the rural people. However, during the past few decades anthropogenic pressure coupled with natural changes have significantly altered many of these lagoons effecting their hydrology as well as faunal structure. Chilka is one such lagoon affected by incessant anthropogenic activities resulting in gradual decline in abundance of the important commercial shell and fin fishes.

CIFRI, as part of their environmental monitoring programme of various aquatic resources in the country took up a thorough investigation on the ecological and biological aspects of Chilka. The outcome of this comprehensive work has generated valuable data which has been documented in this publication.

I am sure this document would be of immense use for planners conservationists, development organisations and people in general to have a detail information on its present status so as to plan and act in future.

M. Sinha
Director

Investigators

R.K. Banerjee
P.K. Pandit
S.K. Chatterjee
B.B. Das
&
A. Sengupta

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INTRODUCTION

Brackishwater lagoons are usually formed by the sudden geometamorphic changes of the earth's crust adjacent to the sea when either a small fraction of the sea surface gets detached from the mother forming a notch or the sea water gushes into the adjacent newly formed depressed land lock. In every case the contact with the mother water body is retained through requisite natural water course. During initial stage, the newly formed water body bears the saline ecology of the sea and in course of time with the ingress of freshwater from rivers and surrounding catchment areas, the lake transforms into a brackishwater lagoon where wide diversity of aquatic organisms of haline, euryhaline and freshwater nature gradually get established. So, for obvious reasons brackishwater lagoons are biological assests for any country. Chilka is one such brackishwater lagoon and it is essential to protect the natural character of its biological wealth both for scientific and economic interest.

Chilka was initially under the joint ownership of the Kings of Parikud, Khallikota and Rambha until the second decade of this century when commercial exploitation of its fish was initiated and gradually intensified with the increase in demand. Now, Chilka has become the source of sustenance of more than 3 lakh people of which 60,000 are active fishers residing around the lake and primarily living on the catches therefrom.

The Chilka lake has witnessed incessant anthropogenic activities during the past few decades which, coupled with the natural changes caused by climatic, geological, physico-chemical and biological degradation, have altered the natural attributes of the lagoon. This necessiated a thorough investigation on the ecological condition and fish & fisheries of the lagoon by CIFRI during 1960-65 (Jhingran & Natarajan, 1966 & 1970) followed by Z.S.I. through a multidisciplinary team in 1985-87 (Siddiqui & Rao, 1995). Since then a lot of changes in the morphology, ecology and fisheries have taken place with the passage of time for which no account is available.

This report on the Chilka is based on one year's exploratory study through seasonal samplings (pre-monsoon, monsoon and post-monsoon) during 1995-96. Besides lacustrine ecology, fish & fishery and the geo-physical conditions, the study also included the aspects of demography and socio-economic condition of the fishers. An attempt has been made to assess the degree of eco-degradation the ecotope has suffered during the last few decades.

Material and methods

The lake was arbitarily divided into three sectors *viz.,* Northern, Central and Southern by Jhingran & Natarajan (1966). In order to have a representative picture of their ecological conditions, ten sampling points spreading over all the sectors were mapped out based on the morphological condition of the ecotope. Accordingly, the points in the Northern sector were Kaluparaghat, Arkhakuda and Kankarkuda; in Central sector Barkulpoint, Titipo, Parikud and Muggermukha and in Southern sector Rambha, Madarchua and Bazarkote *(Map 1).*

The physical parameters considered were depth, temperature and transparency.

The bed soil at each point was analysed for texture, pH, salinity, organic carbon, available nitrogen, available phosphate and sp. conductivity.

In water phase pH, dissolved oxygen, alkalinity, salinity, carbon-di-oxide, ammonia, nitrate, phosphate, calcium, magnesium and potassium levels were determined.

Plankton, benthos and periphyton concentrations were estimated at each point. In addition, tow net was operated at each centre for fifteen minutes duration and the collections were analysed both quantitatively and qualitatively.

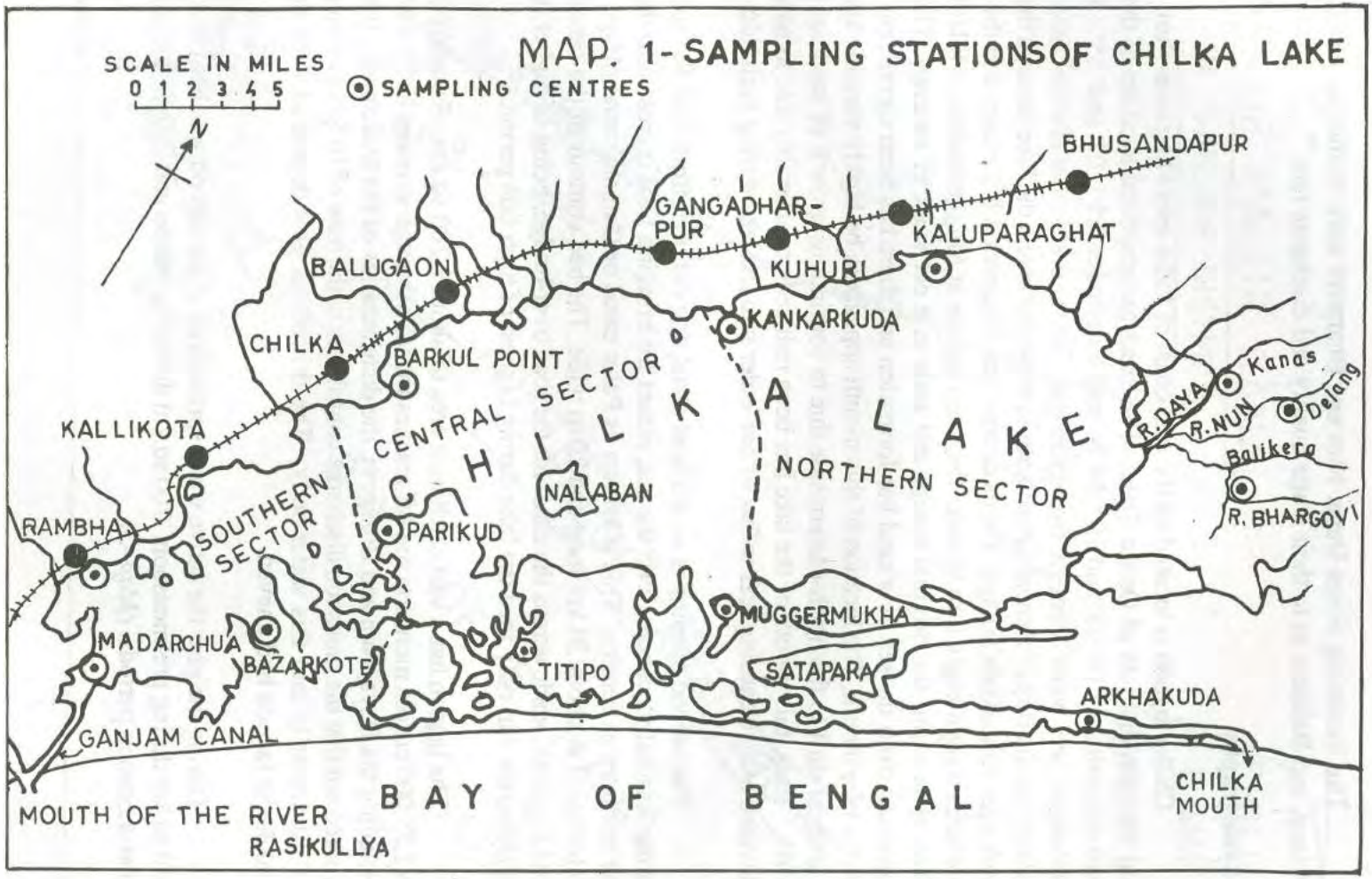
Diurnal variation study of pH, dissolved oxygen and plankton population were conducted at each centre.

Primary productivity of the lagoon water was estimated through dark and light bottle method for a duration of three hours.

An account of gears usually operated in different seasons was also prepared.

Local catch composition at different points was examined *in situ,* and total catch per net for the duration operated has also been recorded.

The fishes and prawns were examined as to their stages, seasonal abundance and species diversity. The catch composition was recorded from the landing centres. The total annual yield from the lake has been worked out from the estimated monthly catch records of the State Fisheries Department.


MAP. 1- SAMPLING STATIONSOF CHILKA LAKE
SCALE IN MILES
0 1 2 3 4 5
SAMPLING CENTRES
N
BHUSANDAPUR
GANGADHAR-PUR
KALUPARAGHAT
KUHURI
BALUGAON
KANKARKUDA
CHILKA
BARKUL POINT
CENTRAL SECTOR
C H I L K A L A K E
NORTHERN SECTOR
KALLIKOTA
SOUTHERN SECTOR
NALABAN
RAMBHA
PARIKUD
MUGGERMUKHA
MADARCHUA
BAZARKOTE
TITIPO
SATAPARA
ARKHAKUDA
GANJAM CANAL
BAY OF BENGAL
MOUTH OF THE RIVER RASIKULLYA
CHILKA MOUTH
Kanas
R.DAYA
R.NUN
Delang
Balikera
R. BHARGOVI

The incoming rivers Daya, Nun and Bhargovi were studied at points Kanas, Delang, and Balikera as to their water quality and discharge rate.

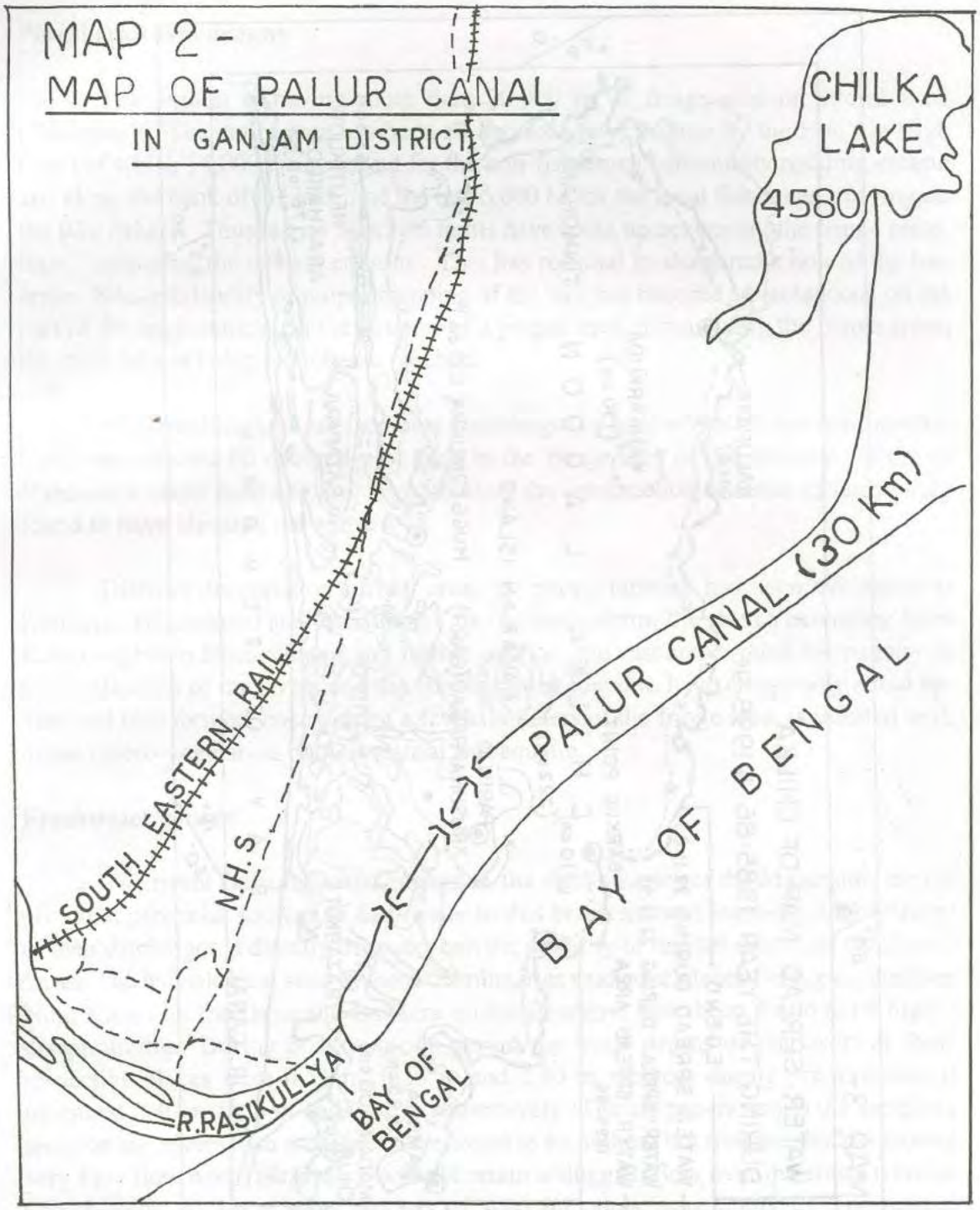
Physiography

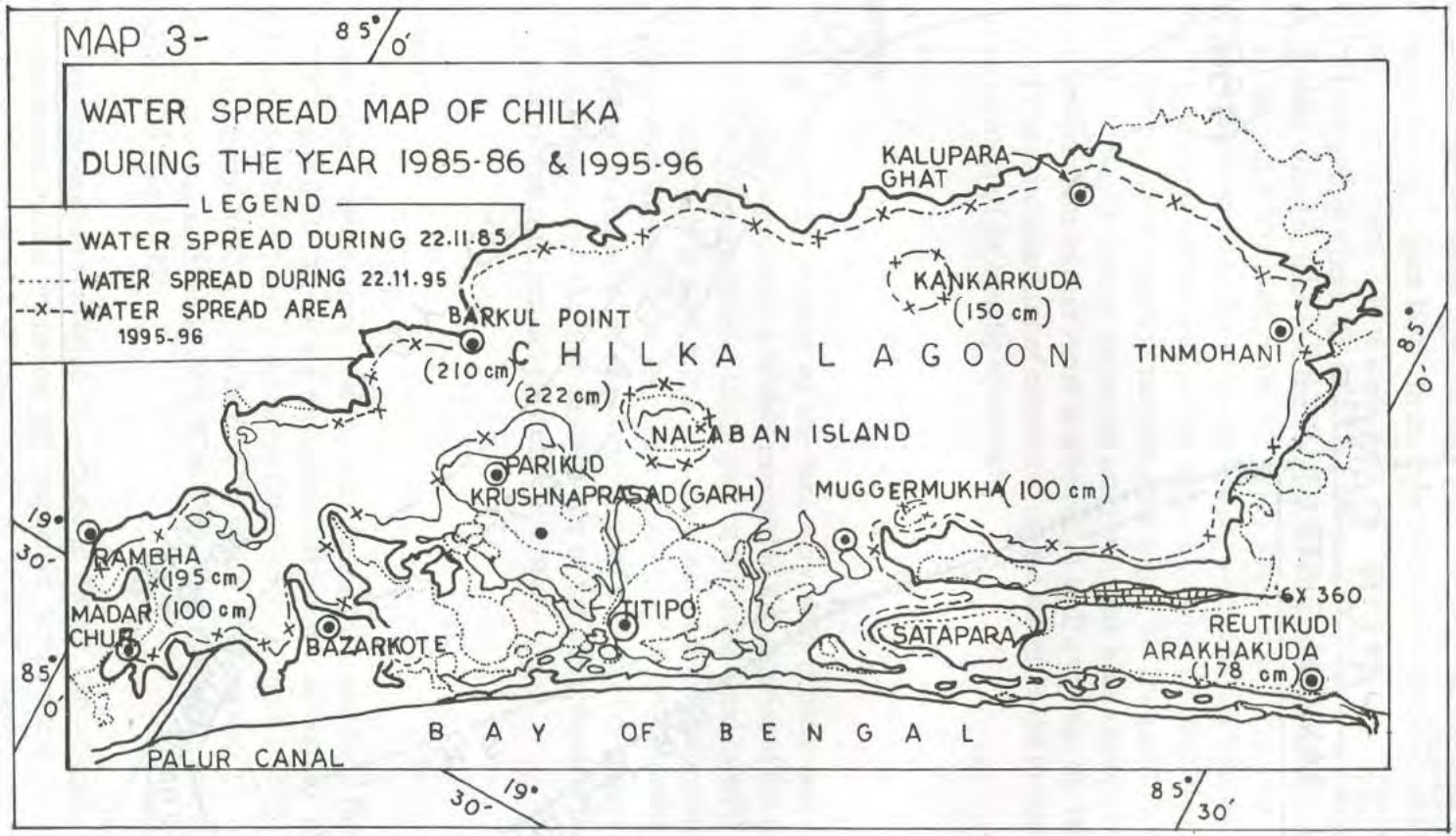
Chilka lagoon is located on the east coast of India sprawling over Puri, Khurda and Ganjam districts of Orissa State. The exact geographical location of the lake is between latitudes 19 °28' and 19° 54' N and longitudes 85° 05' and 85° 38' E. It exchanges sea water through two openings. The natural feeder channel runs parallel to lake and the Bay of Bengal towards south-west and enters the lake through the eastern bank near Arkhakuda village. On its course near Satapara it bifurcates and the broader one takes a right angle turn to enter the main lagoon at Muggermukha, while the other flank runs along the original course and ends in a net work of swamps. The lake is separated from the sea by a sand bar formation and there has been significant shifting of this lake mouth. The location of this mouth appears to be highly variable and shows a gradual shift to the north-eastern side due to continuous growth of sand bar towards north. Thus, this mouth of the lake has been reduced considerably due to narrow and elevated orifice causing less influx of sea water into the lake during high tide.

The second opening is an artificial canal dug out, just from near the confluence of the Rasikullya estuary with the sea, meant for bringing tidal ingress into the lake at the southern extremity. This is known as Palur canal or Ganjam canal *(Map- 2)*. The Palur canal is about 30 km long and 20 m wide. The bed contour of the canal and the R.C.C. plinth, made across the canal for the road over-bridge, being of higher level, the tidal ingress can only feed the lake during highest of high tide period.

The lagoon has a vast catchment area of about 3,200 sq.km. Roughly 2,00,000 to 2,75,000 cusecs monsoon run off reaches the lake through as many as 35 water-ways including the Daya, Nun and Bhargovi, the distributaries of the Mahanadi. It has been worked out that the monsoon discharge contributes to the tune of 10 to 13 million tonnes of silt annually into this water body. The drifted silt gets deposited irregularly and makes the lagoon bed uneven.

During the year the active water spread area of the lagoon was between 620 and 650 sq.km during pre-monsoon, 700 sq.km during monsoon and 700-760 sq.km during post-monsoon periods. *(Map -3)*.


MAP 2 -
MAP OF PALUR CANAL
IN GANJAM DISTRICT
CHILKA
LAKE
4580
PALUR CANAL (30 Km)
BAY OF BENGAL
SOUTH EASTERN RAIL
N.H. 5
R.RASIKULLYA
BAY OF
BENGAL


MAP 3-
85° 0'
WATER SPREAD MAP OF CHILKA
DURING THE YEAR 1985-86 & 1995-96
LEGEND
WATER SPREAD DURING 22.11.85
WATER SPREAD DURING 22.11.95
WATER SPREAD AREA 1995-96
KALUPARA GHAT
KANKARKUDA (150 cm)
BARKUL POINT
(210 cm)
C H I L K A L A G O O N
TINMOHANI
(222 cm)
NALABAN ISLAND
PARIKUD
KRUSHNAPRASAD (GARH)
MUGGERMUKHA (100 cm)
19° 30'
RAMBHA (195 cm)
MADAR CHUK (100 cm)
BAZARKOTE
TITIPO
SATAPARA
6X 360
REUTIKUDI
ARAKHAKUDA (178 cm)
85° 0'
B A Y OF B E N G A L
PALUR CANAL
19° 30'
85° 30'

Peripherial topography

The lagoon is having more than 20,000 ha of fringe area or littoral zone (*'Utapani'*). The entire area has been alloted for prawn culture by the Hon'ble High Court of which 14,000 ha are meant for the non-fishermen community residing around and along the bank of the lake, and the rest 6,000 ha for the local fishermen thriving on the lake fishery. Thus, series of prawn farms have come up occupying the fringe areas, thus, tampering the natural contour. This has resulted in sharp reduction of the bay areas. Non-availability of proper mapping of the lake has become advantageous on the part of the encroachers. In the absence of a proper map, demarcating the fringe areas, the main lake is being heavily encroached.

At Khandawalpur, a place near Bramhagiri, a total of 360 fishermen families have been alloted 60 decimal plot each in the fringe area of the lake for culture of *P.monodon* under *Indira Rojgar Yojona.* Here the construction of series of farms were found to have elevated the entire area.

Distinct decapitation of bay areas by prawn farming has been evidenced at Kumarpur (Bazarkote) and Barkulpoint. In northern sector, the stretch extending from Kaluparaghat to Bhusandapur and further east *i.e.,* the vast area around the vicinity of the confluence of the rivers and the lake has been found to have completely silted up. The land thus formed, encroaching a few kilometers of the fringe area, is infested with dense macro-vegetation both terrestrial and aquatic.

Freshwater source

The rivers Daya, Nun and Bhargovi, the distributaries of the Mahanadi, are the principal perennial sources of freshwater to this brackishwater lagoon but the volume of their discharges is directly dependent on the intensity of rainfall over their catchment areas. The hydrological state of these distributaries studied at places Delang on the river Nun, Kanas on the Daya and Balikera on the Bhargovi have been found to be highly disappointing. During post-monsoon period the water depths of the rivers at these respective places were 0.51 m, 0.35 m and 1.80 m whereas during pre-monsoon it measured 0.40 m, 0.26 m and 0.62 m respectively. During pre-monsoon the sampling spots on the rivers Nun and Daya were found to be nothing but riverine shadow having very little flow while the Bhargovi could retain a sluggish flow over the entire riverine stretch only. At some spots patches of stagnant pools were noticed. The natural discharge rate of all these rivers were found to be greatly reduced by the indiscriminate tapping of water through lift irrigation, diversion canal and barricade to feed the vast

agriculture fields for intensive agriculture. The discharge rate of the Daya was only 1,00,000 cusecs during August 1996. In the river Bhargovi near Balikera the water level rose to 1.12 -3.77 m in July, 3.40 m in August, 3.12 m in September, 2.67 m in October and 2.37 m in November where *'O'* value is 1.09 m. The Talamahal gauge on the river at the confluence with the lake had the reading in respective months 2.25 m, 2.18 m, 2.06 m, 2.10 m, and 2.00 m where the *'O'* level was 0.41 m. The free ingress of the monsoon run off into the lake from the vast catchment areas has been badly restricted as the natural topography of the peripherial areas have been elevated by the unplanned emergence of innumerable prawn farms along the bank. So the quantum of freshwater the lake used to receive during monsoon originally has been considerably reduced. During post-monsoon the excess water is allowed to spill over into the lake. The non-availability of requisite quantum of monsoon ingress hampers the maturity, fecundity and breeding of most of its aquatic inhabitants.

Meteorology

The geographical location of the lake very well depicts that entire eastern periphery of this vast water body is widely exposed to the vagaries of the Bay of Bengal. Such a relief obviously experiences the impact of the trade wind as well as the South-East and Nor'wester and is also prone to occasional cyclonic depression in the sea. Usually strong winds blow over the lake from the south in summer months and generally from the north-east direction in the remaining parts of the year. For proper mixing of the lighter fresh rain water with the high saline water of the lake, physical parameters like wind, temperature and tidal impact play effective roles.

Temperature

Atmospheric temperature over the area during post-monsoon (December) was between 23.5° C and 27.0 °C, in pre-monsoon (May) the temperature increased to the range of 28.0 °C to 37.0 °C and in monsoon (August) the range was 26.5 °C to 30.5 °C *(Table-1)* as compared to 23.2 °C to 28.6 °C in winter (post-monsoon), 25.2 °C to 35.2 °C in summer (pre- monsoon) and 29.0 °C to 35.5 °C in monsoon respectively in 1985-87 (Siddiqui and Rao, 1995).

Water temperature remained very close to the air temperature. During post-monsoon, pre-monsoon and monsoon the respective temperature ranged from 23.0 °C to 26.0 °C; 29.5 °C to 32.5 °C and 29.0 °C to 31.5 °C. During August (monsoon)

at all but one (Rambha) of the sampling points the water temperature was observed to be more than the air temperature. Probably the sandy mucky bed with huge deposition of semi-decomposed aquatic weed as well as the low depth of water kept the lake water warm.

However, the water temperature regime of lake indicates that from the month of February it increases and the peak is reached during May which more or less persists upto September/October and then starts declining to the minimum in December/January.

Rainfall

Rainfall is a vital parameter in monitoring the ecological condition of the brackishwater system. According to meteorological records the annual average precipitation over the area is between 105 and 205 cm. During 1995 the rain gauge at Gangadharpur, a point at the north of the lake, recorded the annual precipitation to be 177.6 cm. while at Talamahal, at the north east, the quantum was 196.5 cm. It is evident from the *Table-2* that the monsoon season from May to October is the peak rainfall period in the area.

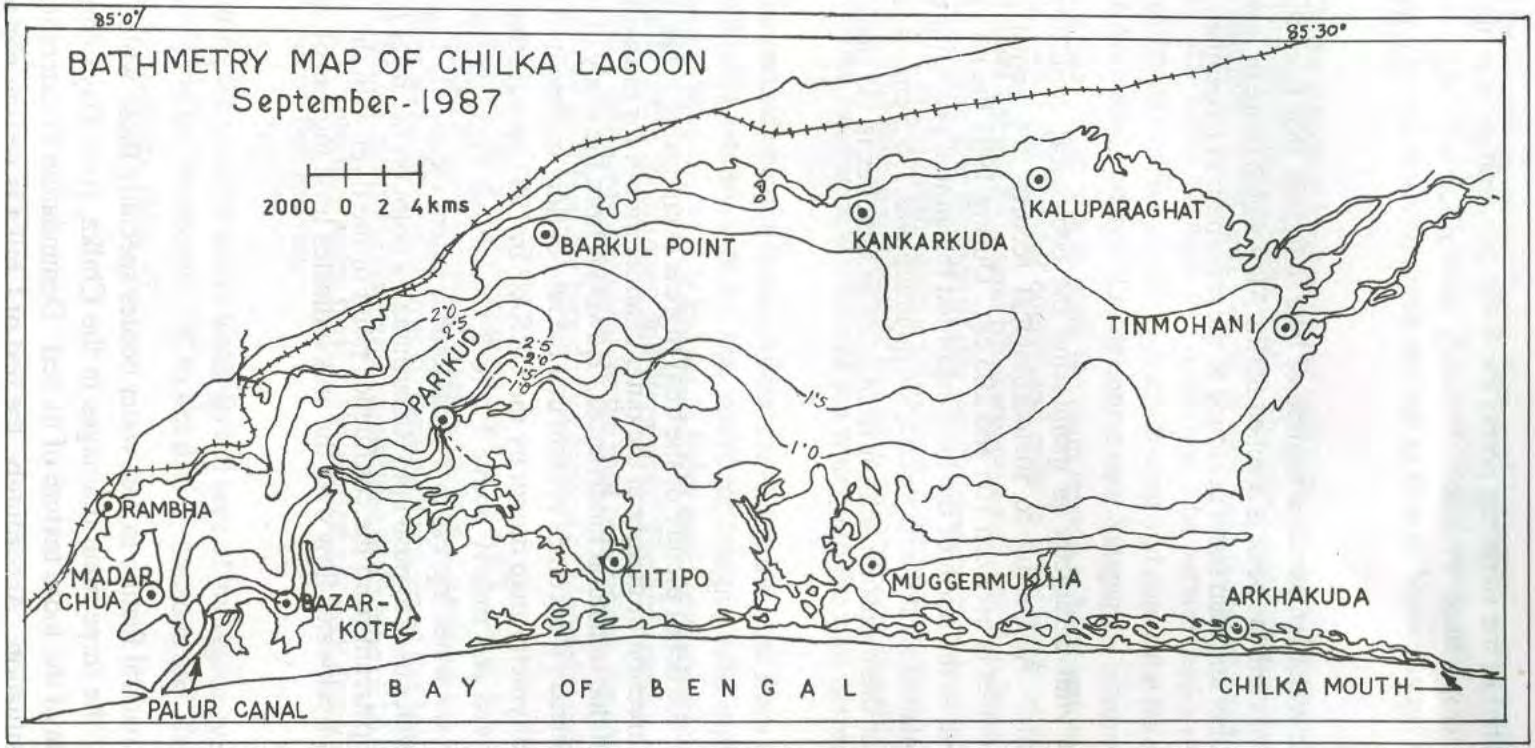
Tidal ingress

No record on the detail picture of the tidal ingress even during lunar phases is available. Probably erection of gauges at the outer channel mouth for measuring tidal amplitudes is difficult due to natural hinderances. However, from the study of the other related physical parameters it becomes evident that the rate of tidal ingress into the lake is declining. The bathymetry map drawn by the ORSAC in 1987 reveals that the bed of the lagoon is uneven and mostly above 1.0 to 2.5 m above MSL that obviously reduces the scope for sea water ingress to a considerable extent *(Map- 4)*. Eight to ten years ago the saline water used to push upto Raharmahal, a point on the river Bhargovi about 14 to 15 km upstream from the confluence point of the river with the lake. At present the perennial freshwater flow over the area indicates little ingress of sea water into the river.

Bathymetry

Siltation is a natural feature in vast water bodies specially those which receive river discharges. Of the three main drainages in the Chilka, river Daya contributes maximum silt because of the loose texture of its bed. Denundation of catchment areas also aggravates the situation. Accordingly, the bed of Chilka is getting elevated at a

MAP 4-



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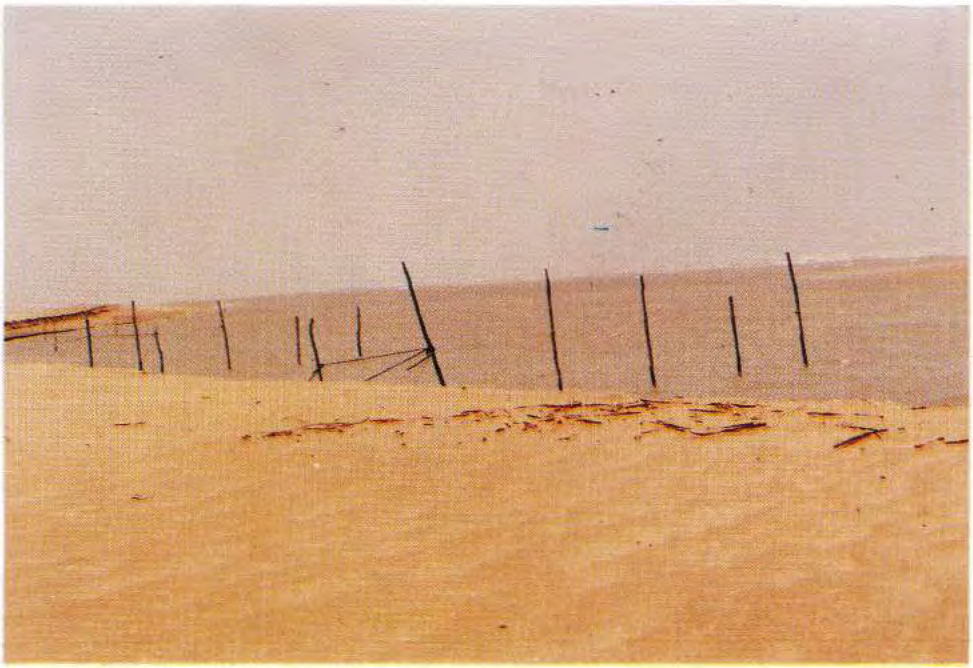
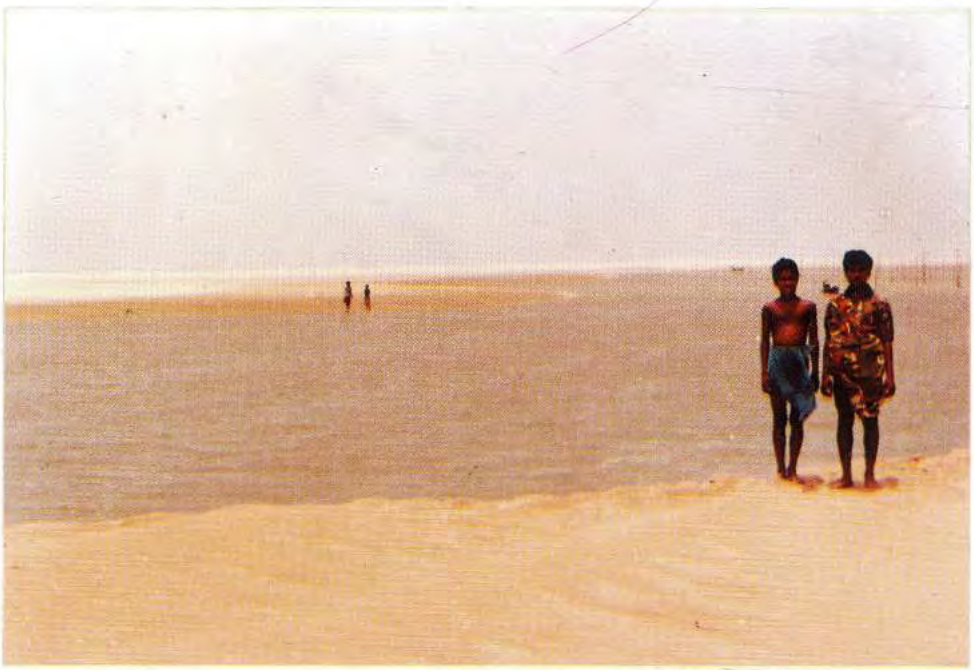
GOVT. OF ORISSA, BHUBANESWAR



Ingress of sea-water through natural mouth of the lake



The present width of the natural mouth at low tide

regular rate. The sedimentation rate in the lagoon has been worked out (ORSAC, 1988) to be 1.36 sq.km/yr contributed by the 13 million tonnes of silt that annually enters into the system. Thus, the water holding capacity of the lake is getting continuously reduced.

The bathymetry indicates the unevenness of the lagoon bed with highly diversed contour lines and also depicts an irregular slope of the bed from north to south. The annual variation of water level has been ascertained by physical measurement of depth at the specific points in all the three seasonal studies and depicted in *Fig. 1* and *Map-4.*

In the present study, a distinct decreasing trend in water depth (maximum value) was observed in southern and central sectors in pre-monsoon and monsoon months when compared with the observation of Siddiqui & Rao,1995. During the post-monsoon the water depth was reduced in southern sector but increased in the central sector as compared to 1985-87 (Siddiqui & Rao, 1995). In the northern sector only slight variation was noticed in the three seasons. Thus, sector-wise water depth of the lake was found to be irregular and variable in different seasons. A gradual sedimentation over the last decade and restricted gushing of freshwater from the river and catchment areas has resulted in hastenning up sedimentation causing irregular rise of bed level at various points in comparison to 1985-87. The comparative data is given below:

Sector-wise seasonal comparison of water depth of the Chilka lake on 1985-87 (Siddiqui & Rao, 1995) and 1995-96

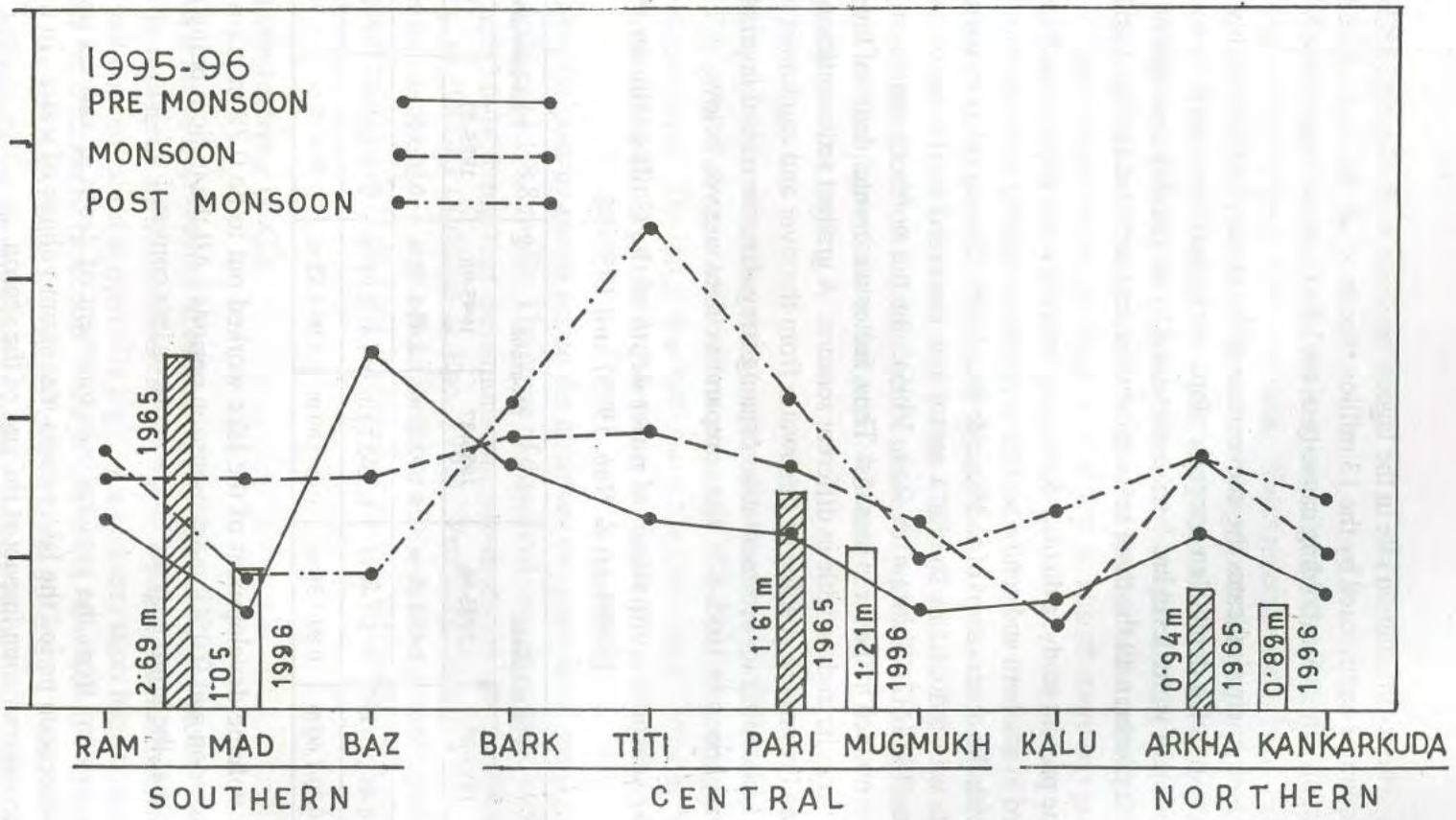
Sectors	Pre-monsoon		Monsoon		Post-monsoon	
	1985-87	1995-96	1985-87	1995-96	1985-87	1995-96
Southern	0.60-2.70 m	0.45-1.40 m	0.50-2.70 m	1.68-1.70 m	0.70-3.30 m	1.00-1.95 m
Central	0.40-2.90 m	0.58-1.44 m	0.55-2.70 m	1.41-1.98 m	0.90-2.80 m	1.10-3.47 m
Northern	0.70-1.60 m	0.80-1.30 m	0.40-1.60 m	1.09-1.82 m	0.70-1.70 m	1.50-1.78 m

The volume development of the lake worked out to be 0.78 in pre-monsoon, 0.778 in monsoon and 0.051in post-monsoon periods. All the indices being less than 1.0 indicate that the bottom of the lake is more or less convex.

It is evident from the seasonal measurement of depth at various points that during post-monsoon period the lake retains maximum volume of water. In other way the lake receives monsoon impact at the end of the season.

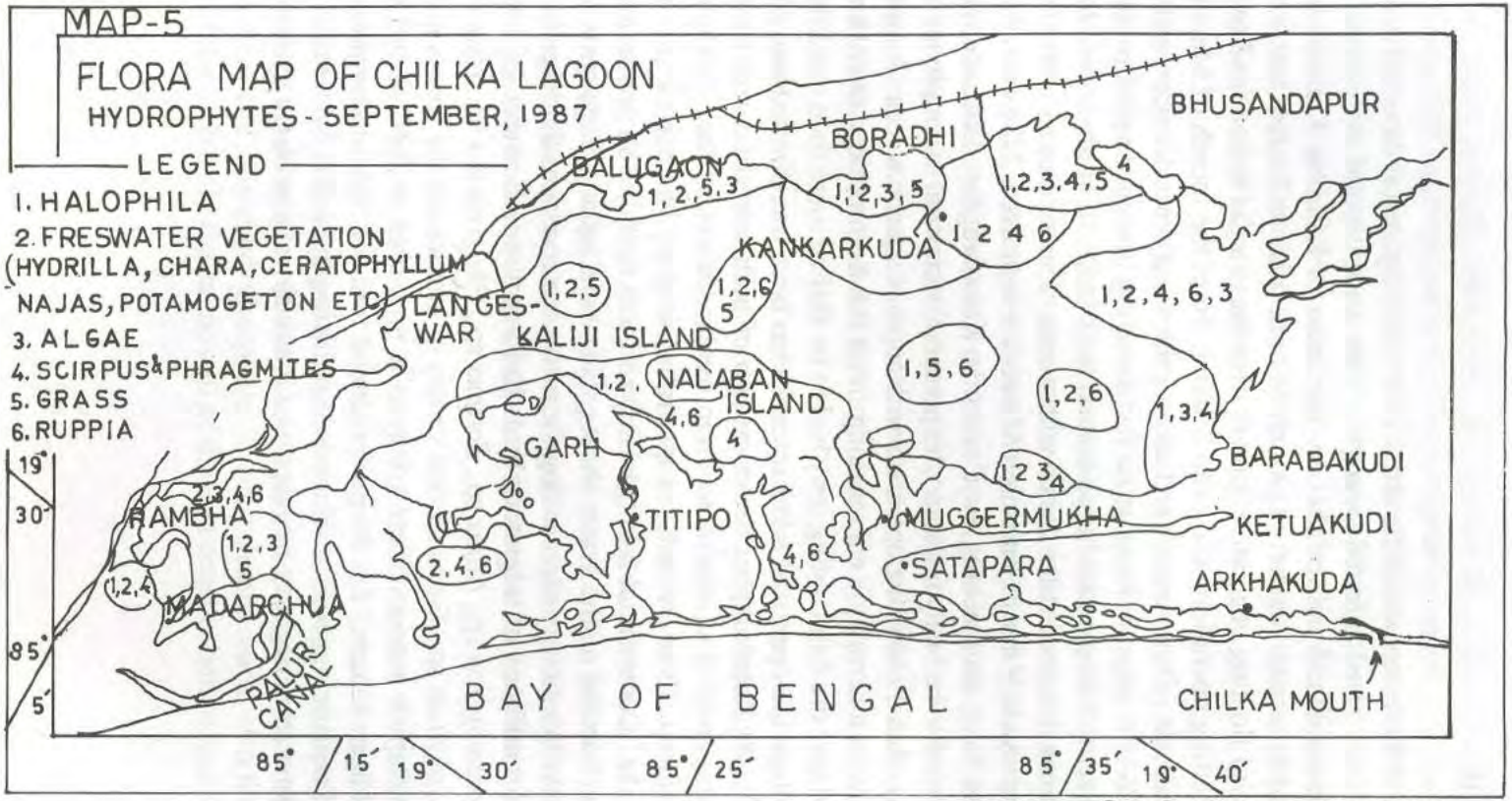
FIG. 1-WATER DEPTH OF CHILKA LAKE AT DIFFERENT CENTRES

DURING 1995-96 AV. (IN BARS) COPARED WITH 1965



Vegetative growth

During post-monsoon period the aerial view of the lagoon (as depicted in *Map-5)* at places, looked like weed infested swamps. Vast areas around the points Titipo, Parikud and Nalbana island and the shallow bay areas of Rambha, Kankarkuda and Bazarkote showed luxuriant vegetative growth of both fresh and saline water weeds. The submerged and floating vegetative growth over these areas were found to be too thick to permit netting operations and even boating. From the month of March/April onwards due to increase of temperature and salinity the weed starts decaying and during pre-monsoon period the weed is found to be fast decaying leaving marked presence of decomposed and semi-decomposed heaps around the islands. The shallower zones of the receded bay areas remained still infested with weeds. During monsoon period from August/September onwards fast regeneration of weeds was noticed. However, the silted up portion of the lake encroaching vast areas at Kaluparaghat, Bhusandapur and Tinmohani was found to be badly infested with perennial terrestrial macrophytes and the adjoining submerged shallower swampy areas with copious aquatic weeds. A rapid land formation along with macrophyte encroaching trend has been noticed over the entire belt. At Bhusandapur the fish landing jetty had to be shifted more than one kilometer into the lake and the wide open vast silted up areas has been transformed into pastures and paddy fields. At Kaluparaghat dense growth of both terrestrial and freshwater macrophytes, rising more than one meter from the land/water surface, has taken the shape of a thick forest. Narrow water strips from the slope has been kept clear for boating into the lake. Commercial fishing of any sort was found to be impossible over this vast shallow fraction of the water sheet. The wide aquatic vegetation around Nalbana has been voluminously encroaching the active water area as the huge quantum of guano from the millions of migratory birds has become rich source of nutrients. *Halophila* sp., *Potamogeton* sp., *Najas* sp., *Scripus* sp., *Phagramites* sp., *Hydrilla* sp., *Chara* sp., *Ceratophyllum* sp., *Typha* sp. and variety of grasses are the weeds generally found. A more detailed account of macrophytes is presented in *Table-3 and Map-5*. However, the huge volume of debris produced out of the decomposed and semidecomposed aquatic vegetation is not only reducing the active water area of the lagoon but also generating negative impact on its brackishwater ecology by mitigating the effect of salinity.



SOURCE- ORSAC BHUBANESWAR

Lagoon bed

The low influx rate of monsoon run off and dense vegetative growth as well as thick bottom debris have resulted in a high rate of silt deposition over the lagoon bed. The low freshwater ingress rate can not generate enough turbulance to drift the sediments out into the sea. Moreover, the aquatic weeds have formed a kind of silt trap and restrained the horizontal transportation of the silt. Accordingly the texture and chemical nature of the lagoon bed have become unstable and non-uniform as is evidenced from *Table -4*. At Kaluparaghat the bed is silty loam in texture so also at Kankarkuda, the two points representing the northern portion of the lake bed. The texture of the bed at Barkulpoint in the central sector has changed to silty sand while the southern portion of the lake bed as represented by Bazarkote is sandy clay. This texture extends eastward upto Titipo and further at Arkhakuda the sand percentage has increased to 96% or more. At Muggermukha, the main area of water exchange, the mechanical composition of bed soil is found as sandy clay.

pH is a singular index that highlights the general condition of any system. Soil in any ecosystem is a more or less stable constituent and frequent variation in soil pH is an unusual feature. Only perceptible physico-chemical disruption in the system can result in noticeable change of soil pH within a short period. Here the lagoon bed has shown marked seasonal variation in soil pH at each of the point studied indicating thereby that the bed is frequently disturbed both physically and chemically.

It is evident from *Table-4* that alomost all the points had maximum soil pH during monsoon when the level was generally between 8.2 and 8.8. During post-monsoon *i.e.*, a lapse of three months, the pH markedly reduced to the range 7.0 to 8.7 and subsequently in May *i.e.*, in pre-monsoon the pH level further reduced to the range 5.9 to 8.5. Only exception Titipo had the level 7.0 in monsoon that increased to 8.5 in post-monsoon and again reduced to 7.5 in pre-monsoon. Highly alkaline pH was noted at Arkhakuda bed where in monsoon the level was 8.8; post-monsoon 8.7 and in pre-monsoon 8.2. Muggermukha was the only point where the pH remained below 8.0 round the year. During post-monsoon Kankarkuda had the lowest pH (7.0) and Arkhakuda highest (8.7) while in pre-monsoon Parikud had the pH level 5.9, the lowest and the highest level (pH 8.5) was at Rambha. During 1985-87 the pH range of the lake was 7.2-10.66 in which the northern sector showed highest pH 10.01-10.66 (Siddiqui & Rao, 1995) in comparison to 7.0-8.8 during the present study.

The most probable reason for the unusual fluctuation of the soil pH is the decomposition and regeneration of the dense vegetative mass. The bed either remains at the anaerobic condition being covered by the debris heaps or gets widely exposed. By that the soil has to part its inherent exchange with short and long exposed chain of the cellulose and hemicellulose which reflects on the soil pH. Moreover, the carbonic acid generated out of the decomposition of the weeds also is responsible for the reduction of the soil pH during summer season.

The brackishwater lagoon bed basically being saline, the electrical conductivity (E.C.) value of the entire bed soil has been estimated to be high. The E.C. values at all the points were minimum during post-monsoon and ranged between 0.6 and 1.30 millimhos/cm^2. The level was maximum during monsoon and the noticeably high values were recorded at Muggermukha (13.0 milli mhos/cm^2), Barkulpoint (12.0 milli mhos/cm^2), Kankarkuda (9.5 milli mhos/cm^2) and Madarchua (11.5 milli mhos/cm^2). During pre-monsoon the values were in between the other two seasonal levels of the respective points. Arkhakuda maintained a reasonably low electrical conductivity compared to other points (1.2-4.0 milli mhos/cm^2).

Organic carbon is a main constituent of soil fertility. The lagoon bed has been found to have a moderate reserve of organic carbon. Kaluparaghat, Tinmohani and Kankarkuda points have the concentration 1.4-2.2%, a level considered to be moderately high. Of the other points Barkulpoint, Parikud and Titipo are with about 1% of organic carbon (0.6-1.4%). Only Arkhakuda has a very low level of the nutrient 0.1-0.3%, average (0.2%). The lagoon being weed infested, that follows a natural cycle of decay and regeneration, the organic reserve of its bed should have been much higher. Probably high salt concentration of the soil resists the carbonisation process of dead aquatic weeds.

The available phosphate level of the bed soil has been estimated to be low and mostly within the range 1.2 to 10.0 mg/100 g of soil (av. 4.7 mg/100 gm). Major portion of the available phosphate might have been used up by the extensive aquatic weeds for their luxuriant growth and according to the phosphate cycle of any ecosystem the absorbed and adsorbed phosphate is not released back into the system after decomposition. Usually the saline soil of the east coast is rich in available phosphate.

The available nitrogen in soil as estimated was high (3.3-34.2 mg/100 g) over the entire bed excepting at Arkhakuda where the maximum concentration was 5.4 and minimum 3.3 mg/100 g soil. The maximum concentration estimated was at Kaluparaghat 18.1 mg/100 g, Kankarkuda 34.2 mg/100 g, Barkulpoint 24.9 mg/100 g, Titipo 23.7 mg/100 g, Madarchua 24.3 mg/100 g and Muggermukha 20.5 mg/100 g soil. Other sampling points had the concentration mostly below 20 mg/100 g soil.

Water quality

It is the quality of water *i.e.,* its physical and chemical conditions and fertility status that governs the ecology of any water body, rather the ultimate productive potentiality of the system. Accordingly, all the index of responses are to be studied and properly interpreted. The data of analytical results on the water quality parameters of the lagoon at all the points in different season is presented in *Table-5.*

pH

pH is a singular index, determination of which enables to form a comprehensive idea regarding the nature of any ecotope. During pre-monsoon highest water pH (8.7) was recorded at Madarchua followed by Bazarkote (8.5). Arkhakuda, Titipo, Muggermukha, Kankarkuda and Rambha had the level 8.4 while the lowest value was estimated at Kaluparaghat and Parikud (8.0). Madarchua located almost at the confluence point of Palur canal with the lake, a more or less stagnant pocket which receives saline water ingress through the Palur canal without any drainage, had pH of 8.7. This physiography might have increased the pH in this area in pre-monsoon. Huge deposition of decayed weeds was probably responsible for high pH levels (8.0) at Parikud and Kaluparaghat. The pH values estimated during monsoon (August) indicated low ingress of monsoon run off and above all its non-uniform distribution over the entire water sheet due to uneven contour of the lagoon bed. During monsoon the high water pH at Bazarkote (8.7), Madarchua (8.7) and Rambha (8.5) was due to non-ingress of freshwater in these shallower bays. The main monsoon discharge enters into the lake from the north and drains out through the outer channel via Muggermukha avoiding both Barkulpoint and Titipo (8.4) where the water pH either increased or was retained as in pre-monsoon. Kaluparaghat, Kankarkuda and Parikud had the pH level of 8.0 due to aforesaid reasons.

During post-monsoon the volume of water in the lake increases, as stated earlier, and impact on pH was felt at some points. Titipo and Arkhakuda had a marked fall in pH (8.0) and rest of the points retained almost same pH level as in monsoon. Only at Parikud there was a marked rise in pH (8.5).

Dissolved oxygen (D.O.)

Dissolved oxygen is a vital parameter, essential for the sustenance, growth and all other biological processes of the aquatics. Water receives maximum oxygen from the atmosphere. The other sources of dissolved oxygen are the photosynthetic activity of both micro- and macrophytes in water and normal chemical and biochemical processes that function in any ecosystem. Increase in water salinity and temperature reduces the saturation level of dissolved oxygen. But intense wind action increases the dissolved oxygen concentration in water as it is able to absorb more oxygen directly from atmosphere.

During pre-monsoon strong south wind blows over the lagoon and the water temperature was observed to be between 29.5° and 32.5 °C and the E.C. between 1.050 and 9.500 micro mhos/cm^2. All the influence of these factors could keep the dissolved oxygen level of the lagoon water between 4.2 and 6.1 mg/l *(Table 5)*. Only at Kaluparaghat it was 9.1 mg/l.

During monsoon when the water temperature was between 29.0° and 31.5 °C and maximum E.C. *(Table-5)* was 9.500 micro mhos/cm^2 there was no marked increase in dissolved oxygen level. The range was between 4.6 and 8.1 mg/l. Only at Arkhakuda the concentration was 6.1 mg/l and at Bazarkote 8.1 mg/l.

During the post-monsoon period the dissolved oxygen was on the higher side in most of the places (4.1-8.8 mg/l). The range of dissolved oxygen content was 7.0-11.2, 4.8-14.6 and 3.0-14.0 mg/l in post-monsoon, pre-monsoon & monsoon months respectively in 1985-87 (Siddiqui & Rao, 1995). Probably the organic suspensoids brought in by the monsoon run off might have utilised some dissolved oxygen for transformation resulting in higher rate of photosynthesis by submerged macrophytes and phytoplankton.

Electrical conductivity (E.C.)

This is an indirect method of estimating the dissolved salt concentration and the resistance is measured in milli mhos/cm^2. Chilka being a brackishwater body, its dissolved salt concentration is normally high, the concentration increases in summer and reduces on dilution in monsoon. Though one sheet of water, the vastness of the water body has attributed wide logical physiographical difference from point to point. The point Arkhakuda, on the outer channel, and Muggermukha just at main lake mouth are under the direct influence of the sea. During pre-monsoon both the points were

Macrophyte encroachment at Kaluparaghat

Weed infestation at Bhusandapur

Dry bed of the lake near Satapara in summer

Exposed sandy bed of the lagoon in summer

having E.C. 3700 mmhos/cm^2 that came down to 1600 mmhos/cm^2 in monsoon and in post-monsoon . Arkhakuda had measured 1650 mmhos/cm^2 while Muggermukha 1200 mmhos/cm^2. During the three seasons the E.C. values at Kankarkuda were 2050, 9500 and 2300 mmhos/cm^2 respectively in pre-monsoon, monsoon & post-monsoon and at Madarchua 1800, 1250 and 5000 mmhos/cm^2 in the respective seasons. At rest of the points the electrical conductivity values at pre-monsoon were between 1050 and 9500 mmhos/cm^2 and during monsoon the electircal conductance increased to the range 1200 to 9500 mmhos/cm^2. Again in post-monsoon, it was measured to be between 1200 and 6000 mmhos/cm^2 *(Table -5).*

This wide difference in E.C. values from one point to another and also the irregular rise and fall during the monsoon and post-monsoon seasons reveal that some points in the lake do not experience the interflow of tidal water that exists in the lake and also proper inter mixing of saline and freshwater does not take place even in post-monsoon when the lagoon retains maximum volume of water.

Salinity

The principal index of response of any brackishwater ecosystem is salinity. The natural variation of salinity with the seasonal changes imposes an impact on the migration, maturity, breeding, growth and survival of euryhaline fishes and prawns. Salinity plays a vital role in the growth, survival and maturity of brackishwater prawn from larval stage to matured stage *i.e.,* the prawn production of any brackishwater ecosystem is directly dependent on its salinity fluctuation.

The Chilka experiences a wide variation in water salinity during the same period of any season because of its topogenic situation and also for the presence of two feeder lines *viz.,* the outer channel and the Palur canal. The areas around the confluence of the feeder channels with the lake remain more saline compared to other portions and also there are some pockets that are deprived of the normal environmental influences like intermixing of fresh and saline water etc. which the water body as a whole experiences.

During pre-monsoon the points Arkhakuda and Muggermukha had the water salinity levels of 35.4 ppt and 34.0 ppt respectively in comparison to 34.0 ppt by Siddiqui & Rao, 1995 and rest of the points were within the range of 4.9 to 8.7 ppt. Only Kankarkuda, a point on the extreme north, had the concentration of 17.8 ppt. During monsoon all the three points Arkhakuda, Muggermukha and Kankarkuda suffered marked reduction in salinity level (7.0-14.6 ppt) while at the remaining points the concentration almost doubled. Kaluparaghat had the salinity level 3.1 ppt and

Kankarkuda 7.0 ppt and rest of the points within the range 10.6 to 14.8 ppt. The rainfall during July and August 1996 at Gangadarpur was only 205 mm and 105 mm as against 270 mm and 371 mm in 1995. The low rainfall rate might have been responsible for the unusual higher salinity level during monsoon which normally is expected to be lower. The salinity curve *(Fig. 2)* drawn reveals that actual monsoon effect in the lagoon was felt during post-monsoon period. At most of the points the salinity slashed down in the post-monsoon period, *e.g.*, at Arkhakuda, Muggermukha and Titipo the concentration were 1.52 ppt, 1.14 ppt and 0.97 ppt respectively as against their level 14.4-14.6 ppt in monsoon. The points Parikud, Kankarkuda, Rambha and Barkulpoint had the post-monsoon salinity level between 1.62 and 2.76 ppt while Bazarkote and Madarchua suffered less dilution effect and the salinity levels were 5.53 ppt and 4.00 ppt respectively. This further substantiates the fact that uniform intermixing of fresh and saline water do not take place in the lagoon even when the maximum ingress of both is there. Based on salinity profile the lake was classified as mixohaline (1.99-34.0 ppt) in outer channel, mesohaline (7.0-17.0 ppt) in the south and central sector and oligohaline (0-14.5 ppt) in northern sector by Siddiqui & Rao, 1995. The present observation more or less conforms to the same.

Alkalinity

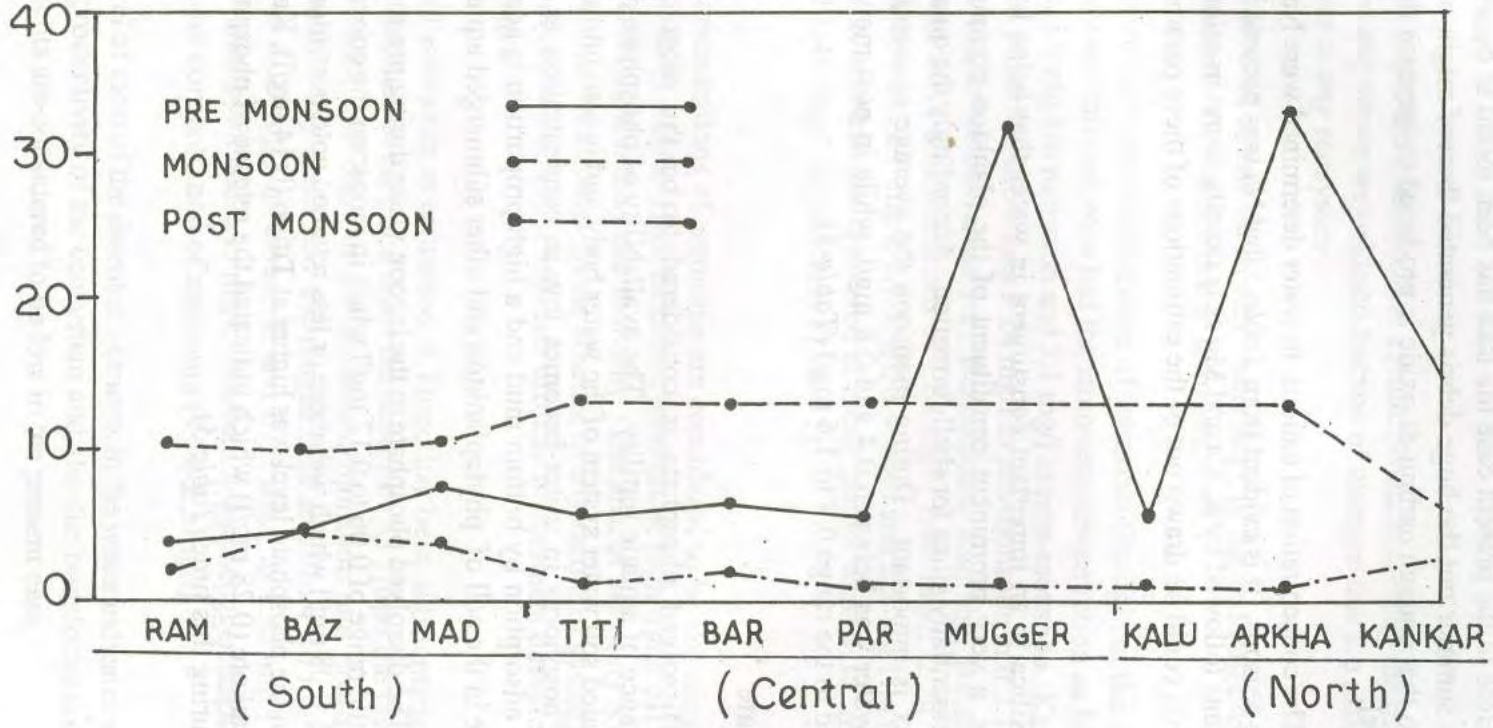
Alkalinity or acid combining capacity of natural water bodies is caused by carbonates and bicarbonates of calcium and magnesium. These alongwith dissolved carbon-di-oxide in water form an equilibrium system which is of primary importance in the ecology of the aquatic environments. Alkalinity has direct favourable effect on the growth and multiplication of phyto- and zooplankton and also on the aquatic insects.

The lake had the alkalinity level between 78.0 and 118.0 mg/l in pre-monsoon and in monsoon between 62.6 and 95.0 mg/l. In post-monsoon season also there was no marked variation in alkalinity values. Only shallow bay areas like Barkulpoint (84.0-88.6 ppm), Rambha (95.0-118.0 ppm), Bazarkote (92.9-112.0 ppm) and Madarchua (95.0-138.0 ppm) maintained slightly high values round the year. The alkalinity was recorded between 51 and 495 ppm during 1985-87 (Siddiqui & Rao, 1995).

High alkalinity values in water indicates a high carbon reserve in the water. The alkalinity in water can only be raised by the carbon-di-oxide that liberates in the course of decay of organic matter.

Fig. 2–

WATER SALINITY OF CHILKA LAKE AT DIFFERENT CENTRES DURING 1995-96.



Here in the present case the lake has been found to be weed infested that dies down in summer but the huge debris generated thereof might not decompose to that extent so that enough carbon-di-oxide is produced to increase the alkalinity to a very high level.

The concentration of cations in water determined were Na, K, Ca and Mg in all the three seasons. It is evident from *Table-5* that Na was present in highest level of the four cations followed by K, Ca and Mg as is usually found in saline water. No effective correlation could be drawn out of the estimations of these parameters.

Silica

Silica is an important constituent in water that helps in the shell formation. Diatoms, a very prominent constituent of the plankton composition in the Chilka, require essentially silica for shell formation. Accordingly the quantitative estimation of the index is important. During monsoon the average concentration of silica in the lagoon water was between 0.4 and 0.8 mg/l, while in post-monsoon period the level increased to the range 0.8 to 1.6 mg/l *(Table-5)*.

Phosphate

Dissolved phosphate is considered to be the most critical factor in the maintenance of aquatic fertility. The availability of phosphate depends on the highly complicated soil water system of the water body and is also on the marl organic matter ratio. Phosphorus in water becomes low in concentration as it rapidly disappears through adsorption by bottom mud and a high proportion is adsorbed and stored at a high rate in the cell of phytoplankton and other submerged aquatic vegetation.

The dissolved phosphate in the lagoon water during pre-monsoon was estimated to be in the range of 0.06 to 0.12 mg/l while in monsoon the concentration was between 0.04 and 0.08 mg/l which was more or less retained upto post-monsoon phase. In post-monsoon the phosphate level was higher at Titipo (0.14 mg/l), Kankarkuda (0.10 mg/l) and Bazarkote (0.28 mg/l) which indicated the release of phosphate from soil to water phase during this time *(Table-5)*.

Ammonia and nitrate

Nitrogen is an important constituent in aquatic production being the main source of protein. Ammonia and nitrate are oxidised fraction of nitrogen that are assimiable by the primary producers in any ecosystem.

The main source of ammonia in any waterbody is the oxidation of organic nitrogen present in water though atmospheric nitrogen.

The Chilka retains a high concentration of ammonia throughout the year. The point Titipo, a highly weed infested zone had the ammonia concentration as high as 7.8 mg/l in pre-monsoon, 5.9 mg/l in monsoon and 3.1 mg/l in post-monsoon. Kankarkuda another weed infested point had the levels 2.24 mg/l in pre-monsoon and 2.18 mg/l in post-monsoon. The shallower bay areas *viz.*, Barkulpoint, Rambha, Bazarkote and Madarchua had the respective concentrations of 1.68 mg/l; 1.40 mg/l; 2.24 mg/l and 0.84 mg/l in pre-monsoon and 3.1 mg/l; 3.1 mg/l; 3.4 mg/l and 2.5 mg/l in monsoon. In post-monsoon the concentrations estimated at these points were 4.34 mg/l; 1.87 mg/l; 3.10 mg/l and 1.40 mg/l respectively *(Table-5)*.

These high concentrations of ammonia are considered to be not congenial for fishes specially in their early stages. High ammonia level under high water pH becomes toxic to the juveniles and might cause mass mortality. The area of the water body being vast fish might be escaping toxic zones. In the absence of any record of systematic seed prospecting studies and routine survey it becomes difficult to comment definitely on the mortality of young fishes.

Higher level of ammonia as estimated at Titipo has been substantiated by the higher nitrate values estimated at the point in all the seasons. At Titipo the levels were 2.52 mg/l, 3.6 mg/l and 1.49 mg/l in pre-monsoon, monsoon and post-monsoon respectively. The shallow bay areas had the ranges 0.28 mg/l to 1.40 mg/l in pre-monsoon, 1.4 mg/l to 3.10 mg/l in monsoon and 0.03 mg/l to 1.87 mg/l in post-monsoon when only Barkulpoint had 2.49 mg/l. Arkhakuda and Muggermukha always had comparatively lower concentration of ammonia (0.84-2.3 mg/l).

The higher level of most of the essential nutrients in the water indicates wide gap between fertility and productivity of the ecosystem and also the transformation rate of the inorganic components are considered to be low in the present case.

Heavy metals

The heavy metals like Zn, Mn and Fe of the lagoon water could only be analysed in pre-monsoon and monsoon months and presented in *Table-6.*

In pre-monsoon Zn content of water has been found in the range of 0.01-0.17 ppm and in monsoon 0.01-0.05 ppm.

The Mn and Fe content in pre-monsoon has been seen to be 0.01-0.27 ppm and 0.02-0.18 ppm while in monsoon the range was 0.08-1.33 and 0.02-2.80 ppm respectively. The higher value of Mn (1.33 ppm) and Fe (2.80 ppm) in monsoon was recorded from Kaluparaghat like previous finding of Jhingran & Natarajan (1970).

Diurnal variation of temperature, dissolved oxygen and pH

Aquatic ecosystem suffers wide diurnal variation in temperature, D.O., and pH depending on the nature of the bottom bed, water quality and as well as the qualitative and quantitative composition of planktonic organisms. Marked variation, though sometimes detrimental to the aquatics, mostly indicates the productive potentiality of the ecotope.

It is evident from the *Tables -5* and *7a* that during pre-monsoon the average depth of the lagoon was 100 cm with maximum at Titipo (144 cm) and minimum at Madarchua (45.0 cm) when the diurnal variation of water temperature at each point was between 1 ° and 2 °C. At each point the water tempeature was maximum at 18.00 hrs and minimum at 06.00 hrs. The peak values were within the range 31.5° C to 35.5 ° C and the lowest between 28.0° and 30.0 °C. The maximum fluctuation of 4 °C to 8 °C in 24 hours was measured at Kankarkuda, Bazarkote, Madarchua and Muggermukha. During monsoon the fluctuation was between 27.5 ° and 32.5° C. *(Table-7b).* The point Bazarkote had the widest variation during the 24 hrs. with the maximum 31.0 °C and minimum 27.5° C. While the point that suffered minimum variation was Rambha (2 °C). During post-monsoon the variation was between 20.5 ° and 28.5 °C at all the points. However, the points Barakulpoint and Parikud had maximum temperature between 25.5 ° and 28.5 °C at 06.00 hrs and minimum 24.5 °C at 12.00 hrs. The point Madarchua suffered maximum fluctuation 5.0 °C and Barkul point minimum 1.0 °C *(Table -7c).*

When any water body under natural condition depicts wide diurnal variation in dissolved oxygen concentration, it indicates high rate of carbon synthesis in the system *i.e.,* high productivity. During pre-monsoon the diurnal fluctuation of D.O. values at points Parikud, Barkulpoint and Muggermukha was between 4.2 and 6.3 mg/l. The variation at Parikud was 2.1 mg/l while at Barkulpoint only 0.6 mg/l. The diurnal range at Kankarkuda was from 2.6 to 6.13 mg/l. At points Bazarkote and Madarchua the D.O. fluctuated between 1.8 and 7.7 mg/l when Madarchua had the maximum variation of 5.9 mg/l. In monsoon the D.O. level at Barkulpoint, Parikud and Kankarkuda fluctuated between 4.6 and 6.3 mg/l where Kankarkuda suffered minimum 0.22 mg/l. At Bazarkote D.O. was 2.4 mg/l at 6.00 hrs and 8.1 mg/l at 12.00 hrs. Madarchua had the peak level 9.4 mg/l at 18.00 hrs and lowest level 4.6 mg/l at 06.00 hrs. At Rambha the concentration varied between 3.4 and 6.3 mg/l during the 24 hrs. In post-monsoon there was a marked rise in the saturation percentage of D.O. During this season at Barkulpoint and Kankarkuda the concentration fluctuated between 5.4 and 7.3 mg/l while at Parikud it was between 3.6 and 8.3 mg/l. At Bazarkote, Madarchua and Rambha the fluctuations were between 6.7 and 11.4 mg/l; 4.1 and 8.1 mg/l; 5.2 and 9.6 mg/l respectively *i.e.,* there was an average variation of 4.0 mg/l. The low water temperature might have increased the saturation level but the wide fluctuation is a definite indication of high productivity.

During pre-monsoon the pH in the lake varied between 8.0 and 9.0 in 24 hrs but centre-wise variation was between 0.2 and 0.5, only at Bazarkote the variation was 0.8 with the peak value 9.0. In monsoon the pH at Barkulpoint, Parikud and Kankarkuda varied between 8.0 and 8.4 and at Madarchua and Rambha between 8.4 and 8.9. At Bazarkote the fluctuation was between 8.0 and 8.8. During post-monsoon there was wide fluctuation mostly between 8.0 and 9.0, but only at Kankarkuda the variation was between 6.2 and 8.2.

The diurnal variation study of the three parameters reveals that due to physiographic variation, there exists in this vast water body marked difference in ecological equilibrium from one point to another. The study also indicates that Bazarkote, Madarchua, Ramba (southern) and Parikud (central) are ecologically more productive.

Primary productivity

Primary productivity is considered to be one of the responsive indices of aquatic production of any ecosystem. This is an indirect method of estimating the energy stored in the water body through carbon synthesis utilising solar energy. This index is highly paradoxial as it depends on a number of natural factors like intensity of sunlight, mode of sampling, accuracy in estimation etc.

The primary productivity during pre-monsoon estimated to be minimum at Barkulpoint (41.66 mg C/ m^3 / hr) and maximum at Muggermukha (515.59 mg C/ m^3 /hr) while Kankarkuda, Parikud and Bazarkote had the values 208.32 mg C/ m^3/ hr, 140.61 mg C/m^3/hr and 104.16 mg C/m^3 / hr respectively. During monsoon the points which could be studied were Parikud (135.4 mg C/ m^3 / hr), Kankarkuda (83.3 mg C/m^3/hr) and Bazarkote (41.6 mg C/ m^3 / hr). In post-monsoon Kankarkuda had the highest value 114.57 mg C/m^3/ hr. The level estimated at Parikuda and Madarchua was 83.32 mg C/ m^3/hr and at rest of the points the primary productivity level was between 41.46 and 72.91 mg C /m^3 / hr.

It is evident from the above *(Table-8)* that there exists no clearcut relationship for the seasonal fluctuation of primary productivity level with total biomass production at different points and it may be due to the present semifluvatile nature of the waterbody as well as excessive growth of macrovegetation.

Plankton

Plankton are vital item in the food chain of fish and prawn especially at their early stages. Plankton are having no locomotion of their own and as such in a semi-fluvatile water body their estimation at one point might not represent the exact qualitative and quantitative presence in the system.

However, a detail qualitative and quantitative account of plankton as estimated in the Chilka with thier seasonal variation is presented in *Table-9(a,b,c,d).*

The total volume of plankton in 50 litres estimated to be trace to 6.00 cc in pre-monsoon; 0.1 cc to 0.5 cc in monsoon and traces to 0.5 cc in post-monsoon seasons. From the estimation, specificity could be drawn about the plankton potentiality of a particular zone or point. Parikud, Muggermukha and Kankarkuda had highest concentration 2.7 cc, 6.0 cc and 2.5 cc respectively in pre-monsoon, while in monsoon the respective volumes were 0.5 cc, 0.4 cc and 0.15 cc. and in post-monsoon the

respective volume remained same at Parikud, Kankarkuda and trace at Muggermukha. Only the point Parikud located almost at the centre of the lake had a sustained high concentration in all the three seasons, (pre-monsoon 2.7 cc, monsoon 0.5 cc and post-monsoon 0.5 cc). At the Southern Sector (Rambha, Madarchua and Bazarkote) plankton volume was 0.1 - 0.8 cc in pre-monsoon, 0.2 - 0.3 cc in monsoon and 0.03 - 0.2 cc in post-monsoon. At Barakulpoint the volume was 0.1 cc in pre-monsoon which increased to 0.15 cc in other seasons.

The population varied between 35 and 180 units/l in pre-monsoon, 12 and 96 units/l in monsoon & 8 and 57 units/l in post-monsoon. Barkulpoint though had lower volume but had the maximum population per litre while Rambha always had the lowest population. The higher volume was mainly due to the presence of prawn, fish larvae and detritus. There was always the dominance of zooplankton over the phytoplankton in each point, in all season that occupied 53.4 to 93.3% of the total population except in freshwater rivers. Phytoplankton percentage was more only at Madarchua in pre-monsoon and monsoon, at Bazarkote in monsoon and at Barkulpoint, Titipo and Parikud in post-monsoon. At Delang (R. Nun) and Balikera (R. Bhargovi) the phytoplankton was available in abundance at pre-monsoon season 83.8-88.2%.

The phytoplankton comprised Myxophyceae, Chlorophyceae and Bacillariophyceae and had the population range 2-52 units/l at the lagoon. In Myxophyceae the dominant species was *Oscillatoria* sp., that was present at all points. *Anacystis* sp. was encountered only at Titipo and Parikud during post-monsoon. Cholorphyceae were represented mostly by *Oedogonium* sp., *Spirogyra* sp. and *Ulothrix* sp. and were second in dominance. The species diversity was maximum from Bacillariophyceae group. Very thin population of *Navicula* sp. and *Nitzschia* sp., were observed in frequency and number. Zooplankton were represented only by Copepod and Rotifer groups and the concentrations were between 6 and 168 unit/l. *Cyclops* sp., *Diaptomus* sp. and nauplii practically occupied the whole zooplankton population with stray presence of *Keratella* sp. and *Brachionus* sp. amongst rotifers over the entire lake throughout the seasons.

The species diversity index worked out to be between 1.3 and 3.0 excepting at the points Titipo and Tinmohani where the value was between 0.5 and 0.8. These areas were found to be emitting gas bubbles out of the decomposition of macrophytes causing ecodegradation during the post-monsoon month when presence of *Anacystis* sp. was also recorded.

However, the dominance of zooplankton like *Cyclops* sp. and *Diaptomus* sp. in the water body indicates the rich reserve of most vital food for the post larvae and early stages of most of the fish and prawn.

Lucifer sp. a marine form was encountered only once in August at Muggermukha point. The noticeable absence of marine form of plankton in the lagoon water throughout the year indicates the low ingress of sea water and slow exchange rate. The diurnal variation of plankton concentration studied at the points do not depict any noticeable information.

Tow net collection

The operation of tow net for definite period of time helps in the screening of total micro biomass present in the sub surface water that includes plankton, fish and prawn larvae, insects, detritus etc. The estimation of this collection not only highlights the total fish food organisms present in the water body but also depicts an over all presence of the fish and prawn seed potentiality of the system.

Table-10 depicts a detail seasonal account of the composition of organisms as well as the total volume obtained from a 15 minutes operation at the points.

During pre-monsoon the volume sieved was generally between 30 cc and 55 cc at all the centres except the collection at Madarchua (95 cc) and Parikud (168 cc). At Parikud the composition was *Diaptomus* sp. 50%, *Mysis* sp. 45% and Miscellaneous 4% while at Madarchua prawn larvae 54%, plankton 15% and fish 10%. The average composition of collection of the entire lake during pre-monsoon was plankton 5 to 40%, fish and prawn larvae 1 to 64%. *Mysis* sp. 10 to 60% and Insect 1%. Debris were more in Arkhakuda (73%) and Rambha (38%).

The monsoon collections were less voluminous (4-75 cc). Tinmohani point, the confluence of rivers with the lagoon, had highest volume 88 cc followed by Kankarkuda 75 cc and Muggermukha 48 cc. The collections at Titipo, Parikud, Rambha and Bazarkote were between 4 and 7 cc. However, in the season the diversity was more with the addition of crab, gastropod, mosquito larvae, fish and mullets. *Lucifer* sp. was detected in high percentage in tow net collection at Muggermukha (45%) and Kankarkuda (60%) but at Arkhakauda, Titipo and Barkulpoint in lesser volumes. The plankton dominated the collection at Arkhakuda (95%), Titipo (95%), and Parikud

(90%) and were in minority at Tinmohani (5%), Kaluparaghat (15%) Bazarkote (2%) and Muggermukha (10%). Insect population was as high as 65% at Bazarkote. The plankton composition were also more diverse in this season.

In post-monsoon the collection at Titipo was measured 70 cc and Kankarkuda 63 cc while rest of the centres were having the volumes between 12 and 46 cc. In this season early fish fry occupied 5 to 25% of the volume at most of the points and at Bazarkote it was as high as 70%. Crustaceans were 90% at Arkhakuda, 80% at Barkulpoint, 60% at Parikud and 30% at Madarchua while at Bazarkote 1% and Muggermukha 2%. Insect larvae was 70% at Rambha, 90% at Muggermukha and 40% at Titipo.

Thus, it is evident that the biological productivity of the lake is high. The food reserve is rich and is supporting not only for the early fish and prawn but also for other higher aquatics.

Bottom biota

Benthos are another index of biological production potentiality in a water body. Its population depends on the fertility level of the bed as well as the supernatant water mass.

The lagoon bed was found to differ in texture and nutrient level but no wide diversity was observed in its bottom biota composition. Gastropod was found to be dominating over the entire bed followed by bivalve and polychaete round the year. The seasonal and zone-wise population and diversity of bottom organisms are depicted in *Table-11.*

During pre-monsoon gastropod was the only form scattered over the entire bed followed by polychaete and bivalve. At Ramba only polychaete was encountered at a very high concentration (1300 nos/m^2). The other forms present were tanaid, mysid and amphipod. Kaluparaghat, Kankarkuda, Titipo and Parikud harboured all the forms recorded. During monsoon no marked change in population and species diversity was found. The population of the dominant form of gastropod was between 1 and 437 nos/m^2 followed by bivalve 1 and 512 nos/m^2. In post-monsoon phase the bottom biota nature and population remained almost unchanged. The polychaete worms were available at Barkulpoint, Bazarkote, Rambha, Titipo, Madarchua, Muggermukha and Kaluparaghat during pre-monsoon and monsoon months and at Parikud in all the seasons.

Gastropod was mainly represented by *Cerithidea* sp., *Bellamya* sp., *Thiara* sp., *Corbicula* sp., *Fovculatus* sp. and *Nassarius* sp., and bivalve by *Modiolus* sp., *Scapharca* sp. and *Corbula* sp.

Crafts and gears

Various types of nets with modification to suit the environment and to enhance catch are in operation in Chilka lake.

The types of nets mostly encountered during the study were :

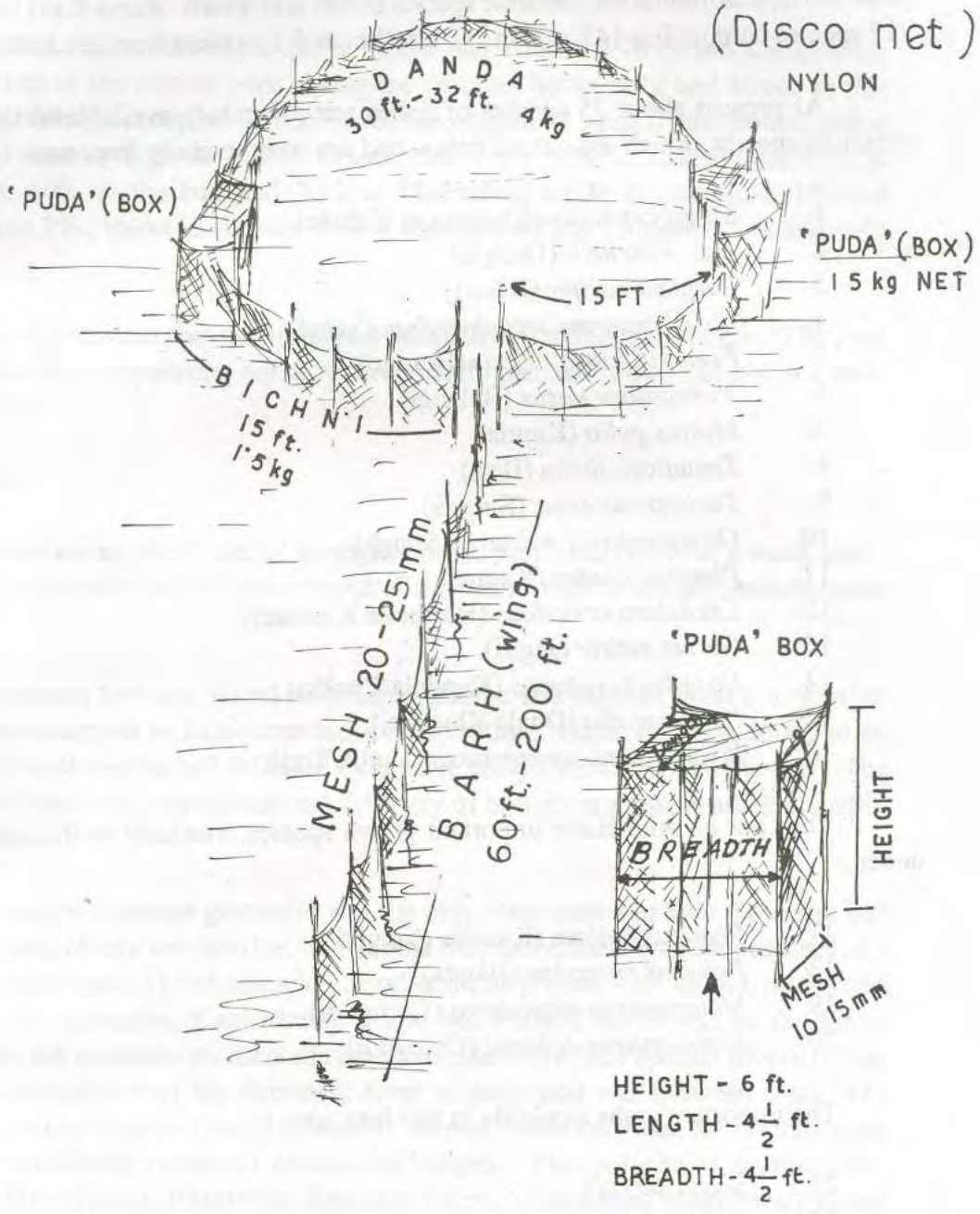
i) Fixed gill net (Panchijal, Dobi jal, Khoinga jal)
*ii) Khonda (disco net) a fixed net
iii) Gill net (bhekti jal, khati jal)
iv) Drag net (bhekti jal, khadi jal/Jangla jal)
v) Cast net (khepa jal)
vi) Seive net (Bada jal)
vii) Scoop net (Pelna jal)

* *Khonda,* popularly called as *'Disco net'*, is a recently introduced modified fixed net made of nylon twine which has replaced the *'Thatta khonda'* made of split bamboo & cotton twine (Mahapatra, 1955) and is widely used probably as an alternative of the traditional *'Jano;* fishery which had lost economic interest under changed ecological condition. Khonda is having a *'Barh'* (wing) 20 to 65 m length that meets *'Bichni'* a 10 m semi-circular end having provided with two box type traps known as *'Puda' (Fig. 3)* in the sides.

Similarly local *'Bahini fishing'* has been replaced by gill-cum-drag netting system. In the rivers mainly nylon gill nets and cast nets were found to be operated. In deeper areas in the lake having less macro vegetation gill-cum-drag net/gill net and drag net with or without pockets were in use.

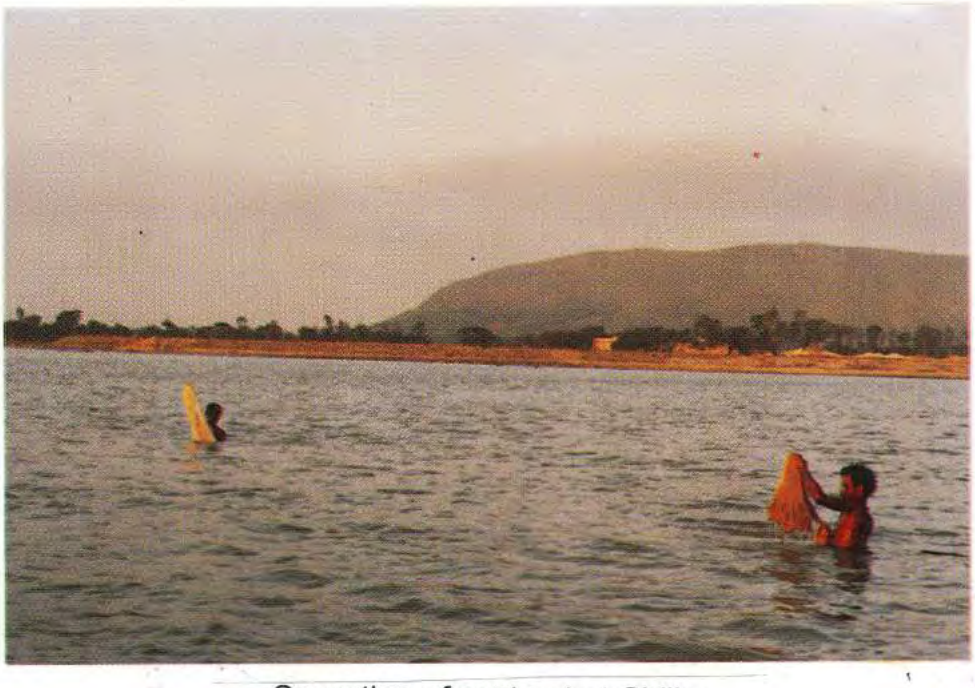
Mostly country boats were used for fishing and mechanised boats though mainly used for transportation were slowly creeping in fishing activities.

SKETCH-1
THE KHONDA OF CHILKA LAKE
(Disco net)



HEIGHT - 6 ft.
LENGTH - $4\frac{1}{2}$ ft.
BREADTH - $4\frac{1}{2}$ ft.

Fishermen with gill net at Noiri



Operation of cast net at Chilka

Fish and fishery

The Chilka maintains an ideal ecological condition to harbour and nurture catadromus, anadromus and endemic species of fish and prawn. Rama Rao (1995) listed 217 species comprising 147 genera, 71 families and 15 orders from the lake.

At present about 35 species of fishes are commonly available in the lake of which 16 species, which are named below and are commercially important :

1. *Mugil cephalus* (Khoinga or Kabala)
2. *Liza troschelli* (Dangla)
3. *Lates calcarifer* (Bekti)
4. *Eleutheronema tetradactylum* (Sahal)
5. *Pseudosciaena coibor* (Borogo)
6. *Nematalosa nasus* (Balangi)
7. *Mystus gulio* (Kontia)
8. *Tenualosa ilisha* (Ilish)
9. *Tachysurus arius* (Singda)
10. *Osteogeniosus militaris* (Sunga)
11. *Plotosus canius* (Kamuda)
12. *Crenidens crenidens* (Haribolia Khuranti)
13. *Gerres setifer* (Jagili)
14. *Etroplus suratensis* (Kundala/Chakki)
15. *Sparus sarba* (Dhala Khuranti)
16. *Strongylurus strongylurus* (Gonia/Tori)

The four commercially important prawn species, available in this lake are as under :

17. *Penaeus indicus* (Kantala chingudi)
18. *Penaeus monodon* (Bagda)
19. *Metapenaeus monoceros* (Chingudi)
20. *Metapenaeus dobsoni* (Chingudi)

The important crabs available in this lake are :

21. *Scylla serrata*
22. *Portunus* sp.

For better monitoring practices these sixteen (16) economic fish species can be classified as under based on their breeding and migration habits.

Mullets *(M. cephalus, L.macrolepis), S.sarba, L.calcarifer* and *C.crenidens* are catadromus by nature.

T.ilisha, N.nasus, P.coibor, T.arius, E.tetradactylum and G.setifer are having anadromous habit.

M.gulio, O.militaris, P.canius, E.suretensis, G.setifer, Beloniforms and *Tricanthus* sp. are endemic to the lake.

However, it is evident from the catch composition that the catadromus and anadromus species occupy more than 80% of the total stock in the lagoon. Most of the catadromus species were reported to breed near the lake mouth or inshore water in the sea while the anadromus species used to breed in the lake areas where the rivers Daya, Nun and Bhargovi discharge their monsoon runoff. The endemic species enjoy the entire northern and central sectors of the lake and Satapara area for breeding purposes. Moreover, the lake has been found to be enriched with variety of natural fish and prawn feed *viz.*, detritus, algae, zooplankton, insect larvae, fish and prawn larvae, periphytic organisms etc. to suit the aquatics in all stages of their life cycle and in all niches.

Information on the fish and fishery of the lake has been collected from the fishermen engaged in fishing inside the lake and also from the fish landing record of the competent authority. Netting operation and catches at different spots in the lake were examined *in situ* in all the three seasons and the output rate and gear efficiency have been worked out.

In pre-monsoon, at Balugaon the gill net catch was 8.6 kg in 06 hrs. It comprised mainly *E. tetradactylum, T.ilisha, Belone* sp., and *Arius* sp., while the drag net yielded 30.0 kg in the same duration with the dominance of *E.tetradactylum, T.ilisha, S.strongylurus, O.militaris, P.canius, N.nasus* and *M.gulio.* At Barkulpoint the drag net contributed 10 kg catch in 8 hrs and *Khonda* (big size) fetched 30-50 kg in 12 hrs. The catch mainly were *E.tetradactylum, Belone* sp., *Arius* sp., *O.militaris, T.ilisha, P.coibor, Tricanthus* sp. and prawn. At Kaluparaghat 10-12 mm mesh size gill net yielded 41.0 kg in 08 hrs and smaller mesh size 15 kg in 10 hrs. The species caught were *Belone* sp. and *E.tetradactylum.* At Kankarkuda the gears operated were gill net, dragnet and longline with the respective catches 10-12 kg in 08 hrs, 8-18 kg in 7/8 hrs and 9 kg in 06 hrs. Long line lifted only *P.coibor,* while other gears yielded *N.nasus,*

E.tetradactylum, Anchovies, Beloniforms. *Tricanthus* sp., *T. ilisha, M.gulio* and prawn. $1^{1}/_{2}$" mesh and 2-3" mesh gill nets operated at Kamarpur (Bazarkote) had the out put of 4.5 kg in 04 hrs and 7.0 kg in 06 hrs respectively. Dubijal gave 3-4 kg and Khonda 0.6-0.8 kg in 10 hrs. The catch comprised mullets, *E.tetradactylum, G.setifer, Puntius* sp. and prawn. At Rambha $1^{1}/_{2}$" mesh gill net produced 2.0 kg in 03 hrs and Khonda 1.5 kg in 10 hrs. The catch composition was more or less the same.

During monsoon, the gears mainly used were Khonda, gill net, fixed gill net and drag net. *Khonda* had the average catch 200 gm to 20 kg in 10 hrs. The local catches comprised mullets, *E.tetradactylum, N.nasus,* Anchovies, *T.sona, P.coibor* and *T.ilisha.*

During post-monsoon 12 hrs gill net operation at Muggermukha area was found to yield 4 to 10 kg fish having average composition of *M.cephalus, P.coibor, O.militaris, E.suratensis, A.sona, Tricanthus* sp., small hilsa and *P.monodon.* The Khonda and gill net operated at Barkulpoint produced *E.suratensis, N.nasus, S.strongylurus* and *P.monodon* and other small varieties of prawns. The drag net operation was observed at Parikud which had a total catch of 70 kg in 3 hauls in 06 hrs. The catch consisted of *M. cephalus, L.tade, Tricanthus* sp., *L. macrolepis, L.viridis, S.strongylurus, Hemiramphus* sp. etc., alongwith some freshwater species like *L.rohita, N.notopterus, B.ticto, B.stigma* and small prawn. At Rambha and Madarchua *'Khonda'* operated at night produced only 800 g - 2 kg fish comprising *M.cephalus, E.suratensis, S.strongylurus, Mystus* sp., *M.pancalus, B.ticto, Tricanthus* sp., *N.nasus,* Anchovies, *P.monodon, P.indicus, P.semisulcatus, M.malcomsoni* and *Acetes sp.*

The seasonal *in situ* observation of netting operation covering almost the entire lake and examination of their catch composition reveal that there is dominance of both catadromus and anadromus species in the lagoon. Moreover, an indication of species-wise dominance of fish can be had on analysing the catch composition. A decreasing trend of euryhaline species with the increase of freshwater species was also noted.

The total fish output from the lagoon as obtained from twelve assembly centres during the months April to July 1996 were 129.6 t, 143.1 t, 142.4 t and 142.5 t respectively and the four months total comes to 557.6 tonnes *(Table-12).* The four months average composition of fish has been found to be prawn 19.7%, mullet 12.5%, Clupeid 15.4%, perch 15.9%, threadfin 3.8%, catfish 9.4% and Beloniform 2.1% and the rest 21.2% miscellaneous species. The fish landing data of 1995-96 *(Table -13)* had also depicted the same pattern where miscellaneous group was 22.9% followed by prawn 16.9%, perch 16.6%, mullet 14.7%, clupeid 14.3%, catfish 8.4%, beloniform 3.6% and threadfin 2.6%.

Assorted fish catch landed at Balugaon

Prawn catch from the lake

Fish catch from the freshwater zone of the lake

A haul of anchovies from the lake

The high percentage of miscellaneous species in the catch composition is highly alarming. Moreover, the percentage of the total catch occupied by Perch, Threadfin and Catfish is also undeserving from economic point of view based on inter-relations of food among fishes. Kontia and Singda utilise substantial quantities of economic prawns, while Sahal, Borogo and Bekti subsist mainly on prawns, forage fish, young ones and adult of other fishes. The very high percentage of prawn seed in the tow net collection is not reflected in the total yield of prawn, the most commercially important species whose food chain is mainly comprised crustacean, detritus and zooplankton. Mullets, in spite of dominating the larval population in the lake, contribute only 12.5% to 14.7% in the total output. The species mainly thrives on bottom biota, mud and algae. Though there is overwhelming abundance of food of prawn and mullets, the predators might be primarily responsible for the comparatively low yield. The Chilka is not a self contained lake, 70 to 80% of its fish load depends on migration to sea. Abundance of migratory species in the lake mainly depends on the condition of the outer channel and unobstructed ingress and egress of water over the area from Satapara to Muggermukha. The low output in the extreme southern sector indicates inactive role of the Palur canal in the migration. Accordingly, low migration rate might be another cause of low output.

Bagda seed fishery

Reddy (1995) observed the migration of post-larvae of *P.monodon* and *P.indicus* from sea to lake throughout the year. *P. monodon* seed collection from the lagoon has of late become a lucrative commercial proposition. Not only the prawn farms developed around the lake have been procuring their seed inputs from the lake, but also the local inhabitants have become actively associated with the seed collection for sale. A battery of seed collection fixed nets are set to collect bagda seed, covering the entire mouth of the outer channel around Arkhakuda. The entire length of the Palur canal is also encroached like wise. Added to this hand scoop nets are operated indiscriminately by numerous local people engaged by the local traders. They retain only bagda seed and pine away other varieties.

Socio-economics

There are 128 fishermen villages in and around the lake with a population of about 60,000 fishers who are dependent on the lake for their livelihood. The fishermen families residing by the side of the lake are found to live below the proverty line. They mostly live in cluster forming a village having few hundred to a few thousand population. In some landing centres the fisherwomen are participating in fish disposal and engage themselves in retail business. Agriculture as usual has been a secondary occupation for some of them. The village-wise, population, family size, nets and boats and other detailed are summarised below :

i) ***Kanas (on river Daya) :*** The fishermen mohalla near the village, Dokonda (old and new) have a population of six hundred (600). There are 60 families in all residing in the village. The average catch per fisherman is reported to be 10 kg to 20 kg/day. They mainly use gill and drag net in the river. The fishermen are also visiting the Chilka lake for fishing in season. There are 3 schools and 2 cooperative societies in the village.

ii) ***Delang :*** The village is on the river Nun with a total population of 5,603. Total fishermen family are 50 nos with 300 active fishermen. The male and female percentage is 49 and 51 with six heads per family. The river Nun retains water throughout the year so fishing is continued with cast net and drag net in deep pools. They have also adopted carp culture in local ponds. The cost of fish varies from Rs. 20-25 per kg for smaller varieties and from Rs. 40-45 per kg for bigger varieties. There are 2 schools and one society.

iii) ***Balikera :*** The village is at the side of River Bhargovi and the place is called Raharmahal. Kamalnarayanpur is the fishing village situated 2 km upstream of this village. The total family of fishermen is 32 and average members per family is 10. The total population of the village is 320. There are 12 country boats and each fisherman possess 3-4 kg nets. The catch consisted of carp, small prawns and fishes. The catch per day per fisherman is 1-2 kg presently. They also operate nets and traps in the adjoining paddy fields and lowlying areas.

iv) ***Kankarkuda :*** The nearest fishermen village near the island is Noiri with a total population of 10,622 people out of which 4,826 are fishermen. While the male and female ratio is 52:48, the average number in each family varies between 5 and 6. The percentage of literacy is 15% and the village is having 3 schools and one cooperative society. About 60% fishermen are possessing their own boats and nets. Total numbers of boats are 70 and average net per head is 30 kg. The present average catch is observed as 5 kg/unit. (1 unit = 3 fishermen, 1 gill net and 1 boat). The selling price of fish varied from Rs. 15-20 per kg as per size.

v) ***Barkulpoint :*** There are two villages adjacent to the lake *i.e.,* Chilka and Chandraput. The village Chilka is having 3,000 fishermen with male : female ratio as 65 : 35. The average family consists of 3 members. There are 60 country boats and 11 mechanised boats found in the village. The village is having 4 schools with 15% literacy.

vi) ***Parikud :*** This is a comparatively larger island with 2 fishermen villages namely (a) Krishnaprasad and (b) Katiakudi. The total fishermen population are 900 and 450 respectively with about 80 families residing in both the villages. The male and female ratio is 50:50. Generally Disco net (Khonda), gill net and drag net are used by them. The present average catch per day per fisherman is varied from 5-7 kg. The lake side areas are shallow and leased out for pen culture of prawn. Each pen area varies from 30-100 acres. Prawn seed (Bagda and Kantala) are brought from Rasikullya estuary and stocked in the pens for culture. There are 4 schools in the nearby areas.

vii) ***Titipo :*** The villatge is adjacent to the Chilka lake but no fisherman population was recorded. The fringe areas of the village is found to be heavily choked with macrovegetation. The areas are also barricated by mosquito net pens (nylon) for prawn culture purpose by the local resident, private party and fisherman from nearby villages.

viii) ***Bazarkote :*** The nearby fishing village is Kumarpur with a total population of 1,500. Out of which about 800 fishermen are actively engaged in fishing activities inside the lake. All sorts of nets operated in the lake are used by them. There are 100 fishing boats and 3 mechanised boats operated by them. The present average catch per fisherman varies from 2-5 kg/day. There are two schools, 1 ice plant and 1 cooperative society in the village.

ix) ***Madarchua :*** The total population is 200 out of which about 100 fishermen are actively engaged in fishing in the lake. There are 30 families with 7-8 members per family. Only 7 country boats, Khondas and gill nets are in possession by them. The daily average catch is 1.0 kg per fisherman and the income varied from Rs. 10-20 per day. Some of them are engaged on daily wages in pens constructed in the lake pockets adjacent to the village. There are 2 primary schools nearby.

x) ***Rambha :*** The 3 mohallas of fishermen in the village are residing in Lakshmipur, Bazarsahi and Banglasahi areas. The total population is 1,450, out of which 450 are engaged in fishing in the Chilka. There are 400 families with average 4 members per family dependent on fishing and other activities. A total of 150 country boats are present and each fisherman is having 30 kg net in their possession. The prsent average catch per Khonda was observed as 1 kg (500 g-2 kg per fisherman). There are 6 schools and 1 college present in the village.

xi) ***Muggermukha :*** The nearest village is Balabhadrapuri on the main Satapara area with a total population of 2,000 fishermen. About 200 families of the village are managing 150 country boats and 20 mechanised boats for fishing. Each fisherman is having 10-12 kg nylon net. The present catch varies between 2 and 4 kg (average 3 kg) per day. The fishing is generally done during the night time. Muggermukha proper is encircled with pens and Khondas. The village is having 1 hospital, 6 schools and 1 college for the benefit of the local poeple. Dolphins are found to have established in this zone.

xii) ***Arkhakuda :*** The village is situated very near to the sea. The present mouth of the Chilka lake has shifted further 3 km east. The old mouth was found to be closed by sand bar. Though the length of the present canal is about 1 km its width is half km only in high tide period. The tidal ingress is nominal. The fishermen of this village are presently engaged in fishing at the sea also. There are 7,000 people residing in the village with 4-5 members per family. The total families are 1,600. About 2,000 fishermen are presently fishing for 12-13 hrs per day in the lake and proper sea (Bay of Bengal). The average daily catch per fisherman per day varied as 2-3 kg. A total of 700 country and 160 mechanised boats are present in the village. Each family is having 4-5 quintals of nets. Mostly all types of nets used in the lake are found in this village. Presently bagda seed *(P.monodon)* is available in the vicinity and per day 500-3,000 numbers of seeds are collected by the fishermen per net (scoop net made with mosquito cloth nylon net). They only keep bagda and dump other associated fish and prawn seed in the lake. There is 1 non-government organisation serving the village people with

ideas of child and health care, education and socio-economic upliftment of the fishermen community. One primary school is operating in the village. The approach road is not in good condition. The bulk of the fish catch is taken to Balugaon and Puri for disposal.

Ecodegradation

The study revealed that the lagoon is under severe physical, chemical and biological strain both due to natural and anthropogenic interventions. Morphological deformities of topogenic contours brought in due to climatogenic changes is a natural function but often accentuate with human intervention. The indiscriminate tampering of the river courses has markedly reduced the monsoon discharge rate resulting in a large scale deposition of silt (more than 13 million tonnes/yr) brought into the lake through monsoon washing. A large quantum of this silt would have drained off to the sea with normal unrestricted high discharge rate of the monsoon ingress of the rivers. But the same is not happening due to restricted discharge of rivers. Thus, the lagoon bed has got elevated by 22% in last six years. The volume development being below 1.0 indicates convex nature of the lagoon bed. The dense macro-vegetative proliferation in the northern sector acts as a silt trap and has helped in land formation over few square kilometers in Bhusandapur-Kaluparaghat area badly encroaching the lagoon bed.

The average depth of the lake recorded in pre-monsoon was 1.05 m in Southern sector; 1.21 m in Central sector and 0.89 m in Northern sector as against 2.69 m; 1.61 m and 0.94 m respectively in 1965 summer *(Fig. - 1)*. This has not only restricted the tidal ingress of sea water into the lake but also reduced the water holding capacity of the lagoon.

The water spread area of the lake was observed to be reducing at an alarming rate. During 1965 the water spread area of the lake was 906 sq.km while the present area is only 620 sq.km, a loss of 286 sq.km in 30 years. ORSAC (1988) reported that the Chilka Lake is suffering a peripherial reduction at the rate of 14.17 sq.km/yr *(Map-3)*.

The Coastal Environment Space Application Centre, ISRO (1992) also reported that the shrinkage is mainly attributable to the increase in sedimentation. ISRO added that two of the three openings of lagoon to the Bay of Bengal, existed in 1973,have closed due to deposition of sediments brought by long shore current and littoral drift. This has greatly reduced the tidal ingress and threatened the total ecosystem badly.

The recently formed mouth is located about 11 km north-east of Arkhakuda village, which in 1965 was at 8 km north-east and in 1914 was just opposite to the village. So the channel is getting elongated resulting in considerable reduction of tidal effect in the lake. The Palur Canal was found to be ineffective in contributing enough sea water and in helping the migration of fish and prawn.

Anthropogenic deformity has been caused by the allotment of the total 20,000 ha fringe areas of the lagoon to the fisherman and non-fisherman residents of the area for prawn farming. This allotment together with illegal encroachment due to absence of well demarcated mapping of the lake has further reduced the active water spread area of the lake to a considerable extent.

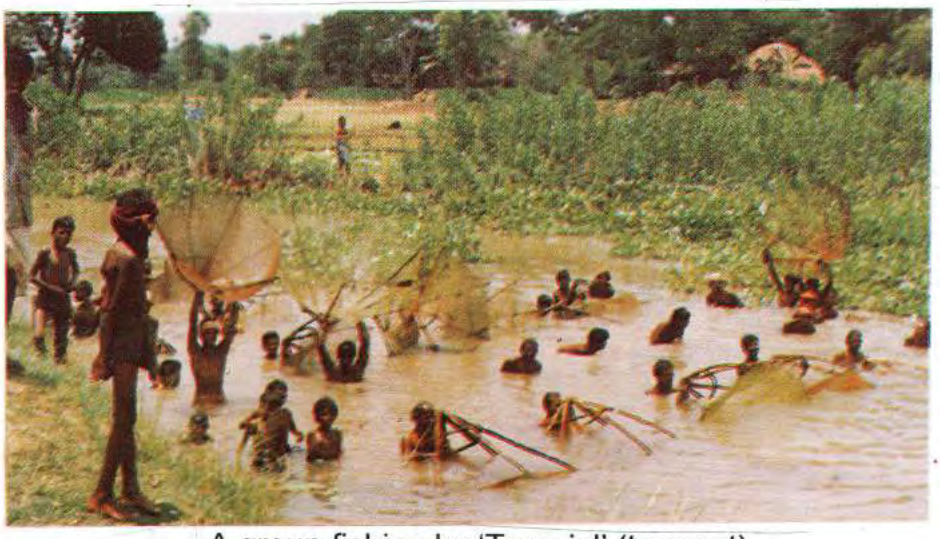
The earlier capture practices with *JANOS* also endangered the lake ecology considerably. *Janos* were huge bamboo strip enclosures often running into miles where large fish and prawn population were trapped during autumn, reared and exploited till the following winter. This semi-permanent structure helped in trapping the silt and formed silt dunes over the enclosed bed. *Khondas (Sketch-1)* that have replaced *Janos* are finely meshed net barriers fixed for short duration. This system captures even the juveniles of fish and prawn and thus endangers the normal recruitment process in the lake.

The dense vegetative growth covering a considerable water area of the lagoon and its rapid propogation are highly alarming for the ecosystem. In post-monsoon, the entire water body was found to be more or less infested with submerged macrovegetation leaving only the deeper zones. Till 1963 there was no indication about the imminent danger the lake was going to face due to the macrophytic aggression. Presently the macrophyte population was dominated by freshwater species. The propagation of the macrovegetation has been aggravated by the fall in water salinity and excess ammonia produced from the guano of the innumerable migratory birds supplemented by the fall in water level. This vegetative encroachment has reduced the active water area for the aquatic animals to a considerable extent and if left uncared might transform the vast lake in course of time into a vast swamp.

Salinity, the seasonal fluctuation of which within a definite range monitors the ecology of any brackishwater system, has been found to have declined alarmingly in concentration as compared to earlier years. During November '95 the salinity levels at sampling point of Rambha, Muggermukha and Arkhakuda were 2.69 ppt, 1.14 ppt and 1.52 ppt respectively as against the respective levels of 8.08 ppt, 3.31 ppt and 3.50 ppt in November 1960 *(Table - 14)*. Earlier studies by Jhingran & Natarajan (1970) and

Arkhakuda - a fishing village

Bagda seed collection by a scoop net



A group fishing by 'Topa jal' (trap net)

Palur canal barricaded with 'Khondas'

Pen culture in the peripherial region of the lake

Operation of 'Khonda' inside a pen at Muggermukha

Banerjee & Roy Chowdhury (1971) elucidated that there has been a gradual marked fall in salinity regime of the lagoon for decades as it succumbs to topogenic variation. The salinity of the lake is greatly influenced by the river discharge in the flood season as well as sea water influx. In 1960, only part of the northern and central sectors attained freshwater condition alongwith the outer channel. The present study reveals that the entire lagoon attained freshwater character during December/January. In monsoon the salinity level at Arkhakuda, a point in outer channel, came down to 14.6 ppt from a concentration of 35.4 ppt in pre-monsoon. The marked reduction in freshwater discharge rate of the rivers as well as untimely discharge of the freshwater might be primarily responsible for the ecological disorder in the ecotope. *Fig. 2* depicts that the salinity level of the lake has suffered a decline by about 65 to 70% during a period of 35 years. ISRO (1992) recorded the salinity as 0.21 - 4.72 ppt and 8.4 - 18.5 ppt in the northern and southern sectors respectively.

During 1960's numerous marine forms of plankton specially copepods were found to adopt themselves in the lake when the water salinity remained high *(Table-15)* while in 1995 only one marine form could be detected at Arkhakuda. This indicated the lagoon has much reduced ingress of saline water at present.

A critical analysis of total annual group-wise fish landings from the Chilka Lake during 1957 to 1965 *(Table-16)* and 1990 to 1995 *(Table-17)* reveal a definite decreasing trend of fish and prawn output from 1957 to 1965 with the regular increase of miscellaneous species percentage. The average percentages in the total yield of prawn and fish were 28.08% and 68.50% respectively while during 1990 to 1995 the prawn output has come down to 14.40%. The total fish and prawn output during 1996 has been computed to be 1,671.8 tonnes as against the average yield 4,237.41 tonnes during 1990-95. In 1995-96 the total fish landing was 1,269.80 tonnes only.

The Chilka has been a known potential source of priced prawn fishery for decades. During 1957 to 65 prawn occupied 28.08% of the total catch followed by mullets 19.07% and miscellaneous (the less priced catch) 3.42% *(Table-16)*. During 1991-95 the prawn catch came down to 14.4% *(Table-17)* and in 1995-96 16.9% The present catch as projected through the month-wise fish landings during April-July 1996 (4 months) is highly disappointing. The prawn catch was 19.7%, mullet 12.5% while miscellaneous group occupied 21.2% of the total catch.

This gradual decline of the commercial lucrative fishery of prawn and commercially important fishes is the synergestic effect of physical and ecologial degradation the lake has been experiencing from some time past.

Conclusion and Recommendations

The Chilka, a precious gift of the nature and the country's largest brackishwater lagoon on Orissa coast, was in past a potential source of fishery. The study undertaken in 1995-96 indicates that the natural heterogenity of the ecotope is in peril due to regulated inflow of the freshwater discharge through the temporary nalas and rivers (Rivers Daya, Nun, Bhargovi, Makara etc.). The irrational reduced ingress of sea water from the Bay of Bengal through its two openings near Arkhakuda and Palur canal had restricted the tidal flow in the lagoon. The frequent shifting of the natural lake mouth north-eastwards and the loose sand deposition on the Palur canal have resulted in lesser and lesser ingress of tidal water. The lagoon size is reducing at a alarming rate of 1.42 sq.km/yr and about 13 million tonnes of silt is drained into it per year. Thus, the euryhaline nature of the lake is badly threatened. Due to the physiographic changes and anthropogenic intervention the topography and original character of the lake have been fastly degrading. Finally, the environment of the lagoon is under threat resulting a marked fall in fish yield especially the prized prawn catch. Presently the lagoon bed soil is sandy-clay to sandy-silty-clay in nature and alkaline in reaction. The huge muck deposition has enriched it with high organic carbon and available nitrogen reserve. Salinity, the vital parameter in brackishwater ecosystem, which influences the natural productivity of the lake for the growth of fish and prawn has gone down in the main lagoon. During pre-monsoon months the outer channel area near the natural mouth has higher salinity due to ingress of sea water and in monsoon the mouth region suffered marked dilution due to freshwater discharge from the catchment areas and rivers but a sharp increase of salinity is noticed during this time at the central and southern sectors of the lagoon. In post-monsoon months the entire ecotope assumes freshwater character. This sharp fall in salinity may be a prime cause of dwindling of prawn fishery of the lake.

The gradual and persistant propagation of fresh and brackishwater macrophytes spreading over the entire water body leave an indication of ecological changes in the physico-chemical nature of the lagoon. Added to this, the mass decomposition of the aquatic vegetation in increased salinity level condition during pre-monsoon period pollutes the lagoon water in patches as indicated by the species diversity index of plankton at Titipo and Kaluparaghat area, which gradually changed from moderately polluted to normal condition during rest of the year.

The restricted flow of saline water, reduction of water depth coupled with available guano from 158 species of residential and migratory birds, allowed luxuriant growth of aquatic weeds covering a vast area in the vicinity of Nalabana, Titipo, Parikud, Rambha, Madarchua and Kankarkuda. At places the density of the macrophytes was recorded as high as 50-60 kg/m^2.

Since ages the Chilka has been acting as the breeding and feeding grounds of a variety of commercially important fish, prawn, mollusc and crab that are being autostocked from sea. During early fifties, the increasing demand of commercially important fish and prawn caused intensification of fishing effort by 22,095 active fishermen inhabiting in 128 villages around the periphery of the lagoon. They engaged themselves in catching fish, prawn, crab as well as bagda seed by employing different types of suitable gears resulting in mass destruction of the present stock. The enthusiastic fishermen of the locality have started barricading the entire outer channel, including natural mouth area and Palur canal with fixed small meshed gill nets and Khondas. This not only prevents the breeding migration of adult fishes to sea, but also sieves the young ones to a damaging extent while they are returning to the lagoon. In addition, the lake is harbouring the huge endemic and migratory fish and prawn population and is acting as the rearing ground for their post larvae, juvenile and adult stages to enrich the lake fauna year after year. The shallower zones and the bay areas of the lagoon have been encircled to construct pens with fine mesh nylon mosquito curtain netting cloth for the culture of penaeid prawns (bagda and kantala). Due to gradual improvement of transport system in the interior areas the fish and prawn industry of the lake has become very lucrative to the local inhabitants as well as to the outsiders.

Thus, all these accumulated results have caused a gradual decline of lucrative commercial fishery of the Chilka lake which demands a rational and judicious exploitation of fish and prawn from the lagoon for a consistent higher yield.

Topographical and physiographic deformities have been identified to be prime cause for the gradual decline of output of this brackishwater ecosystem of immense economic potentiality. Human intervention could be brought under control through administrative regulations but for an all out reclamation process scientific monitoring is indispensible to revive the lake.

Undermentioned measures need be taken immediately to rejuvenate this important brackishwater lake before it is too late and the lagoon reaches a point of no return.

a) The prime step should be to prepare a proper land use map of the lake.

b) Silt has been found to be a primary menace to reduce the water holding capacity to tamper the lagoon bed and to hinder proper exchange of fresh and saline water. Thus, the transportation of silt into the lake through monsoon run off is to be minimised by rapid aforestation programme of the denunded catchment areas of the incoming rivers and silt trap to be installed at suitable areas.

c) Tapping of river courses have resulted in lower discharge rate. This low discharge not only helps the silt to settle on the lagoon bed but also assists in scouring away the deposited silt into the sea. Accordingly, unscientific barricades from the rivers are to be revoked to increase discharge rates. The fruitful corrective measure would be to evaluate the most approximate requirement of freshwater ingress for normal maintenance of its brackishwater character and to set up a monitoring team by the Fisheries Department in collaboration with the Irrigation Department to regulate the discharge.

d) The life of the Chilka primarily depends on the proper functioning of the feeder channel. It has been evidenced that 70 to 80% of the lagoon's production depends upon successful recruitment from the sea. In other way, a healthy feeder channel is indispensible for the Chilka for undisturbed to and fro movement of the migratory fishes and prawns which might result in a better yield. At present the frequent shifting of channel mouth north-east ward during last few decades is an alarming indication for the life of the lake as it reached the extreme end. It has become essential to conduct a hydrographic survey immediately by a competant authority and to stabilise the position and width of the lake mouth at an ideal point by providing required safe guards.

e) Muggermukha is a highly strategic area for sea and freshwater exchange and also for recruitment of fish and prawn. It is imperative that the area should be kept deep to a considerable level and that should be monitored round the year. Added to this, the area should be brought under non-fishing zone to help the uninterrupted recruitment.

f) The contribution of Palur Canal in enriching the southern sector has been found to be not upto expectation. The canal requires immediate renovation so that in each high tide sea water may gush into the lake. It will be all the more better if another feeder canal at a suitable site is excavated.

g) Macrophytes from all the sectors are to be essentially eradicated by mechanical means. Bhusandapur-Kaluparaghat area should be dredged to recover the encroached area of the lake.

h) Legislation should be enforced forbidding the setting of *Khondas* in the feeder canal and other strategic areas important for recruitment of fish and prawn to the lake.

i) The present practice of indiscriminate intensive culture of *P.monodon* in the fringe areas should be stopped forthwith.

j) The biological productivity of the lake has been estimated to be very high. Accordingly supplementary stocking with mullet and prawn of desired varieties by rearing them in pens and cages in the lake might be effective and advantageous .

k) Juvenile catch should be restricted by increasing mesh size of nets.

l) Conservation of this marvellous bounty is a challenging task. Scientists alone can not accomplish the job without peoples' participation. So, help and cooperation of people from all walks of life, are essentially required for successful preservation and maintenance of this national wealth.

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Table - 1 : Air and water temperature of Chilka Lake during 1995-96

Place	Air Temp. (°C)			Water Temp. (°C)		
	Pre-monsoon May '96	*Monsoon Aug. '96*	*Post-monsoon Dec. '95*	*Pre-monsoon May '95*	*Monsoon Aug. '96*	*Post-monsoon Dec. '95*
I. RIVERS						
1. Delang	37.0	-	26.0	32.5	-	23.5
2. Kanas	34.5	-	27.0	32.5	-	25.5
3. Balikera	30.5	-	26.5	31.5	-	24.5
4. Tinmohani	-	30.0	-	-	30.0	-
II. SOUTHERN SECTOR						
1. Ramhba	34.5	30.5	24.5	31.0	30.0	26.0
2. Madarchua	28.0	26.5	23.5	30.5	29.0	23.0
3. Bazarkote	30.0	29.5	26.0	30.5	31.0	25.0
III. CENTRAL SECTOR						
1. Barkulpoint	33.0	30.0	26.0	32.0	31.5	24.5
2. Titipo	30.0	28.5	24.5	29.5	31.0	24.0
3. Parikud	31.5	30.0	26.5	29.5	31.5	24.5
4. Muggermukha	30.5	30.5	27.0	30.0	30.0	26.0
IV. NORTHERN SECTOR						
1. Kaluparaghat	32.0	28.5	-	31.0	30.0	-
2. Arkhakuda	30.2	28.0	26.5	32.5	29.5	24.0
3. Kankarkuda	30.5	28.0	25.5	32.2	29.0	23.5

Table - 2 : Rainfall data of 1995-96 at Talamohal and Gangadharpur

Name of months	Name of Centres and Years of reading		
	Talamohal '95 (in mm)	*Gangadharpur '95 (in mm)*	*Gangadharpur '96 (in mm)*
January	25.0	37.0	15.0
February	nil	-	12.0
March	60.0	26.0	4.0
April	nil	4.0	47.0
May	910.0	378.0	83.0
June	73.0	105.0	105.0
July	139.0	270.0	205.0
August	302.0	371.0	105.0 (up to 21st)
September	168.0	223.0	-
October	288.0	235.0	-
November	neg.	127.0	-
December	neg.	-	-
Total	**1965.0**	**1776.0**	**576.0**

(Source : Block Development Office, Govt. of Orissa)

Table - 3 : Availability of macrovegetation, plankton and species diversity index in Chilka during 1995-96

Name of the centres	Macrovegetation	Dominant Plankton	Phyto (u/l)	Zoo (u/l)	Species diversity index (SDI)
I. RIVER CONFLUENCE					
Tinmohani	*Eichhornia* sp. *Ceratophyllum* sp., *Lola* sp. *Potamogeton* sp. *Hydrilla* sp. *Vallisnaria* sp., *Scirpus* sp. *Ruppia* sp., *Halophila* sp., *Draparnalia* sp., *Typha* sp.	*Cyclops* sp., Nauplii	5-12	8-168	0.8-1.7
II. SOUTHERN SECTOR					
Rambha		*Ulothrix* sp., *Cyclops* sp., *Diaptomus* sp., Nauplii	4-10	11-28	1.6-2.6
Motherchua		*Spirogyra* sp., *Synedra* sp., *Navicula* sp., *Cyclops* sp., *Diaptomus* sp., Nauplii	2-52	19-20	1.8-3.0
Bazarkote		*Spirogyra* sp., *Brachionus* sp., *Cyclops* sp., *Diaptomus* sp., Nauplii	2-34	9-44	1.8-2.4
III. CENTRAL SECTOR					
Barkulpoint		*Navicula* sp., *Cyclops* sp., *Diaptomus* sp., Nauplii	10-37	24-100	1.8-2.2
Titipo		*Synedra* sp., *Diaptomus* sp., *Cyclops* sp., Nauplii	3-28	18-59	0.5-2.4
Parikud		*Moina* sp., *Cyclops* sp., *Diaptomus* sp., Nauplii	12-28	16-68	1.5-2.3
Muggermukha		*Oscillatoria* sp., *Diaptomus* sp., *Cyclops* sp., Nauplii	2-20	6-48	1.8-2.3
IV. NORTHERN SECTOR					
Kaluparaghat		*Diaptomus* sp., Nauplii	5-20	23-112	1.3-2.0
Arkhakuda		*Navicula* sp., *Brachionus* sp., *Cyclops* sp., *Diaptomus* sp., Nauplii	2-8	12-48	1.9-2.4
Kankarkuda		*Cyclops* sp., *Diaptomus* sp., Nauplii	4-12	9-44	1.9-2.3

Table - 4 : Chilka lake, soil status during 1995-96

Name of Places	Season	Mechanical analysis				*Electrical conductivity (milli mhos/ cm²)*	*Organic carbon (%)*	*Available Phosphate (mg/100 g)*	*Available Nitrogen (mg/100 g)*
		Sand %	*Silt %*	*Clay %*	*pH*				
1	2	3	4	5	6	7	8	9	10
I. RIVER									
Tinmohani	Pre-monsoon								
	Monsoon				8.5	5.5	1.6	10.0	14.1
	Post-monsoon								
II. SOUTHERN SECTOR									
Rambha	Pre-monsoon				8.5	3.5	0.4	6.0	17.5
	Monsoon				8.8	4.0	0.7	8.0	16.8
	Post-monsoon				8.3	1.3	0.6	1.6	15.8
Madarchua	Pre-monsoon				7.4	9.0	1.1	6.0	19.7
	Monsoon				8.0	11.5	0.8	2.4	24.3
	Post-monsoon				8.1	1.1	0.6	6.8	18.3
Bazarkote	Pre-monsoon				6.9	5.5	0.5	6.0	17.5
	Monsoon	85.5	1.2	13.3	8.6	4.0	0.4	6.0	3.4
	Post-monsoon	87.7	0.3	12.0	7.7	1.0	0.5	2.8	16.5

Contd. ..... table 4.

III. CENTRAL SECTOR

1	2	3	4	5	6	7	8	9	10
Barkulpoint	Pre-monsoon				8.1	3.0	0.9	10.0	10.6
	Monsoon	45.3	53.4	1.3	8.3	12.0	1.4	3.2	24.9
	Post-monsoon	45.4	53.4	1.2	7.9	1.1	0.8	2.8	18.6
Titipo	Pre-monsoon				7.5	7.0	1.1	6.0	23.7
	Monsoon	80.1	3.1	16.8	7.0	6.5	0.6	6.0	15.0
	Post-monsoon	83.5	1.1	15.4	8.5	0.6	0.8	4.8	16.8
Parikud	Pre-monsoon				5.9	6.5	1.1	6.0	22.8
	Monsoon				8.3	7.0	0.8	6.0	16.5
	Post-monsoon				7.6	1.0	0.9	1.6	23.7
Muggermukha	Pre-monsoon				7.1	8.0	0.4	4.0	11.3
	Monsoon	44.1	15.1	40.8	7.6	13.0	0.3	2.4	17.9
	Post-monsoon	49.1	11.2	39.7	7.9	0.6	0.9	1.6	20.5

Contd. ..... table 4.

IV. NORTHERN SECTOR

1	2	3	4	5	6	7	8	9	10
Kaluparaghat	Pre-monsoon	14.3	56.8	28.9	8.1	5.5	1.4	4.0	18.1
	Monsoon				8.2	5.5	1.8	1.2	18.0
	Post-monsoon							-	
Arkhakuda	Pre-monsoon				8.2	1.2	0.2	6.0	5.1
	Monsoon				8.8	4.0	0.3	4.0	5.4
	Post-monsoon	97.9	1.1	1.0	8.7	1.2	0.1	2.4	3.3
Kankarkuda	Pre-monsoon				7.7	9.5	1.9	6.0	23.1
	Monsoon	18.3	57.1	24.6	8.3	9.5	2.2	4.0	22.8
	Post-monsoon				7.0	1.2	1.8	2.4	34.2

Table - 5 : Physical & Chemical characteristics of Chilka water during 1995-96

Places	Seasons	Water depth (m)	Transp. (Cm)	Air temp. (°C)	Water temp. (°C)	D.O. (ppm)	Free CO_2 (ppm)	pH	Electric cond. (mmhs/cm^2)	Tot. Alk. (ppm)
I. RIVERS										
DELANG	Pre-monsoon	0.40	36.0	37.0	32.5	5.5		7.9	330	92.0
	Monsoon									
	Post-monsoon	0.51	0.35	26.0	23.5	5.7		7.4	265	84.0
KANAS	Pre-monsoon	0.26	31.0	34.5	32.5	4.4		7.8	550	114.0
	Monsoon									
	Post-monsoon	0.35	0.27	27.0	25.5	8.06		8.0	295	92.0
BALIKERA	Pre-monsoon	0.62	26.0	30.5	31.5	5.3		8.0	200	46.0
	Monsoon									
	Post-monsoon	1.80	0.52	26.5	24.5	6.2		7.8	205	82.0
TINMOHANI	Pre-monsoon									
	Monsoon	1.15	23.0	30.0	30.0	4.4		8.0	125	82.08
	Post-monsoon									

Contd. ..... table 5.

Places	Seasons	Water depth (m)	Transp. (Cm)	Air temp. (°C)	Water temp. (°C)	D.O. (ppm)	Free CO_2 (ppm)	pH	Electric cond. (mmhs/cm^2)	Tot. Alk. (ppm)
II. SOUTHERN SECTOR										
RAMBHA	Pre-monsoon	1.40	27.00	34.5	31.0	5.5		8.4	7000	118.00
	Monsoon	1.69	107.00	30.5	30.0	4.8		8.5	1200	95.04
	Post-monsoon	1.95	1.53	24.5	26.0	5.2		8.7	2400	102.00
MADARCHUA	Pre-monsoon	0.45	47.00	28.0	30.5	4.2		8.7	1800	108.00
	Monsoon	1.70	1.70	26.5	29.0	4.6		8.7	1250	95.04
	Post-monsoon	1.00	0.76	23.5	23.0	4.1		8.4	5000	138.00
BAZARKOTE	Pre-monsoon	1.30	75.00	30.0	30.5	5.1		8.5	7500	112.00
	Monsoon	1.68	1.68	29.5	31.0	8.1		8.7	1400	92.88
	Post-monsoon	1.05	1.05	26.0	25.0	8.8		8.8	6000	94.00

Places	Seasons	Water depth (m)	Transp. (Cm)	Air temp. (°C)	Water temp. (°C)	D.O. (ppm)	Free CO_2 (ppm)	pH	Electric cond. (mmhs/cm^2)	Tot. Alk. (ppm)
III. CENTRAL SECTOR										
BARKULPOINT	Pre-monsoon	1.25	15.00	33.0	32.0	4.7		8.2	1050	84.00
	Monsoon	1.98	76.00	30.0	31.5	5.2		8.4	1550	88.56
	Post-monsoon	2.10	0.62	26.0	24.5	7.0		8.4	3350	88.00
TITIPO	Pre-monsoon	1.44	28.70	30.0	29.5	5.1		8.4	9500	82.00
	Monsoon	1.98	103.00	28.5	31.0	4.8		8.4	1650	84.24
	Post-monsoon	3.47	1.87	24.5	24.0	5.7		8.0	1300	91.56
PARIKUD	Pre-monsoon	1.28	34.00	31.5	29.5	5.5		8.0	8500	94.00
	Monsoon	1.82	115.00	30.0	31.5	5.0		8.0	1600	84.00
	Post-monsoon	2.22	0.52	26.5	24.5	8.3		8.5	2200	96.00
MUGGERMUKHA	Pre-monsoon	0.58	20.00	30.5	30.0	5.1		8.4	3700	110.00
	Monsoon	1.41	27.00	30.5	30.0	5.7		8.3	1600	79.92
	Post-monsoon	1.10	0.62	27.0	26.0	8.0		8.4	1200	64.00

Contd. ..... table 5.

Places	Seasons	Water depth (m)	Transp. (Cm)	Air temp. (°C)	Water temp. (°C)	D.O. (ppm)	Free CO_2 (ppm)	pH	Electric cond. (mmhs/cm²)	Tot. Alk. (ppm)
IV. NORTHERN SECTOR										
KALUPARAGHAT	Pre-monsoon	0.80	24.00	32.0	31.0	9.1		8.0	1450	84.00
	Monsoon	1.09	7.00	28.5	30.0	4.7		8.0	4200	62.64
	Post-monsoon									
ARKHAKUDA	Pre-monsoon	1.30	45.00	30.2	32.5	5.3		8.4	3700	102.00
	Monsoon	1.82	54.00	28.0	29.5	6.1		8.4	1600	77.76
	Post-monsoon	1.78	0.26	26.5	24.0	7.4		8.0	1650	64.00
KANKARKUDA	Pre-monsoon	0.85	22.00	30.5	32.5	6.1		8.4	2050	78.00
	Monsoon	1.56	24.00	28.0	29.0	5.2		8.0	9500	73.44
	Post-monsoon	1.50	0.59	25.5	23.5	5.5		8.2	2300	92.00

Contd. ..... table 5.

Places	Seasons	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Salinity (ppt)	Nitrate (ppm)	Phosphate (ppm)	NH_3 (ppm)	Silicate (ppm)
I. RIVERS										
DELANG	Pre-monsoon	5.0	125.0	6.2	1.20		1.68	0.04	3.0	1.20
	Monsoon									
	Post-monsoon	1520.0	420.0				2.18	0.16	3.72	1.0
KANAS	Pre-monsoon	25.0	150.0	3.8	0.4		0.84	0.12	1.4	1.2
	Monsoon									
	Post-monsoon	1400.0	490.0				0.95	0.22	1.87	0.60
BALIKERA	Pre-monsoon	0.02	100.0	4.0	2.2		1.40	0.06	1.96	0.06
	Monsoon									
	Post-monsoon	1500.0	380.0				1.87	0.04	2.18	1.0
TINMOHANI	Pre-monsoon									
	Monsoon	3.0	140.0	6.8	18.4	0.7		0.08		
	Post-monsoon									

Contd. ..... table 5.

Places	Seasons	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Salinity (ppt)	Nitrate (ppm)	Phosphate (ppm)	NH_3 (ppm)	Silicate (ppm)
II. SOUTHERN SECTOR										
RAMBHA	Pre-monsoon	1500.0	250.0	7.8	14.6	4.9	0.84	0.06	1.40	0.80
	Monsoon	3000.0	400.0	10.6	29.6	11.3	2.20	0.06	3.10	
	Post-monsoon	4500.0	750.0	3.1	4.6	2.7	0.64	0.06	1.87	1.00
MADARCHUA	Pre-monsoon	2450.0	275.0	13.8	33.2	8.7	0.84	0.04	0.84	0.80
	Monsoon	2100.0	325.0	11.8	29.6	11.3	2.00	0.06	2.50	
	Post-monsoon	1200.0	950.0	2.9	11.0	4.0	0.03	0.06	1.40	0.80
BAZARKOTE	Pre-monsoon	1000.0	175.0	11.6	8.2	5.2	1.40	0.06	2.24	0.80
	Monsoon	1700.0	300.0	9.6	35.2	10.6	3.10	0.06	3.40	
	Post-monsoon	1400.0	1100.0	3.1	14.3	5.5	0.61	0.28	3.10	1.40

Contd. ..... table 5.

Places	Seasons	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Salinity (ppt)	Nitrate (ppm)	Phosphate (ppm)	NH_3 (ppm)	Silicate (ppm)
III. CENTRAL SECTOR										
BARKULPOINT	Pre-monsoon	1100.0	175.0	8.0	20.4	7.6	0.84	0.08	1.68	0.80
	Monsoon	900.0	200.0	6.8	56.0	14.8	2.80	0.06	3.10	
	Post-monsoon	6700.0	850.0	2.2	7.0	2.8	2.49	0.06	4.34	1.00
TITIPO	Pre-monsoon	1200.0	250.0	8.0	16.2	6.6	2.52	0.04	7.80	0.80
	Monsoon	1000.0	300.0	9.0	42.0	14.4	3.60	0.06	5.90	
	Post-monsoon	3000.0	700.0	1.7	3.0	1.0	1.49	0.14	3.10	0.80
PARIKUD	Pre-monsoon	800.0	200.0	8.0	14.8	6.7	0.84	0.06	1.40	0.60
	Monsoon	600.0	210.0	10.4	31.2	14.2	2.20	0.04	2.80	
	Post-monsoon	4500.0	750.0	2.1	4.2	1.6	1.26	0.04	1.87	1.00
MUGGERMUKHA	Pre-monsoon	36000.0	650.0	22.2	99.4	34.0	0.28	0.06	0.84	0.40
	Monsoon	32000.0	670.0	12.0	40.2	14.6		0.04		
	Post-monsoon	3100.0	650.0	1.8	2.3	1.1	1.87	0.04	2.18	0.80

Contd. ..... table 5.

Places	Seasons	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Salinity (ppt)	Nitrate (ppm)	Phosphate (ppm)	NH_3 (ppm)	Silicate (ppm)
IV. NORTHERN SECTOR										
KALUPARAGHAT	Pre-monsoon	1900.0	275.0	9.60	33.00	5.60	0.28	0.06	0.84	0.40
	Monsoon	700.0	200.0	11.60	20.60	3.10		0.08		
	Post-monsoon									
ARKHAKUDA	Pre-monsoon	11000.0	525.0	26.00	92.80	35.40		0.06		
	Monsoon	9000.0	550.0	8.40	54.00	14.60	1.40	0.08	2.30	
	Post-monsoon	3800.0	750.0	2.20	2.70	1.52	1.56	0.04	1.56	0.84
KANKARKUDA	Pre-monsoon	3100.0	350.0	15.20	47.60	17.80	1.40	0.06	2.24	0.60
	Monsoon	1350.0	275.0	6.40	24.60	7.00		0.08		
	Post-monsoon	4800.0	750.0	1.20	6.20	2.09	1.87	0.10	2.18	1.60

Table - 6 : Heavy metal concentration in Chilka water (ppm) during 1995-96

Name of Centres	Zinc		Manganese		Iron	
	Pre-monsoon	*Monsoon*	*Pre-monsoon*	*Monsoon*	*Pre-monsoon*	*Monsoon*
RIVERS						
Delang	0.02	x	0.05	x	0.04	x
Kanas	ND	x	0.01	x	ND	x
Balikera	ND	x	0.27	x	ND	x
Tinmohani	x	ND	ND	0.18	x	0.03
SOUTHERN SECTOR						
Rambha	0.02	0.01	0.21	0.09	ND	0.04
Madarchua	0.03	0.01	0.10	0.10	ND	0.03
Bazarkote	0.09	0.02	0.06	0.10	ND	0.02
CENTRAL SECTOR						
Barkulpoint	0.06	0.05	0.23	0.21	0.07	0.07
Titipo	0.02	0.03	0.08	0.14	0.18	0.09
Parikud	0.02	0.03	ND	0.12	0.02	0.06
Muggermukha	ND	ND	0.02	0.17	0.02	0.03
NORTHERN SECTOR						
Kaluparaghat	0.01	0.03	0.15	1.33	ND	2.80
Arkhakuda	0.02	ND	0.16	0.08	0.04	0.02
Kankarkuda	0.17	ND	0.04	0.13	0.04	0.02

ND = Not detected

Table - 7a : Seasonal diurnal variation at various centres in Chilka lake *(Pre-monsoon)*

Centres	Date	Time (hrs.)	Temperature		pH	DO (ppm)	Primary productivity (mgC/m ^{3}/hr)	Sp. Conductivity (millimhos/cm)
			Air (°C)	Water (°C)				
1	2	3	4	5	6	7	8	9
SOUTHERN SECTOR								
Rambha								
Madarchua	22.5.96	12.00	28.0	30.5	8.7	4.2	Cloudy	1800
	22.5.96	18.00	31.5	35.5	8.7	7.7		
	22.5.96	24.00	29.5	30.0	8.4	3.6		
	23.5.96	6.00	29.0	28.0	8.2	1.8		
Bazarkote	21.5.96	12.00	30.0	30.5	8.5	5.1	104.16	7500
	21.5.96	18.00	29.5	33.0	9.0	6.1		
	21.5.96	24.00	29.0	28.5	8.4	2.4		
	22.5.96	6.00	28.5	29.0	8.2	1.8		

Contd. ..... table 7a.

CENTRAL SECTOR

1	2	3	4	5	6	7	8	9
Barkulpoint	18.5.96	12.00	33.0	32.0	8.2	4.7	41.66	1050
	18.5.96	18.00	31.0	31.5	8.4	5.1		
	18.5.96	24.00	*No collection due to stormy weather*					
	19.5.96	6.00	28.5	30.0	8.2	4.5		
Parikud	19.5.96	12.00	31.5	29.5	8.0	5.5	140.61	8500
	19.5.96	18.00	32.0	31.5	8.4	6.3		
	19.5.96	24.00	29.0	30.5	8.4	4.9		
	20.5.96	6.00	28.0	29.0	8.0	4.2		
Muggermukha	25.5.96	12.00	30.5	30.0	8.4	5.1	515.59	3700
	25.5.96	18.00	33.0	33.5	8.7	6.1		
	25.5.96	24.00	30.0	30.5	8.5	5.3		
	26.5.96	6.00	29.0	29.5	8.5	4.4		
NORTHERN SECTOR								
Kankurkuda	24.5.96	12.00	30.5	32.5	8.4	6.1	208.32	2050
	24.5.96	18.00	31.0	33.5	8.2	4.8		
	24.5.96	24.00	30.0	31.5	8.0	2.6		
	25.5.96	6.00	30.0	29.5	8.0	3.4		

Table - 7b : Seasonal diurnal variation at various centres in Chilka lake *(Monsoon)*

Centres	Date	Time (hrs.)	Temperature		pH	DO (ppm)	Primary productivity (mgC/m ^{3}/hr)	Sp. Conductivity (miliimhos/cm)
			Air (°C)	Water (°C)				
1	2	3	4	5	6	7	8	9
SOUTHERN SECTOR								
Rambha	19.8.96	12.00	30.5	30.0	8.5	4.8		1200
	19.8.96	18.00	28.0	30.0	8.4	6.3		
	19.8.96	24.00	27.0	29.0	8.5	6.3		
	20.8.96	6.00	28.0	31.0	8.5	3.4		
Madarchua	19.8.96	12.00	26.5	29.0	8.7	4.6	Rainy	1250
	19.8.96	18.00	29.0	30.5	8.9	9.4		
	19.8.96	24.00	26.5	29.0	8.8	6.8		
	20.8.96	6.00	26.5	29.0	8.7	4.6		
Bazarkote	18.8.96	12.00	29.5	31.0	8.7	8.1	41.6	1400
	18.8.96	18.00	29.0	30.5	8.8	7.6		
	18.8.96	24.00	25.0	27.5	8.7	3.3		
	19.8.96	6.00	25.5	27.5	8.0	2.4		

Contd. ..... table 7b.
CENTRAL SECTOR

1	2	3	4	5	6	7	8	9
Barkulpoint	15.8.96	12.00	30.5	32.5	8.4	5.2		1550
	15.8.96	18.00	30.0	31.5	8.2	5.7		
	15.8.96	24.00	29.5	32.0	8.4	4.8		
	16.8.96	6.00	28.0	30.5	8.4	5.0		
Parikud	16.8.96	12.00	30.0	31.5	8.0	5.0	135.4	1600
	16.8.96	18.00	28.5	31.0	8.4	6.3		
	16.8.96	24.00	28.5	30.0	8.2	4.6		
	17.8.96	6.00	28.0	29.0	8.0	4.6		
Muggermukha								

Contd. ..... table 7b.

NORTHERN SECTOR

1	2	3	4	5	6	7	8	9
Kankarkuda	21.8.96	12.00	28.0	29.0	8.0	5.2	83.3	9500
	21.8.96	18.00	28.5	30.0	8.0	5.0		
	21.8.96	24.00	29.0	29.5	8.0	5.2		
	22.8.96	6.00	27.5	28.5	8.0	5.2		

Table - 7c : Seasonal diurnal variation at various centres in Chilka lake *(Post-monsoon)*

Centres	Date	Time (hrs.)	Temperature		pH	DO (ppm)	Primary productivity (mgC/m ^{3}/hr)	Sp. Conductivity (millimhos/cm)
			Air (°C)	Water (°C)				
1	2	3	4	5	6	7	8	9
SOUTHERN SECTOR								
Rambha	5.12.95	12.00	24.5	26.0	8.7	8.3	41.46	2400
	5.12.95	18.00	23.5	25.0	8.7	9.6		
	5.12.95	24.00	20.0	24.2	8.7	7.5		
	6.12.95	6.00	21.5	20.5	8.7	5.2		
Madarchua	7.12.95	12.00	23.5	23.0	8.4	4.1	83.32	5000
	7.12.95	18.00	25.5	26.0	8.6	8.1		
	7.12.95	24.00	21.5	24.5	8.6	6.2		
	8.12.95	6.00	17.0	21.0	8.6	5.4		
Bazarkote	6.12.95	12.00	26.0	25.0	8.8	8.8	52.08	6000
	6.12.95	18.00	25.5	26.0	9.0	11.4		
	6.12.95	24.00	25.0	25.5	9.0	8.8		
	7.12.95	6.00	22.0	23.0	9.0	6.7		

Contd. ..... table 7c.

CENTRAL SECTOR

1	2	3	4	5	6	7	8	9
Barkulpoint	1.12.95	12.00	26.0	24.5	8.4	7.0	72.91	3350
	1.12.95	18.00	26.0	24.5	8.4	7.3		
	1.12.95	24.00	25.5	25.0	8.2	7.3		
	2.12.95	6.00	21.0	25.5	8.4	5.7		
Parikud	3.12.95	12.00	26.5	24.5	8.5	8.3	83.32	2200
	3.12.95	18.00	25.5	25.0	8.4	7.5		
	3.12.95	24.00	25.0	25.5	8.0	3.6		
	4.12.95	6.00	23.5	28.5	8.1	5.4		
Muggermukha								
NORTHERN SECTOR								
Kankarkuda	30.11.95	12.00	25.5	23.5	8.2	5.6	114.57	2300
	30.11.95	18.00	23.5	24.0	8.2	7.0		
	30.11.95	24.00	22.5	23.5	6.2	8.0		
	1 .12.95	6.00	22.0	22.5	8.0	5.4		

Table - 8 : Primary productivity (mgC/m^3/hr) of Chilka lake during 1995-96

Name of centres	Pre-monsoon	Monsoon	Post-monsoon
SOUTHERN SECTOR			
Rambha	Cloudy	Cloudy	41.46
Madarchua	Cloudy	Cloudy	83.32
Bazarkote	104.10	41.60	52.08
CENTRAL SECTOR			
Barkulpoint	41.66	Cloudy	72.90
Parikud	140.61	135.40	83.32
Muggermukha	515.59	-	-
NORTHERN SECTOR			
Kankarkuda	208.32	83.30	114.57

Table - 9a : Plankton availability in Chilka lake (1995-96)

Centre	Season	Total Vol. (cc)	PHYTOPLANKTON (U/L)				ZOOPLANKTON (U/L)						
			Chloro-phyceae	Baci-llario-phy-ceae	Myxo-phy-ceae	Total No. %	Cope-pod	Roti-fer	Pro-tozoa	*Luci-fer* sp.	My-sid	Total No. %	Misc.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
RIVERS													
Delang	Pre-M	Tr.	82	52	16	150 (88.2)	20	-	-	-	-	20 (11.8)	
	M	-	-	-	-	-	-	-	-	-	-	-	
	Post-M	0.3	2	-	-	2 (10.0)	18	-	-	-	-	18 (90.0)	
Kanas	Pre-M	Tr.	4	-	4	8 (8.0)	88	-	4	-	-	92 (92.0)	
	M	-	-	-	-	-	-	-	-	-	-	-	
	Post-M	0.1	-	4	8	12 (42.9)	10	6	-	-	-	16 (57.1)	
Balikera	Pre-M	Tr.	64	56	4	124 (83.8)	24	-	-	-	-	24 (16.2)	
	M	-	-	-	-	-	-	-	-	-	-	-	
	Post-M	0.3	6	6	2	14 (58.3)	8	-	2	-	-	10 (41.7)	

Contd. ..... table 9a.

CONFLUENCE

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tinmohani	Pre-M	-	-	-	-	-	-	-	-	-	-	-	
	M	Tr.	4	-	-	4 (33.3)	8	-	-	-	-	8 (66.7)	Fish larvae
	Post-M	-	-	-	-	-	-	-	-	-	-	-	

M = Monsoon, Tr = Trace

Table - 9b : Plankton availability in Chilka lake (1995-96)

Centre	Season	Total Vol. (cc) in 50 l	PHYTOPLANKTON (U/L)				ZOOPLANKTON (U/L)						
			Chloro-phyceae	Baci-llario-phyceae	Myxo-phy-ceae	Total No. %	Cope-pod	Roti-fer	Pro-tozoa	*Luci-fer* sp.	My-sid	Total No. %	Misc.
SOUTHERN SECTOR													
Rambha	Pre-M	0.1	3	-	4	7 (20.0)	28	-	-	-	-	28 (80.0)	
	M	0.3	5	-	2	7 (46.7)	7	1	-	-	-	8 (53.3)	
	Post-M	0.03	2	-	8	10 (41.7)	14	-	-	-	-	14 (58.3)	*
Madarchua	Pre-M	0.8	48	-	4	52 (72.2)	20	-	-	-	-	20 (27.8)	
	M	0.2	15	16	2	33 (60.0)	16	-	-	6	-	22 (40.0)	Gastro-pod - 2 Fish scale - 1
	Post-M	0.2	2	-	-	2 (9.1)	16	4	-	-	-	20 (90.9)	
Bazarkote	Pre-M	0.7	8	-	-	8 (15.4)	44	-	-	-	-	44 (84.6)	
	M	0.2	24	8	2	34 (79.1)	9	-	-	-	-	9 (20.9)	
	Post-M	0.2	-	-	2	2 (12.5)	12	2	-	-	-	14 (87.5)	

Contd. ..... table 9b.

CENTRAL SECTOR

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Barkulpoint	Pre-M	0.1	8	4	-	12 (10.7)	92	-	8	-	-	100 (89.3)	
	M	0.15	6	1	7	14 (14.6)	82	-	-	-	-	82 (85.4)	
	Post-M	0.15	-	25	8	33 (57.9)	20	-	4	-	-	24 (42.1)	
Titipo	Pre-M	Tr.	10	8	-	18 (37.5)	30	-	-	-	-	30 (62.5)	
	M	0.5	-	2	1	3 (4.8)	59	-	-	-	-	59 (95.2)	
	Post-M	Tr.	-	-	28	28 (60.9)	18	-	-	-	-	18 (39.1)	
Parikud	Pre-M	2.7	35	1	-	36 (34.6)	68	-	-	-	-	68 (65.4)	
	M	0.5	4	-	-	4 (8.5)	43	-	-	-	-	43 (91.5)	
	Post-M	0.5	-	-	20	20 (55.6)	16	-	-	-	-	16 (44.4)	Mosquito larvae - 3 Bivalve - 3

M = Monsoon, Tr = Trace

*Gastropods - 2; Mosquito larvae - 2; Crustacean eggs - 2; Fish larvae - 1; Fish scale -1

Table - 9 c : Plankton availability in Chilka lake (1995-96)

Centre	Season	Tot. Vol. (cc)	PHYTOPLANKTON (U/L)				ZOOPLANKTON (U/L)						
			Chloro-phyceae	Baci-llario-phy-ceae	Myxo-phy-ceae	Total No. %	Cope-pod	Roti-fer	Pro-tozoa	*Luci-fer* sp.	My-sid	Total No. %	Misc.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
CENTRAL SECTOR													
Muggermukha	Pre-M	6.0	12	-	8	20 (29.4)	28	-	20	-	-	48 (70.6)	
	M	0.4	-	-	2	2 (6.1)	26	-	-	5	-	31 (93.9)	
	Post-M	Tr.	2	-	-	2 (25.0)	6	-	-	-	-	6 (75.0)	
NORTHERN SECTOR													
Kaluparaghat	Pre-M	0.4	-	4	8	12 (6.7)	168	-	-	-	-	168 (93.3)	
	M	0.3	-	3	2	5 (18.5)	19	-	-	-	3	22 (81.5)	Fish larvae - 1
	Post-M	-	-	-	-	-	-	-	-	-	-	-	
Arkhakuda	Pre-M	0.2	4	4	-	8 (14.3)	48	-	-	-	-	48 (85.7)	Gastro-pod - 1
	M	0.1	3	3	-	6 (30.0)	14	-	-	-	-	14 (70.0)	
	Post-M	Tr.	2	-	-	2 (14.3)	10	2	-	-	-	12 (85.7)	

Contd. ..... table 9c.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Kankarkuda	Pre-M	2.50	12	-	-	12 (21.4)	36	-	-	-	8	44 (78.6)	
	M	0.15	1	3	-	4 (33.3)	8	-	-	-	-	8 (66.7)	Crustacean eggs - 1
	Post-M	0.15	-	-	4	4 (11.8)	30	-	-	-	-	30 (88.2)	

M = Monsoon, Tr = Trace

Table 9 d : Plankton availability in Chilka lake (1995-96)

PHYTOPLANKTON

Chlorophyceae :	*Eudorina* sp., *Mougeotia* sp., *Oedogonium* sp., *Spirogyra* sp., *Ulothrix* sp., *Pediastrum* sp., *Chaetomorpha* sp.	
Bacillariophyceae :	*Fragilaria* sp., *Navicula* sp., *Nitzschia* sp., *Melosira* sp., *Pinnularia* sp., *Synedra* sp., *Coscinodiscus* sp., *Gyrosigma* sp., *Asterionella* sp.	
Myxophyceae :	*Oscillatoria* sp., *Anabaena* sp., *Anacystis* sp., *Lyngbya* sp., *Netrium* sp.	

ZOOPLANKTON

Copepods :	*Cyclops* sp., *Diaptomus* sp., Nauplii	*Pre-monsoon :* 18.5.96 - 29.5.96 (Tr. - 6.00 cc)
Rotifers :	*Keratella* sp., *Brachionus* sp.	*Monsoon :* 15.8.96 - 23.8.96 (0.1 - 0.5 cc)
Protozoa :	*Lacane* sp., *Arcella* sp.	*Post-monsoon :* 3.11.95 - 12.12.95 (Tr. - 0.5 cc)

Table - 10 : Tow net collection from various centres in Chilka lake during 1995-96

Centres	Seasons	Total vol. (cc)	Crus-ta-cean (%)	Fish (%)	Fish lar-vae (%)	Gas-tro-pod (%)	Insect & larvae (%)	*Luci-fer* sp. (%)	Mo-llusc (%)	*Mysis* sp. (%)	Misc. (%)	Plank-ton (%)	Pra-wn (%)	Prawn larvae (%)	Plant ma-tter (%)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I. RIVERS															
Balikera	Pre-monsoon														
	Monsoon														
	Post-monsoon	25		15							5		80		
Tinmohani	Pre-monsoon														
	Monsoon	88	2	35		5	1				3	5	49		
	Post-monsoon														
II. SOUTHERN SECTOR															
Rambha	Pre-monsoon	48								50	38	10	2		
	Monsoon	5		2			20				28	20	30		
	Post-monsoon	46		10			70				20				
Madarchua	Pre-monsoon	95		10			1				20	15	54		
	Monsoon	20									25	5		70	
	Post-monsoon	45	30	20							50				
Bazarkote	Pre-monsoon	30	4	30			1				25	20	20		
	Monsoon	4					65		2		6	2	25		
	Post-monsoon	19	1	70							29				

Contd. ..... table 10.

III. CENTRAL SECTOR

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Barkulpoint	Pre-monsoon	***Due to cyclonic weather townet could not be operated***													
	Monsoon	15			5		5		5		55	30			
	Post-monsoon	14	80	10							10				
Titipo	Pre-monsoon	32			50						20	30			
	Monsoon	5			2						3	95			
	Post-monsoon	70	15	5			40				40				
Parikud	Pre-monsoon	168								45	5	50			
	Monsoon	7									10	90			
	Post-monsoon	38	60	25							15				
Muggermukha	Pre-monsoon	36							2	10	38	40			10
	Monsoon	48						45			10	10	35		
	Post-monsoon	19	2				90				8				

Contd. ..... table 10.

IV. NORTHERN SECTOR

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Kaluparaghat	Pre-monsoon														
	Monsoon	40			50	5					5	15			25
	Post-monsoon														
Arkhakuda	Pre-monsoon	32		1			1				73	15	10		
	Monsoon	15									5	95			
	Post-monsoon	12	90								10				
Kankarkuda	Pre-monsoon	55		30			5			60		5			
	Monsoon	75		20				60			5	5			10
	Post-monsoon	63	40		55		0.5				4.5				

Table - 11 : Benthic population encountered in Chilka lake during 1995-96

Centres	Season	Amphi-pod	Algae	Bi-valve	Fish lar-vae	Gas-tro-pod	Insect	Insect larvae	Iso-pod	My-sid	Poly-chaete	Plant seed	Prawn & Prawn larvae	Plant frag-ment	Tan-aid
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I. RIVERS															
Delang	Pre-M					6									
	M	*No collection*													
	Post-M			2		437					1				
Kanas	Pre-M			5		7									
	M	*No collection*													
	Post-M	1		2		34		14							
Balikera	Pre-M					2		4			8				
	M	No collection													
	Post-M					6					3		1		
Tinmohani	Pre-M	No collection													
	M			3		47									
	Post-M	No collection													

Contd. ..... table 11.

II. SOUTHERN SECTOR

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rambha	Pre-M										1300				
	M	10		31		29					2				
	Post-M					1							1	20 **	
Madarchua	Pre-M										3				2
	M	5									4				
	Post-M	4	Many *					14		5			2		
Bazarkote	Pre-M					4						1			
	M							2			5				2
	Post-M	78		3		17				3			6		

Contd. ..... table 11.

III. CENTRAL SECTOR

Barkulpoint	Pre-M	35		70		12									
	M			16							1				
	Post-M			1				5							
Titipo	Pre-M	25			1	1					4				2
	M					5					2				
	Post-M					10		30							
Parikud	Pre-M	3		1		12				11	30				
	M		5								3			1	
	Post-M										34				
Muggermukha	Pre-M			7		18					3				
	M			19							24				
	Post-M	3		512					10	2		1	3		2

Contd. ..... table 11.

IV. NORTHERN SECTOR

Kaluparaghat	Pre-M	21				14		1			1				13
	M	16				80									40
	Post-M	No collection													
Arkhakuda	Pre-M			1		6									
	M			12		4									
	Post-M					1				2					
Kankarkuda	Pre-M	7		2		47					11				30
	M			29		28						2			
	Post-M	1		2		34		14							

M= Monsoon, * = *Oscillatoria* sp., ** = *Ruppia* sp.

Table - 12 : Group-wise fish landing (in kg) in Chilka during April-July, 1996

	April '96	May '96	June '96	July '96	Percentage
Mullets	15,425.0	18,258.0	18,605.0	17,261.0	12.5
Clupeids	18,036.0	20,942.0	18,670.0	28,419.0	15.4
Perches	24,538.0	25,090.0	21,736.0	17,189.0	15.9
Threadfins	3,725.0	5,086.0	5,735.0	6,910.0	3.8
Catfishes	9,976.0	12,462.0	15,370.0	14,419.0	9.4
Beloniforms	3,175.0	3,006.0	3,067.0	2,706.0	2.1
Prawns	26,198.0	29,196.0	27,707.0	26,616.0	19.7
Miscellaneous	28,530.0	29,036.0	31,533.0	28,943.0	21.2
Total	**129,603.0**	**143,076.0**	**142,423.0**	**142,463.0**	

(Source : Dept. of Fisheries, Govt. of Orissa)

Table - 13 : Group-wise fish landings of Chilka Lake from April 1995 to March 1996 (in kg)

Centre	*Mullet*	*Clupeid*	*Perch*	*Threadfin*	*Catfish*	*Prawn*	*Beloniform*	*Others*	*Total*
Balugaon	101167	79014	125922	15044	36110	139600	26471	107387	630715
Arkhakuda	11254	7755	6309	2020	3620	20204	955	6831	58948
Noiri (Kankarkuda)	4493	7295	5452	1169	6027	4370	2223	16899	47928
Kaluparaghat	9315	13148	6670	2168	9486	5885	1596	26559	74827
Soran	5516	14073	8702	1791	11223	7519	3929	30163	82915
Boridi	4343	7993	7211	1255	7067	4936	1777	20960	55544
Mangaljodi	4393	6488	2049	1213	5022	1634	989	17454	39242
Bhusandapur	7850	14567	4946	2549	7940	3021	1477	25789	68139
Rambha	6124	4372	5249	1178	4957	2123	1125	5970	31098
Sabulia	7055	6906	7682	1510	5481	2202	1500	7829	40165
Keshpur	13078	10280	14260	1961	5535	11537	1805	12631	71087
Pathara	11696	8953	16079	1473	4434	10615	2125	11814	67189
Total	186286	180844	210531	33331	106902	213646	45972	290286	1269789
Percentage	14.7	14.3	16.6	2.6	8.4	16.9	3.6	22.9	100

(Source : Dept. of Fisheries, Govt. of Orissa)

Table - 14 : Some hydrological parameters of Chilka lake during 1957-1960 & 1995 *(only for the month of November)*

	1957	*1958*	*1959*	*1960*	*1995*
Rambha					
Salinity (ppt)	19.27	6.49	7.57	8.08	2.69
Silicate (ppm)	2.5	3.2	3.4	4.8	1.0
pH	8.7	8.4	8.2	8.4	8.7
Phosphate (ppm)	1.6	0.01	Trace	0.01	0.06
Satapara (Muggermukha)					
Salinity (ppt)	7.0	1.04	2.10	3.31	1.41
Silicate (ppm)	2.8	3.5	4.0	4.5	0.80
pH	8.3	8.1	8.4	8.7	8.4
Phosphate (ppm)	0.09	Trace	Trace	0.02	0.04
Arkhakuda					
Salinity (ppt)	25.54	3.0	2.58	3.50	1.52
Silicate (ppm)	3.0	4.5	3.2	2.8	0.8
pH	8.5	8.5	8.4	8.6	8.0
Phosphate (ppm)	0.02	Trace	Trace	0.02	0.04

(Source for the years 1957-60 - Banerjee & Roychoudhury, 1970)

Table - 15 : Comparison of plankton availability in Chilka lake between 1958-60 and 1995-96

Year	Plankton availability in c.c.	
	Minimum	*Maximum*
1958-59 *	9.53	78.23
1959-60 *	5.85	47.50
1995-96	Traces	6.00
*** Available Marine forms of Plankton in 1958-60**		

1. *Isias tropica*
2. *Labidocera pavo*
3. *Acartia centrura*
4. *Oithona brevicornis sphaericus*
5. *Oithona nana*
6. *Paratagestes* var. *similis*
7. *Saphirella* sp.

(Source - Jhingran, 1963)

Table - 16 : Fish catch from Chilka lake in tonnes during 1957-65

	1957	1958	1959	1960	1961	1962	1963	1964	1965	Av.	%
Prawn	1119.48	1158.56	1209.17	917.79	863.85	920.62	657.00	548.24	1862.53	1028.58	28.08
Fish	3310.97	2613.62	2390.14	1526.73	3886.81	2774.00	3128.72	2584.28	2369.32	2509.39	68.50
Misc.	25.23	65.70	197.43	159.06	110.50	202.25	142.63	82.38	143.78	123.44	3.42
Total	**4455.68**	**3837.88**	**3796.74**	**2603.58**	**4861.16**	**3896.87**	**3928.35**	**3214.90**	**4375.83**	**3661.41**	

Source : Jhingran and Natarajan, 1969.

Prawn - 28.08%, Mullet - 19.1%, Perch - 11.0%, Catfish - 12.4%, Clupeoid - 12.1%, Sciaenid - 5.9%, Threadfin - 6.4%, Beloniform - 1.5% and Misc. - 3.4%

Table - 17 : Fish catch from Chilka lake in tonnes during 1990-95 and April-July, 1996

	1990-91	1991-92	1992-93	1993-94	1994-95	Av.	%	April-July 1996 *
Prawn	481.20	876.10	951.20	686.50	176.30	643.26	14.40	109.7
Fish	4273.30	4556.19	4158.28	3484.70	1415.20	3577.53	85.20	447.8
Crab	23.57	29.63	15.44	11.37	3.10	16.62	0.40	0.3
Total	**4778.07**	**5461.92**	**5124.92**	**4182.57**	**1594.60**	**4237.41**		1671.8 (computed)

Source : Department of Fisheries, Govt. of Orissa

12 Landing Centres : Balugaon, Keshpur, Pathara, Rambha, Sabulia, Bhusandapur, Noiri, Kaluparaghat, Saran, Baridi, Arkhakuda and Mangal Jodi

* Prawn - 19.7%, Mullet - 12.5%, Clupeoid - 15.4%, Perch - 15.9%, Catfish - 9.4%, Beloniform - 2.1%, Threadfin - 3.8% and Misc. - 21.2%