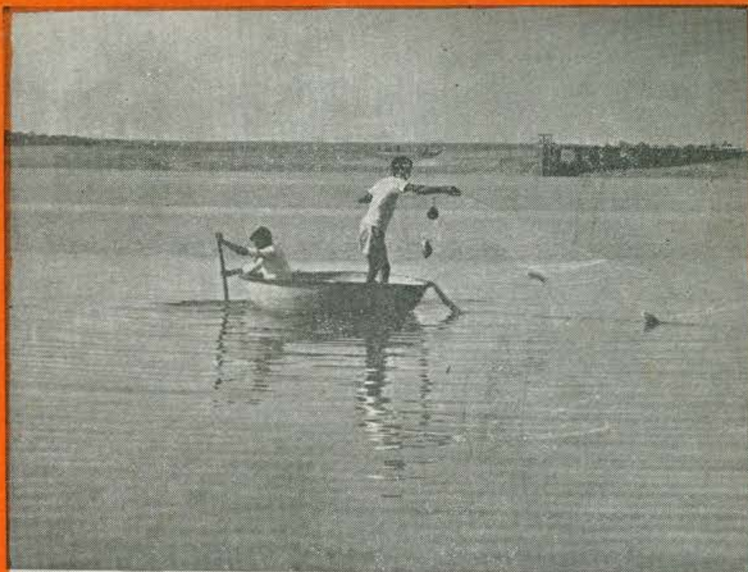

1971-81

FINAL REPORT

ALL INDIA CO-ORDINATED RESEARCH PROJECT

ECOLOGY AND FISHERIES OF FRESHWATER RESERVOIRS

NAGARJUNASAGAR

INLAND FISHERIES RESEARCH
INFORMATION SERIES 3
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FOREWORD

Nagarjunasagar was taken up as a centre under the All India Coordinated Project on Ecology and Fisheries of Freshwater Reservoirs under the IV Five Year Plan and the investigations started in 1971. In spite of many handicaps faced by this centre including want of a boat, that came in the way of full-scale investigations, the studies revealed many interesting findings in terms of physico-chemical parameters; primary productivity; biotic communities like plankton, benthos, etc. and fish populations and their behaviour. Nagarjunasagar in limnological terms is quite productive though this is not reflected in the yield output. Over the years, the catch structure has changed with the dominant note of carp initially, giving way to catfishes subsequently and this is one of the primary reasons for the reduced fish productivity from the reservoir. In addition, the studies have also shown that reservoir remained largely unexploited in the intermediate sector and exploited only marginally in lotic sector. All these factors plus free fishing policy have contributed to a lower catch and catch per unit area from this reservoir. Investigations have also enlarged our understanding of limnology and fisheries of the reservoir. It is hoped that the recommendations and suggestions made in the report would lead to better production from the reservoir.

It gives me great pleasure to place on record the excellent cooperation extended to the Reservoir Project unit by the Director and staff of the Department of Fisheries, Government of Andhra Pradesh and the Officials of State PWD at Nagarjunasagar and Srisailam.

5. 3. 1983

A.V. Natarajan
Director

C O N T E N T S

1 INTRODUCTION

Considerable importance has been given in the Five Year Plans to the construction of reservoirs. These are primarily meant for irrigation and power generation and in some cases for flood control and water supply to urban areas and industries. At present the total area under reservoirs is put at 3 million hectares. This is expected to double at the turn of the century with the construction of more dams to meet the ever growing demand for power, irrigation and drinking water. These water bodies are no less important for fish production. Our per capita consumption of protein is dismably poor and to meet the protein requirements of our growing population, it is imperative that all the available water bodies are made productive in terms of fish.

At the present level of management, the fish yield from reservoirs is rather poor at an annual average of 6 to 7 kg/ha. This situation arises mainly from lack of understanding of reservoir ecosystem and lack of expertise on the principles of stock dynamics *vis-a-vis* fishing effort and mesh size, leading to wrong selection of species for stocking and irrational exploitation. The All India Coordinated Project on Reservoir Fisheries was launched in 1971 with centres at different eco-climatic condition with a view to elucidating principles of scientific management of reservoirs so as to obtain maximum sustained yield. One of the centre is at Nagarjunasagar, Andhra Pradesh.

Nagarjunasagar Centre came into existence in 1969. Detailed investigations onthe ecology and fisheries were under taken during 1971-80. The results of these investigations embody this report.

1. METHODOLOGY OF SAMPLING

Basic morphometric data as given in 'Methodology on Reservoir Fisheries Investigation in India' were collected from local P.W.D. Authorities. Shore line, shore development were computed.

Daily water level, inflow and outflow data were obtained from local P.W.D. authorities. Monthly average level, corresponding average area and average capacity were computed. Monthly total inflow and outflow were estimated. Annual water level fluctuations were arrived at.

Daily minimum air temperature and maximum air temperature and precipitation at the dam site were obtained from P.W.D. authorities. Monthly averages of minimum air temperature, maximum air temperature and total rain fall were computed. Wind velocity could be collected only for a few months as the anemometer became out of order later.

Physico-chemical properties of water and soil

Water

For the purpose of sampling the reservoir has been divided into three sectors *viz*. lentic, intermediate and lotic (Fig. I). Lentic sector covers the dam site and adjoining regions where lacustrine conditions prevail. Lotic sector covers the region from Srisailam at the head end to down upto about 20 km. This region is characterized by the existence of fluviatile conditions during summer and monsoon and lentic conditions during post monsoon months when the reservoir is full. The three bays Peddamungal, Shunkishala in the lentic sector and Dindi bay in the Intermediate sector were treated seperately for sampling purpose.

Three samples for water quality were taken monthly from each sector and bays from littoral and limnetic regions covering both the banks in alternate months. However from 1974 quarterly collections were made in Lentic, intermediate and Peddamungal bay. With the boat becoming out of order only one sample has been taken each from Lentic, lotic and Peddamungal bay with the help of coracle.

Depth studies were made regularly in profundal zones of all sectors from 1974 onwards at every 1 m in summer and at every 3 m in other seasons.

Diurnal variation studies were made from June 1974 onwards. Surface samples were collected at 0600, 1200 and 1800 hrs from profundal zones of each sector and Peddamungal Bay. Data were presented only from 1975 to 1977, when significant changes were noted.

Soil

Samples were collected once in six months, generally during April/May and November/December. In the absence of boat samples were collected with the help of coracle from November 1971 to June 1973 and after the boat was available from November 1973 to October 1974, samples were collected using the boat. Later the programme could not be pursued as the boat became out of order. Initially the samples were collected for every 2 square miles area and later for every 10 square miles area.

Primary Productivity

From November 1971 to September 1973, primary production studies were made onlya at the surface of various sectors only. in the litteral zone. From October 1973, quarterly studies were made in littoral, sublitteral and profundal zones of each sector and Peddamungal bay from surface to compensation depth (approximately). Studies were made by light and dark bottle method and the incubator period was generally 12 hrs.

Plankton

Plankton samples were collected alongwith water samples, vertical hauls were taken with a nylobolt (No. 25) plankton net of 30 cm diameters. Hauls were taken at littoral, deep and middle regions of each sector in every month.

Bottom biota and Periphyton

Quarterly sampling was made from July 1973 to June 1974 from the three sectors and Peddamungal bay and Shunkishala bay. Samples were collected at every 2 m depth upto 10 m depth, at every 5 m upto 30 m depth, at every 10 m upto 50 m depth and at 75 m depth using an Ekman dredge (6"x6").

Periphyton samples from natural substrata were collected from January 1975 to December 1976 and on artificial substrata (supended slides) during 1977. The slides were fixed at every 1 m interval from surface upto 4 m and samples were collected once in every 15 days.

Reproduction and recruitment

Spawn collections were made during monsoon using standard shooting nets at Srisailam. During 1974, 75 and 76. Dragnets of 1/8" and 1/16" meshes were operated once in a month in Peddamungal bay, lotic and lentic sectors for juvenile collection.

Yield estimation

Sampling was done at the four main landing centres *viz.*, Sagar camp (for lentic sector catches), Macherla (for intermediate sector catches), Srisailam (for lotic sector catches) and Peddamungal (for Peddamungal bay catches) for four days in every month generally and the monthly estimates of landings were made. Samples of fishes were measured for length frequency studies.

Stocking

Data obtained from State Fisheries Department were analysed.

2 DAM DETAILS AND MORPHOMETRY OF THE RESERVOIR

Nagarjunasagar Dam is constructed across the river Krishna in the Districts of Guntur/Nalgonda of Andhra Pradesh. The location of the dam is 16°34'N/79° 19'E. Construction of this multipurpose dam was started in the year 1955 and it was completed in 1969.

Name of River : Krishna

Location : (a) Latitude/Longitude - 16°34'N/79°19'E.

(b) State : Andhra Pradesh

(c) District : Guntur/Nalgonda.

Year of commencement of construction - 1955

Year of completion of construction - 1969.

Purpose : Irrigation, hydel and flood control

Dam details :

Left earth dam	2560.219 m
Right earth dam	853.406 m
Central Spillway section of masonary dam	470.897 m
Left non-overflow section of masonary dam	425.789 m
Right non-overflow section of masonary dam	552.885 m
Total dam length	4863.196 m

Level (above M.S.L.) of :

River bed at dam site	73.149 m
Diversion Tunnel	121.915 m
Pen stocks	123.439 m
Chutes	137.155 m
Left and Right canals	149.041 m
Spillway crest	166.414 m
F.R.L.	179.825 m
Maximum submergence	181.044 m
Road level on masonary dam	184.397 m

No. of spillway vents/size : 26 nos, 45' x 44' each.

No. of left Penstocks : 8

No. of Right Penstocks : 3

Level, area and volume : Areas capacity curve (Fig.2)

	ft Level (above M.S.L)	Area (ha)	Capacity (T.M.C.ft) = (milliard m^3)
River bed	240	-	-
Dead storage	400	8,383.3	49,939(1.41)
F.R.L.	590	28,474.8	408.237(11.56)
Max. submergence	594	29,771.7	421.419(11.93)

$$\text{Average area} = \frac{\text{Area at FRL} + \text{Area at dead storage}}{2}$$

= 18,429 ha

Area irrigated : 33.80 lakh acres

= (13.678 lakh ha)

Power generation : 905.6 MW(expected).

Rivers and streams falli g in reservoir

Name	Length	Perennial/seasonal
Krishna (Source to sea)	775 miles (1247.242 km)	Perennial
Krishna (Source to Dam)	600 miles (965.606 km)	"
Peddavagu (")	60 miles (96.561 km)	Seasonal
Uppuvagu (Tributary of Peddavagu)	40 miles (64.374 km)	"
Dindi(Source to dam)	125 miles (200 km) approx.	"

Catchment area with average rainfall :-83,087 sq.miles. (2,15,194.333 km2), 35" /annum (838.965 mm)

Area submerged : Forest/agriculture/rocky.

Factory effluents into reservoir : Nil

Maximum length of reservoir : 60 miles at FRL(96 km)

Annual expected inflow : 34.34 million acre feet. (42.358 milliard m^3)

Annual expected outflow : 34.78 million acre feet (42.900 milliard m^3)

Shore line length : 293.28 miles (471.538 km)

Mean depth : 133.2' at FRL(40.537 m)

Shore development : 7.89 } derived from the data

Volume development : 1.13 } derived from the data

Average annual fluctuation in water level : 72.3 ft (from 1971 to 1979)

Mean depth at average level of 495'

$$\left(\frac{400 + 590}{2}\right)$$

= 98.2 ft (29.9 m). (i.e. at average area of 18,429 ha)

Maximum discharge

From both chutes	20,000 cusecs
From Diversion tunnel	20,000 "
From Right canal	21,000 "
From Left canal	12,000 "
From each vent at EL.594'	58,840 "
From all vents(26 nos)	15,29,840 "
Through penstocks @ 5,000 cusecs each	55,000 "

Year of start of fishery exploitation : 1968

Exploited by : Fishermen (Fishing with licence without any fee).

Fishermen population around reservoir :

Name of village	Population
Srisailam	30 fishermen
Peddamungal	50 do
Hill colony	30 do
Pylon	50 do
Vijayapuri South (including Sagar Camp)	100 do

Ice factories near reservoir :

	Production capacity/day
a) Government	5 tonnes
b) Private	nil

Fish farm :

	Description	No.	Area
1	Hatcheries	-	-
2	Cement cisterns	27	0.477 acres
3	Nursery ponds	9	0.250 "
4	Rearing ponds	9	0.780 "
5	Stocking ponds	6	0.950 "
	Total		2.457 "

The reservoir is multipurpose expected to irrigate more than 3 million acres and produce 905.6 MW of power. It is surrounded by heavy ridges and is well contained within the gorge.

The annual evaporation losses in the reservoir have been taken as 82 inches (2.03m). There is considerable uncertainity with regard to the rate of silting after the reservoir is constructed. The Krishna does not carry as much silt as Himalayan rivers. Nevertheless, the silt content in Krishna is greater than in Mahanadi and other rivers in the south. Now as the Srisailam Dam has come up, the silt problem will be further lessened.

The annual fluctuations in water level, which is known to influence the productivity and the biotal characteristics is 79.3 ft (1971-79). The shoreline is very irregular, shore development being 7.89. The volume development is 1.13, indicating the concave nature of the basin towards water. The mean depth is about 133.2 ft (41.5 m).

3 LEVEL, INFLOW AND OUTFLOW

The monthly minimum, maximum and average levels of reservoir and annual fluctuations in water levels are shown in Table-1 for the period 1971-72 to 1979-80. Generally the minimum water levels were reached during April, extending from March to July, while the maximum levels were in October extending from July to December. The minimum level obtained so far was 488.40 ft(July, 1972) and maximum level 590.10 ft (October, 1978). The monthly average levels fluctuated between 492.40 ft (May 1972) and 589.75 ft (November 1978), with their minimum generally in May and maximum during September to November. The extent of shallow areas (under 5' and 10' depth) in relation to reservoir levels between 480' and 590' are given in Table-2, as the minimum level obtained till now and FRL are in between this range. From the table it can be seen that shallow areas under 5 feet never exceeded 3.9% of total area and those under 10 feet never exceeded 7.5% at any level of reservoir during the period of study. However, these shallower areas almost form a constant percentage except at the highest levels of 585' and 590'. Thus, productive area almost remains constant throughout the year. The littoral development (under 30 ft area) was between 13 and 18% in the total area, betwen these levels.

The monthly inflow and outflow values in cusecs are presented in Table-3. Generally, the minimum inflow was during April extending from March to May occasionally, whereas the minimum outflow was always in May. Maximum inflow was in July during the period from 1971-72 to 1973-74, in October during 1974-75 and 1975-76 and in August during the period from 1976-77 onwards. However, the maximum outflow was in October during 1971-72, 1974-75 and 1975-76 in July during 1972-73 and in August during 1973-74 and 1976-77 onwards. However, the outflow is generally regulated depending on the irrigational requirement. During the period of study maximum total inflow and outflow in one year were in 1975-76. In future the fnflow will be restricted due to Srisailam Dam.

4 METEOROLOGICAL OBSERVATIONS

The average minimum air temperature ranged from 16.39°C(December 1975) to 30.12°C (May,1973). Similarly the average maximum air temperature ranged between 29.51°C(December 1971) and 43.51°C (May,1973) (Table-4). The minimum values generally were in December, extending from November to January and maximum values in May, extending from April to June.

The dam site gets maximum rainfall during south-West monsoon. The effect of North east monsoon is negligible (Table-4).

High velocity winds blow during May to October (South-West monsoon) continuously at an average speed of 28 km/hr. On some occasion it reaches as high as 60 km/hr.

5 PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOIL

5.1 Physical features :

The sand, silt and clay composition(average values for the collection period) of soil of each sector and Peddamungal bay are shown in Fig.3. Lentic and intermediate sectors are richer in clay, while sand dominated in lotic sector. Among the three bays, Peddamungal bay is richer in clay content. In general soil texture varied as sandy loam, loam sand, clay, silty clay loam and clay loam.

5.2 Chemical features :

Peddamungal bay is more fertile having maximum values of organic carbon (1.25%), available nitrogen (18 mg/100 g) and available phosphorus (0.45 mg P_2O_5/100g) (Fig.4) than other sectors. The phosphorus content was poor in all the sectors. The other two bays Dindi and Shunkishala also had comparatively higher values of organic carbon, available nitrogen and available phosphorus in comparison to the three sectors. The soil was alkaline with an average pH of 7.5. Free calcium carbonate(average 6.76%) and pH were highest in lotic sector and minimum in lentic sector. Specific conductivity ranged between 290.0 (lentic sector) and 517.5 micromhos (lotic sector).

Though, the organic carbon is average, available nitrogen and phosphorus are poor in the soil, the water quality is richer (given elsewhere), indicating that the water quality is influenced more by the nature of the soil of the catchment rather than the basin soil.

6 PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER

The ranges and average values of sector-wise physico-chemical characteristics of surface water during 1971-79 are presented in Table-5. Seasonal variations in the sectors of the physico-chemical characteristics during the period 1974-79 are shown in Table-6.

6.1 Physical parameters :

6.1.1 Water temperature :

Water temperature and its seasonal variation have a great bearing on the thermal feature and productivity of the reservoir. Surface values ranged between 23.5 and 33.5°C with minimum values in winter (December-February) and maximum during Summer (April to June). The seasonal difference in temperature is of low order as expected in the lower latitudes (16°34'N).

6.1.2 Water transparency :

Reservoir water was very clear, secchi disc reading ranging between 5.8 cm and 545.5 cm. Transparency increased from lotic to lentic sector. There was a sudden fall in transparency during flood season (July-September), but increased rapidly with the cessation of floods. In general, monsoon floods and wind turbulence contributed to the turbidity in the reservoir. In Peddamungal bay plankton blooms sometimes lowered transparency.

It was observed that the heavier particles, generally, contribute to the turbid condition rather than colloidal silt suspensions. This was apparent from the rains and that in deeper zones water was highly transparent throughout the year.

6.2 Chemical parameters :

6.2.1 pH

Water was always alkaline with pH ranging from 7.6 to 8.6. Maximum pH was seen in Summer (April-June). A sudden drop was observed during flood (July-September) due to the free carbon dioxide and increase of $H^{+}CO_2 + H_2O = H_2CO_3 = H^{+} + HCO^{-}_3$) and it was more marked in lotic and intermediate sectors, where free CO_2 was always found during floods.

6.2.2. Carbon dioxide, carbonate and bicarbonate

Free carbon dioxide was observed only during floods to the extent of 8.8 ppm. In lotic sector free carbon dioxide was always recorded during June to September, while it was observed in Intermediate Sector during August and occasionally during November. In lentic sector and bays, however, it appeared at times. During heavy floods in 1975 free carbon dioxide was noticed in all sectors between June and November.

In lotic sector, carbonate alkalinity was observed in the first and last quarters (during March and December). In intermediate sector it was always present in first and second quarters (during February and May), being present in the last quarter also during 1976 and 1978. In Peddamungal bay it was absent only during the fourth quarter (October) of 1977. In lentic sector it was noticed throughout the period except in July 1975, October 1975, October 1977 and October 1978. Presence of carbonate alkalinity almost throughout the period in Peddamungal bay and lentic sector indicated the rare occurrence of carbon dioxide in these areas. The carbonate alkalinity from nil to 34.56 ppm was observed in the reservoir throughout the entire period of investigation, the maximum value being noticed in lotic sector. The average value was lowest in lentic sector.

Bicarbonate alkalinity was very high in this reservoir, its values ranging between 51.00 and 163.35 ppm. The average value of bicarbonate was maximum in lotic sector and this value was recorded during 1st quarter, and in other sectors during second quarters, with the onset of monsoon in June concentration of bicarbonate declined due to the influx of flood water, reaching minimal values in the third quarter. In fourth quarter a phenomenal increase was noticed especially in lotic and intermediate sectors, where free carbon-di-oxide was always noticed during floods. This free carbon-dioxide dissolved the carbonate deposits into bicarbonate, ($CO_3^- + CO_2 + H_2O \rightleftharpoons 2HCO_3^-$) thus causing increase in bicarbonate values. In lentic sector and Peddamungal bay, where free carbon-dioxide /value in fourth quarter.

The seasonal variation of these three constituents along with pH, which also should similar trend as bicarbonate, has great bearing on the productivity of the reservoir.

6.2.3 Calcium, Magnesium and Total hardness :

These three constituents were represented in reservoir water in fairly high concentration. Calcium ranged between 9.2 and 42.8 ppm, Magnesium between 1.44 and 27.60 ppm and total hardness (as $CaCo_3$) between 70 and 200 ppm. Lotic sector was /richest in these cons- /the tituents among the three sectors and Peddamungal bay was leading among the three bays.

Seasonal distribution indicated that the three were highest in the first quarter in lotic sector and in the second quarter in the other two sectors. Monsoon floods brought down their concentration in the third quarter, especially in lotic and intermediate sectors. After the floods they showed remarkable improvement in lotic and intermediate sectors in fourth quarter. Lentic sector, however, showed further decline in the last quarter. Peddamungal bay showed similar trend as lentic sector.

/ was noticed occasionaly, there was further decline in bicarbonate

6.2.4 Specific conductivity :

For production of biomass in a sheet of water soluble salts are one of the essential ingredients and they were represented in fairly high values in all the sectors of the reservoir. Specific conductivity ranged between 172.53 and 1114.7 micromhos. Among the three sectors lotic sector showed maximum value of specific conductivity and Peddamungal bay among the three bays.

The seasonal vairation of specific conductivity was similar to that of calcium, magnesium, total hardness and bicarbonate.

6.3 Nutrient features :

6.3.1 Phosphate and Nitrate :

The nutrient status of Nagarjunasagar with respect to phosphate was very poor. Often phosphate was in traces and the maximum value observed was only 0.02 ppm. No seasonal pattern was observed.

Though phosphate was poor, nitrate nitrogen was very high, when compared to many southern reservoirs in India. Its concentration varied between 0.10 and 3.2 ppm. The average value of nitrate nitrogen was higher in lotic sector than in the other two sectors, while Peddamungal bay recorded the highest concentration (3.2 ppm in April 1975). The seasonal variation was not regular.

Ammonium nitrogen varied between 0.03 and 0.60 ppm. Its concentration was highest in lotic sector among the three sectors and in Shunkishala bay among the three bays.

6.3.2 Silicate :

Silicate was remarkably in high concentration in this reservoir. Its value ranged between 19.0 and 53.0 ppm. The average value was higher in lotic and lentic sectors and Peddamungal bay recorded maximum concentration (53.0 ppm). In all the sectors it decreased from first to third quarter and improved in the last quarter.

6.3.3 Iron :

The concentration of iron was in the range of 0.02 and 3.20 ppm. Lotic sector showed highest values. Seasonal distribution showed its increase with the onset of monsoon indicating that a lot of iron was being brought into the reservoir from the iron ore rich catchment.

6.3.4 Organic carbon :

Organic carbon, which indicates the oxidisable matter, was always high in this reservoir. Its value ranged between 0.06 to 4.87 ppm. Lentic sector showed maximum concentration among the three sectors and Shunkishala bay among the bays. No regular seasonal pattern was observed. High values of total lakalinity specific conductivity nutrients NO_3, silicate etc.and organic carbon all suggest the productive nature of the reservoir.

6.4 Depth variation of physico-chemical parameters:

Depthwide variations of physical and chemical parameters in lentic sector during summer month and Peddamungal bay in October are shown in Fig. 5.

6.4.1 Thermal features of the reservoir :

It is generally believed that the drawdown of bottom waters through the outlets at low levels influence the physical phenomenon (thermal features) to a great extent. But in Nagarjunasagar, however, though a substantial portion of its capacity remains as dead storage free from wind and water action, the difference in temperature between surface and bottom was not as high as observed in North Indian Reservoir, which show a strong thermal stratification during summer (a difference of even more then 10°C was noticed. A very weak indication of thermal stratification with a difference of 3 to 4°C was noticed in summer in Nagarjunasagar. Being situated in lower latitudes the seasonal difference in temperature is very low in this reservoir and the slight indication of thermal stratification in the reservoir was due to its morphometric conditions rather than to climatic conditions. This fact is supported by the absence of thermal stratification in many southern reservoirs. The circulation of water is an important physical phenomenon that assists in bringing chemical nutrients locked up in the tropholytic zone to the trophogenic zone(also known as photosynthetic zone). In Nagarjunasagar monsoon inflow and wind furbulance are important factors in the vertical mixing of water.

Heat budget of the reservoirs :

The annual heat intake (heat budget) measured in ton calories/m^2 was of low order in this reservoir (81.2). The reservoir being situated at lower latitude received more heat energy from the sun per year than the subtropical reservoir(at higher latitude) but the amount of heat required to maintain the annual heat cycle was comparatively low, the increase in heat content from winter to summer being from 1015.0 to 1096.2 ton calories/m^2. This may be attributed to the narrow seasonal differences in water temperature and absence of thermal stratification.

6.4.2 Dynamics of chemical constituents in the reservoirs.

From the point of view of biological productivity the waters of a reservoir consist of two fundamentally different regions, one below the other in which opposing chemical reactions take place. These are the regions of photosynthetic production (trophogenic zone) and the regions of break down below (tropholytic zone). The intensity of these chemical reactions is reflected in the phenomenon of chemical stratification. The most important among chemical changes is the oxygen depletion in the tropholytic layers of the reservoir brought about by the oxidative processes. Under otherwise equal conditions a reservoir with rich organic deposits and therefore rich biota will show greater oxygen deficiency in deep waters than a poorer one. Hence, relative productivity can be estimated from the magnitude of oxygen decline in tropholytic layers.

In Nagarjunasagar a strong oxygen decline from surface to bottom was noted during summer months. It decreases in lentic sector from 8.93 to 4.65 ppm during April 1973, from 8.19 to 5.34 ppm in April 1974, 5.72 to 2.82 ppm in April 1976, 5.90 to 2.60 ppm in April 1977, 5.83 to 3.24 ppm in April, 1978 and 6.84 to 2.88 ppm in April 1979 and in Peddamunagal bay from 6.24 to 2.26 ppm in October, 1977. Similar oxygen decline has also been onserved in the productive reservoirs like Bhavanisagar and Amaravaty. Hish photo-synthetic activities on the surface and high tropholytic activities at the bottom cause. "Klinograde" distribution of oxygen and hence oxygen curve is an important parameter for determining the degree of productivity of a reservoir. The Klinograde oxygen curve observed in Nagarjunasagar (Fig.5) showed its productive nature. In low productive reservoir a near uniform distribution of oxygen from surface to bottom (Orthograde distribution) has been observed.

The decomposition of bottom organic sediments and decline of oxygen was always accompanied by accumulation of carbon dioxide. The enriched CO2and subsequent increase in hydrogen ion ($H_2O + CO_2 = H_2CO_3 = H^+ + HCO_3^-$) lowers the pH of the bottom layers. The hypolimnetic accmulation of carbon dioxide and decline of pH are also indications of productive reservoirs. In Nagarjunasagar in lentic sector a decline of pH ranging from 8.7 to 7.8 in 1973 to 8.6 to 8.2 in 1976 was noticed during summer months, the carbondioxide being absent on the surface and of the order of 6 ppm in the bottom layers.

Carbondioxide liberated at the bottom by the decomposition of organic sediments caused dissolution of carbonate deposits as bicarbonate

($CO_3^{--} + CO_2 + H_2O = 2HCO_3$), thereby increasing the bicarbonate and hence specific conductivity in the bottom layers, which could not mix with the surface waters in the absence of any mixing. In Nagarjunasagar in lentic sector an increase of bicarbonate from 94.5 to 100.8 ppm in 1973, 83 to 111 ppm in 1974, 125.02 to 150.4 ppm in 1976, 95.0 to 115.2 ppm in 1977, 82.56 to 103.68 ppm in 1978 and 99.84 to 120.0 ppm in 1979 from surface to bottom. Specific conductivity also showed similar increasing trend. The bottom accumulation of carbondioxide, fall in pH, increase in bicarbonate and specific conductivity together with decline of oxygen from surface to bottom, noted in this reservoir all serve to reflect its high productivity.

The role of bottom accumulated carbon-di-oxide can be seen from the distribution of chemical parameters like pH, O_2, CO_3, HCO_3 and specific conductivity, from surface to botton in Peddamungal bay. This bay has a huge population of molluscs (gastropods and bivalves), which get exposed and die during summer due to decline in reservoir level. With the subsequent rise in reservoir level during monsoon, the later developed vegetation and the exposed mollusc shells get submerged. Carbon-di-oxide (released from the decomposition of submerged vegetation and the organic material contained in these shells) attack the calcareous shells and dissolves them as bicarbonate (conversion of carbonate to bicarbonate in the presence of free carbon-di-oxide). This causes the phenomenal increase in bicarbonate and hence specific conductivity in bottom layers. This was observed more during the period of high water level (eith r July or October). An increase of bicarbonate from 119.80 to167.66 ppm was observed during October 1975, from 121.60 to 161.50 ppm in July 1976, and from 64.32 to 186.24 ppm in October 1977. Specific conductivity also showed similar phenomenal increase from 381.7 to452.8 micromhos, 579.5 to 725.0 micromhos and 259.0 to 527.1 micromhos during the three respective years.

The reservoir also showed an increasing trend of nitrate nitrogen(not shown in Table) from surface to bottom during stratification period. An increase from 0.14 to 0.44 ppm and 0.18 to 0.45 ppm during April 1977 and 1978 was noted in nitrate nitrogen from surface to bottom in lentic sector. This may be due to liberation of NH_3 during decomposition of organic bottom sediments and its subsequent conversion to nitrate causing its increase in the bottom layers, whereas surface layer showed lower values due to its use.

Summer stratification established in April continued to be present till it was broken by the influx of flood waters.

6.4.3 Chemi.al reactions in th. near bottom layers and the bottom energy.

The oxidative processes near the bottom layer are represented below :

$$C_6H_{12}O_6+6O_2(g) = 6CO_2(g)+6H_2O(l)+674 \text{ cal} \quad ...1$$

$$C + O_2 = CO_2 + 94 \text{ cal} \quad ...2$$

The value of H (heat energy liberated) in the above equation (1) will depend on whether H_2O is in the l or g state. At 25°C and one atmospheric pressure when H_2O is in l state CO_2 in g state and $C_6H_{12}O_6$ in s state H = -674 cal/glucose oxidised, thus 674 calories of energy is liberated per mole of glucose oxidised or per 6 moles of oxygen consumed. Similarly in equation(2) H = -94 cal/mole of CO_2 liberated. Consumption of oxygen and liberation of CO_2 in the bottom layers are therefore a measure of energy available at the bottom as organic detritus. The intensity of decomposition in the tropholytic zone reflected by the decline of oxygen can therefore be used as a direct measure of the energy resource at the bottom. Bottom energy calculat d from oxygen cons nption in the ropholytic layers of the reservoir was of the order of 1,39,000 cal/m^2 which if proper y utilized can enh nce the energy output from this reservoir.

7 ENERGY TRANSFORMATION THROUGH PRIMARY PRODUCTION

The measurement of rate of transformation of solar electromagnetic waves to chemical energy by chlorophyll bearing organisms gives a dependable parameter for assessing the potential energy resource of the aquatic ecosystem. The process of energy transformation through primary production is represented by the basic equation.

$$6\ CO_2 + 6\ H_2O + 709\ \text{Cal} \xrightarrow[\text{energy}]{\text{Solar}} C_6\ H_{12}\ O_6 + 6O2$$

This process is endergonine in nature requiring more than 100 cal/mole of CO_2 reduced and consequently photosynthetic organisms can store large amount of energy through this reaction. The efficiency of energy transformation is known as photosynthetic efficiency. From the above equation it is apparent that the energy required to liberate one milligram of oxygen through algal photosynthesis is approximately 3.68 calories and hence the amount of oxygen liberated gives a measure of solar energy transformed to chemical energy of producers.

Thus

$$WO_2 = \frac{F \times S}{3.68} \quad (\text{S in cal/cm}^2\text{/d})$$

$(mg/cm^2/d)$

or

$$WO_2\ (g/m^2/d) = 2.71 \times F \times S\ (\text{S in Cal/m}^2\text{/d})$$

where

WO_2 = oxygen liberated during photosynthesis

F = efficiency of energy transformation

S = Visible light energy available on the water surface in the wave length range 4000 to 8000 A^o.

Thus the capacity of any water body to produce oxygen through photosynthesis (primary production) can be predicted from a knowledge of the amount of solar radiation available on the water surface provided the efficiency F is known. The light radiation (S) can be obtained from the radiation chart furnished by United States weather Bureau at different latitudes and efficiency from the formula F = H/S. The energy H can be obtained from the amount of oxygen produced during photosynthesis.

7.1 Seasonal variation in primary production

The seasonal variation of primary production is shown in Fig.6. The gross production declined from a high value of 590.0 mgC/m^2/d or 5,794.0 cal/m^2/d during summer (April to June) to a very low value of 220 mgC/m^2/d or 2160.0 cal/m^2/d during flood season (July - September). It again increased from October-December to January-March, reaching a maximum of 915.0 mgc/m^2/d or 8,985.3 cal/m^2/d in the first quarters. Net production also showed a similar trend with minimum of 145 mgC/m^2/d or 1423.9 Cal/m^2/d during July-September and a minimum of 640.0 mg C/m^2/d or 6,284.8 cal/m^2/d during January-March.

7.2 Sectoral variation in energy fixation

The rate of energy fixation by primary producers (calories/m^2/day) showed variation in different sectors. This was obtained by multiplying carbon value with 2.67 (to convert carbon to oxygen) and then with 3.68 (to convert oxygen values to calories of energy). Among the three sectors, the rate of energy fixation was highest in lentic sector (6500 Cal gross and 3,900 cal net) and lowest in lotic sector [2,450 cal gross and 1,200 cal net]. Peddamungal bay recorded highest energy fixation rate of 9,400 cal (gross) and 6,200 cal(net) (Fig.7). The other two bays, in which very few studies were made, showed higher energy fixation than the three sectors but lesser than Peddamungal bay.

7.3 Relation between environmental factors and their rate of energy fixation :

The factors like pH, alkalinity, specific conductivity and water transparency showed wide range of seasonal fluctuations. Generally, the seasonal trend in the rate of energy fixation by primary producers was similar to the seasonal trend of the above factors except during 1976-77, when regular sampling could not be made from all the sectors. The fair degree of positive correlation obtained between the rate of energy fixation and the factors like pH (correlation coefficiency r = 0.63), alkalinity (r = 0.75) and dissolved salts or specific conductivity (r = 0.71) showed the influence of these environmental factors on the production rate. It also showed a positive correlation with transparency of water (r = 0.72), on which the light penetration or photosynthetic zone depends. It has been considered that waters with high alkalinity and dissolved salts are more productive.

8 PLANKTON

8.1 Standing crop of plankton

Monthly fluctuations of the standing crop of plankton (ml/m^3) for the whole reservoir during the period April 1974 to September 1979 are presented in Fig. 8.

Three peaks could be discerned during a year, a major peak during March-April (summer) and two smaller peaks during September-October (post monsoon) and December-January(Winter). The summer peak was dominated by Anacystis (= Microcystis). The plankton densities during the summer peaks were 12.028 ml, 6.927 ml, 2.746 ml, 7.246 ml and 23.778 ml respectively during 1975 to 1979. The winter peak was generally contributed largely by copepods except during 1976-77 and 1978-79, when they were dominated by the diatom Fragilaria. Similarly the post-monsoon peak was dominated by copepods except in 1976 and 1977, when the diatom Melosira dominated.

Myxophyceae and copepoda were the two major constituents of plankton in the reservoir (Fig. 9 & 10). Myxophyceae bloomed during March-April with the intensity of the blooms varying from 189 x10^3 /m^3 (March 76) to 6152 x 10^3/m^3(April 1979). Anacystis formed 99.3% of the blue green algae (Table 7). Chlorophyceae were rich during May-June and in some years (1976) Spirogyra (56.7%) and Pediastram(40.9%) were the major genera. Bacillariophyceae bloomed during December to February. In January, 1979, the bloom was as dense as 17844 x 10^3 units/m^3. Dense blooms were also observed in September during 1976 616 x 10^3 and 1977 (2330 x 10^3. Fragilaria (95.1%) accounted for most of the diatoms followed by Melosira (4.3%).

8.2.1.1 Lotic sector

Phytoplankton was scarce in July and thereafter is attained three peaks, in August/September, February/March and May/June. In Myxophyceae the first two peaks were due to *Anacystis*, and the summer peak (May/June) was due to *Oscillatoria*. The peaks of Chlorophyceae were due to *Pediastrum* in August/September and May/June or to Spirogyra, which dominated in February. The diatom pulses were due to *Tabellaria*, *Fragilaria*, *Melosira* and *Navicula*.

on page 23

Copepods recorded a summer pulse (June-July) and a post mons on pulse in September. Flood water diluted in August. From October to March, they showed irregular trend without any definite pattern. Generally, they were represented in good quantity, their numbers being above $8 \times 10^3/m^3$ in most of the months. They reached their peak production of $206 \times 10^3/m^3$ during October 1978. Nauplii (50.9%), Cyclops (40.2%) and Diaptomus (8.9%) were the representatives of copepods (Table-8). Rotifers showed similar trend as copepods, but their density was much less. Their peaks, generally, ranged between 3×10^3 and $28 \times 10^3/m^3$. Keratella (59.2%) was the major rotifer followed by Lecane (12.8%), Brachionus (8.5%), Noteus (7.6%), Conochilus (6.0%), Filina (2.5%) and others. Cladocerans were important next to Rotifera with post monsoon peak ranging between 2.7×10^3 to 36×10^3. Sporadic summer abundances were noticed in April 1975 ($22{,}812/m^3$), July 1977 ($8{,}278/m^3$) and July 1978 ($7{,}900/m^3$). Chydorus (41.0%) was the main cladoceran, followed by Daphnia (39.1%), Ceriodaphnia (18.3%) and Diaphanosoma (1.6%).

8.2 Seasonal fluctuation in different sectors :

8.2.1 Phytoplankton :

The seasonal trends of phytoplankton in different sectors are shown in Fig. 11. Phytoplankton was scarce in July and thereafter, it attained three peaks, in August/September, February/March and May/June. In Myxophyceae the first two peaks were due to Anacystis and the summer peak (May/June) was due to Oscillatoria. The peaks of Chlorophyceae were due to Pediastrum in August/September and May/June or to Spirogyra, which dominated in February. The diatom pulses were due to Tabellaria, Fragilaria, Melosira and Navicula.

8.2.1.2 Intermediate sector:

Myxophyceae were maximum during May in most of the years reaching upto 676×10^3 units/m^3 in 1978. Chlorophyceae was the second important group till 1976, reaching upto $8{,}520/m^3$ in May 1975. Bacillariophyceae replaced chlorophyceae in dominance since 1976 Bloom of Fragilaria in February 1979 consisted of 36794×10^3 units/m^3.

Dinophyceae were maximum (2,827 units/m^3) in Feburary 1979 and rare in other months.

8.2.1.3 Lentic sector :

In this sector myxophyceae showed two pulses every year in May and October/November. Density of the May maxima was higher than the second peak. Chlorophyceae was poor in this sector with a maxima during September-December. Diatoms dominated in this sector, forming blooms from August to February. The blooms were irregular and did not show recurring trends. Generally their density ranged between 3 lakhs to 19 lakhs/m^3, with an exceptionally high bloom of 3 crores/m^3 of Fragilaria in January, 1979. Blooms formed either due to Fragilaria or Melosira alternating with each other. Ceratium represented dinophyceae occurred spradically during February to May is very poorly represented.

8.2.1.4 Peddamungal bay :

Myxophyceae showed two peaks in April and October. April peak was of greater magnitude (13 lakhs to 52 lakhs/m^3) than October peak (40,000 to 1 lakh units/m^3). Both the peaks were due to the blooms of Anacystis. Chlorophyceae showed peak abundance during June, September/October and January. June peak was dominated by Spirogyra and other peaks by Pediastrum. Diatom pulses were observed in July, September, November and January. July peak was dominated by Navicula and the others by Melosira and Fragilaria. Dinophyceae, represented solely by Ceratium, was maximum during January 1978 (221 x 10^3/m^3), February 1977 (33 x 10^3/m^3) and January 1972(148 x 10^3/m^3).

8.2.2 Zooplankton

The seasonal trends of the zooplankton in lotic sector, lentic sector and Peddamungal bay are presented in Fig.12.

8.2.2.1 Lotic sector :

Protozoans appeared sporadically. Rotifera showed three pulses in May, September and January/February, the latter was of higher magnitude. The May peak was determined by Conochilus, Filina or Brachionus and the other two by Keratella. Cladocera was in good numbers from January to May (5597 to 76.553 units) being in significant in other months. Chydorus and Ceriodaphnia were the main forms. Copepoda followed almost the same trend as cladocera with peaks during January/February and April/May (800-28,553 units). They were dominated by Cyclops or its larval forms.

8.2.2.2. Intermediate sector :

Copepoda was the important zooplanktonic group followed by Rotifera and Cladocera. Protozoa represented by Arcella rarely occurred. Rotifera showed one peak on May (upto 15,548/m^3) contributed by Keratella Conochilus and Noteus. Cladocerans were observed intermittentlyreaching a peak of 9,904/m^3 in July 1979. Daphnia and Chydorus were dominating during the earlier years. Later Chydorus was replaced by Ceriodaphnia. Copepods showed a peak in February or May (957 to 88,976 units).

8.2.2.3 Lentic sector :

Copepods were highest in concentration followed by rotifers and cladocerans. Rotifer peaks (11,000-47,000) did not follow any seasonal pattern. Maximum abundance were in May, July; September and February and were dominated by Keratella, Conochilus and Noteus. Cladocera showed three peaks in July, September and January (5,361 and 14,107 units/m^3) contributed by Daphnia in earlier years and Ceriodaphnia and Chydorus in later years. Copepods showed a minor peak during March/April declined in May, but increased through June to attain a peak in July. The pulses from September to February did not show any regular trends in different years. Cyclops dominated in March-April and July pulses and nauplii from September to February.

8.2.2.4 Peddamungal bay :

Arcella was the only protozoan recorded. Rotifers formed four peaks during March/April, June, September/October and January (13,093 to 90,640 /m^3) dominated by Keratella. Cladocerans had their peaks in April, June/July, September/October and December/January. Magnitude increased from April to September/October peak. The highest peaks ranging between 18 x 10^3 and 108 x 10^3 units/m^3 were mainly due to Daphnia and Chydorus. Copepods were always very dense, the peaks attaining upto 6 lakhs/m^3 were observed during March/April, June/July, September/October and December/January. Nauplii and Cyclops dominated them.

9 BENTHOS

9.1 Bottom macrofauna

9.1.1 Depth-wise distribution of bottom macrofauna:

The distribution of bottom macrofauna is presented in Fig. 13. Insect larvae were found upto 50 m. Of these, Chironomids were more oriented towards shallower regions (upto 10 m) with the maximum abundance at 6m. Insect nymphs were restricted upto 8 m. Oligochaetes were at 10 and 15 m. Bivalves were found from 8 m onwards and they increased towards depths, denser in 20 m and 40m. Gastropods were rich in all depths with maximum concentration in 10 and 40 m.

9.1.2 Seasonal variation in abundance of bottom macrofauna :

Bottom fauna was poor in the quarter July-September and was restricted to shallower regions. In the quarters October-December and January-March, the maximum abundance was at 4 m and 40 m respectively. During April-June they were more at 15 m, decreasing both towards shore and deeper regions. During July-September molluscs were few (5.88%) and the fauna consisted of insect larvae (81.10%) and oligochaetes (12.08%). Molluscs increased (17.20%) in October-December and reached their maximum abundance during the subsequent two quarters (Fig.14). Generally during the floods bottom macrofauna depleted, but picked up after the reservoir stabilised later.

9.1.3 Sectoral distribution of bottom macrofauna :

Bays were richest (Table 9) by number, volume and weight per square meter. Lotic sector was poorest. Intermediate sector recorded more numbers and volume than lentic sector, while their weight/m^2 was more in the lentic sector. Molluscs were rare in lotic sector and increased towards lentic sector reaching their maxima in the bays, where they form 84.16% of bottom macrofauna. Among molluscs gastropods outnumbered bivalves in all the sectors and bays except in lotic sector. Gastropods were represented by Viviparus bengalensis, V. variatus, Melanoides tuberculatus, Thiora scabra, Amnicula travencorica, Digoniostoma pulchella, Lymnaea accuminates, Indoplanorbis exnotus and Gyrulus convexiscalus. Bivalves were Lamellidens marginalis, Parreysia curragata, Corbicula striatella and Piscidium sp. Insect larvae were more in intermediate sector than in lentic sector. Ologochaetes occured 39 units/m^2 in lotic sector, while they were very less in other sectors and bays.

9.2 Periphyton :

9.2.1 Periphyton from natural substratas :

The periphyton attached to natural substrates like submerged rocks etc., was found to be of irregular growth due to heavy fluctuations in water level of the reservoir. It was not observed at all during many months. Sometimes the values were greatly exaggerated due to the presence of debris and mud along with scratched samples from their substrates.

In lentic sector, the abundance of periphyton in the five samples, that could be collected, varied from 2.37 g/m^2(3.57 ml) to 802.31 g/m^2(521.12 ml). In

Intermediate sector two samples in February and May 1975 gave 1266.0 g/m^2(1318.0 ml) and 356.9 g/m^2(375 ml) respectively. In Peddamungal bay, the only sample in October 1975 yielded 92.2 g/m^2 (130.52 ml) of periphyton. The organisms, generally, encountered were Spirogyra, Oscillatoria, Nitzschia, Synedra and Tabellaria.

9.2.2 Periphyton on suspended slides :

9.2.2.1 Seasonal and vertical distribution :

The vertical and seasonal variations in the volume of periphyton (ml/m^2) are shown in Fig.15, along with seasonal changes of specific conductivity and transparency of reservoir water. Periphyton was least during the third quarter (July-September) and richest in the second quarter (April-June). In the third quarter, it declined sharply with depth, while in summer in increased from surface to 3 m and then declined. In the other two quarters a gradual decline with depth was observed.

Specific conductivity and transparency seemed to have a direct relationship with periphyton. It was restricted to the upper water column during the third quarter, when water was most turbid, while the periphyton was found in deeper waters also during first and last quarters when water was most transparent.

Myxophyceae, Chlorophyceae and Bacillariophyceae formed the bulk of the flora. The former two groups showed more or less similar trend in their seasonal and vertical distribution.

On the surface myxophyceae increased sharply in the summer (April-June) and declined during monsoon (July-September) and again increased/winter. Oscillatoria /in formed the main species. Chlorophyceae were denser than Myxophyceae. In the first and last quarters they increased in numbers towards 1 m. Spirogyra was the main species. followed by Ulothrix and Oedogonium. Cosmarium was the important desmid genus. Bacillariophyceae decreased upto third quarter. Vertical distribution of diatoms was similar to the above two groups. Numerical abundance of diatoms was very high than the above two groups. Amphora was the common diatom followed by Tabellaria, Fragilaria, Navicula, Asterionella, Cymbella, Melosira and Synedra.

Protozoa, Gastrotricha, Rotifera, Turbellaria Nemata and Annelida were the fauna generally observed in the periphyton.

Among protozoans ciliates were represented by 13 genera. They recorded maximum density in the second quarter and minimum in the third quarter. In the first quarters they were more at 2 m depth, while they oriented more towards deeper zone in second quarter and towards surface in third quarter. In the last quarter they were abundant at 1 m and 3 m. The main forms were Vorticella, Loxodes, Lionotus, Epistylis and Hexatrichia.

Rotifera followed similar trend as ciliates. Brachionus was the most common form followed by Furcularia, Euchlaris and Scaridium.

Highest periphyton production was noticed during the period of minimum water discharge with comparatively static reservoir level. Organisms like Ulothrix, desmids, Amphora, Asterionella and Diatoma, which were either absent or insignificant in plankton, contributed significantly to periphyton. Ciliates were not represented at all in the plankton, while they formed substantial part in periphyton. Among rotifers forms like Scaridium and Furcularia were not present in plankton. Presence of many a group of organisms native to periphytic environment is of limnological significance.

9.3 Larger aquatic plants and associated fauna

Except for the presence of a few pieces of Hydrilla entangled in the meshes of rangoon nets and for the presence of a few Vallisneria and Hydrilla at places where streams join the bays, large scale occurrence of aquatic plants was not noticed.

10. FISH FAUNA

Sixty nine species of fishes and two species of prawns as detailed below have been recorded in the reservoir. These include indigenous as well as introduced species (marked with asterisk).

Latin name	Local Telugu name
Phylum : Vertebrata	
Sub-phylum : Craniata	
Super Class : Gnathostomata	
Class : Teleostomi	
Sub-class : Actinopterygii	
Order : Clupeiformes	
Sub-order : Notopterdei	
Family : Notopteridae	
1) Notopterus notopterus(Pallas)	Ullenka/Valaka sacchua
Order : Cypriniformes	
Division : Cyprinii	
Sub-order : Cyprinoidei	
Family : Cyprinidae	
Sub-family : Abramininae	
2) Chela atpar (Hamilton)	'Bedisa'
3) Oxygaster phulo(Hamilton) (= Salmostoma phulo phulo)	'Bedisa'

4)	O.clupeioides(Bloch)	Walaga bedisa
	Sub-family : Rasborinae	
5)	Barilius bendelisis(Hamilton)	Chintagachcha
6)	B.evezardi Day	
7)	B.barna (Hamilton)	
8)	Danio aequipinnatus (McClelland)	Kola parka
9)	Danio (Brachidanio)rerio (Hamilton)	
10)	Esomus danrica (Hamilton)	
11)	Rasbora daniconius (Hamilton)	Kodipe
	Sub-family : Cyprininae	
12)	Aspidoparia morar (Hamilton)	
13)	Tor khudree (Sykes)	Pachcha rekalu/kalpagende
14)	Puntius jerdoni(Day) /P.dobsoni (day)/ /P.pulchellus (Day)/	Peddabochcha
15)	P.kolus (Sykes)	Kolisa
16)	P.sarana (Hamilton)	Tellamosu
17)	P.sophore (Hamilton)	Pittaparige
18)	P.ticto(Hamilton)	Banda mosu
19)	P.ambassis(Day)	
*20)	Catla catla (Hamilton)	Dobi
*21)	Cirrhinus mrigala(Hamilton)	Dosagallu
22)	Cirrhina cirrhosa(Bloch)	
23)	C.reba (Hamilton)	Bonti parakalu
24)	Garra mullya(Sykes)	Nallamosu
25)	Labeo bata (Hamilton)	Errakallamosu

26) L.boggut (Sykes)

27) L.calbasu(Hamilton) Nalla bochcha

28) L.fimbriatus(Bloch) Errakalladd

*29) L.rohita(Hamilton) Ravva

30) L.pangusia(Hamilton)

31) L.potail(Sykes)

32) L.gonius (Hamilton)

33) Osteobrama cotio(Hamilton) Batta gande

34) O.vigorsii(Sykes) Batta gande

35) O.neilii(Day)

36) Rohtee ogilbii(Sykes)

37) Thynnichthys sandkhol(Sykes) Thinnikithisu

*38) Cyprinus carpio(Linnaeus)

Family : Cobitidae

39) Noemachilus botia aureus Day

Division : Silurii

Sub-order : Siluroides

Family : Siluridae

40) Ompok bimaculatus(Bloch) Marpu

41) O.pabo (Hamilton)

42) Wallago attu (Schneider) Walaga

Family : Bagridae

43) Mystus aor (Hamilton) Pottimukkujella
= (Aorichthys aor)

44) M.cavasius(Hamilton) Rekujella

45) M.seenghala(Sykes) (= Aorichthys seengh la)	Podugumukkujella
46) M.punctatus (Jerdon)	Ponduga
47) M.vittatus(Bloch)	
48) Rita kuturnee(Sykes) (= R.hastata Gunther)	Burrajella
49) R.pavimentata	Pachcha Jella/Banka jella

Family : Sisoridae

50) Bagarius bagarius(Hamilton)	Banda jella
51) Gagata itchkeea(Sykes)	

Family : Schilbeidae

52) Neotropius khavalchor Kulkarni	
53) Pangasius pangasius (Hamilton)	Palupu jella
54) Pseudeutropius taakree(Sykes)	Opasjella/Gaddijella
55) Silonia childreni(Sykes)	Pangasjella

Order : Anguilliformes.

Sub-order : Anguilloidei

Family : Anguillidae

56) Anguilla bengalensis(Grey and Hardwicke)	Malugu pamu

Order : Beloniformes

Sub-order : Scomberscocoidei.

Family : Belonidae

57) Xenentodon cancila(Hamilton)	Kaddridindu

Order : Cyprinodontiformes

Sub-order : Cyprinodontoidei

Super family : Cyprinodontoidae

Family : Cyprinodontidae

58) Oryzias melastigmus(McClelland)

Order : Mugiliformes

Sub-order : Mugiloidei

Family : Mugilidae

59) Rhinomugil corsula(Hamilton) Netthi kallu

Order : Ophiocephaliformes

Family : Ophiocephalidae (= Channidae)

60) Channa gachua (Hamilton) Korrameenu/Korra matta

61) C.marulius (Hamilton) Poola chapa

62) C.striatus(Bloch) Korra matta

Order : Perciformes

Sub-order :Percoidei

Super-family :Percoidae

Family : Centropomidae (= Ambassidae)

63) Chanda nama (Hamilton) Cheera barra

64) C.ranga (Hamilton)

65) C.baculis(Hamilton)

Family : Cichlidae

66) Etroplus maculatus(Bloch) Bette marpu

Sub-order : Gobioidei

Super-family : Gobioidae

Family : Gobiidae

Sub-family : Gobiinae

67) Glossogobius giuris(Hamilton) Isaka dondu

Order : Mastocembeliformes

Family : Mastocembelidae

68) Mastocembelus armatus(Lacepede) Peddabommidayi

69) M.pancalus(Hamilton) -do-

Phylum : Arthropoda

Class : Crustacea

Sub-class : Malacostraca

Series : Eumalacostraca

Division : Eucarida

Order : Decapoda

Sub-order : Macrura

Section : Caridea

Family : Palaemonidae

1) Macrobrachium malcolmsonii Milne Edward Pedda royya

2) M.lamarrei Chinna royya

11. BREEDING AND RECRUITMENT

Spawn collections were made during the monsons of 1974, 1975 and 1976 at Srisailam in letic sector. In addition, dragnetting was also done.

Spawn collected was in the form of hatchlings and fry in the size range of 6-10 mm indicating that the breeding grounds were far above the Srisailam dam nearby. The reared spawn showed the presence of commercial species like L.fimbriatus (27.75%), L.rohita (0.25%), P.dobsoni (0.25%) and L.bata (6.62%). The rest were mostly trash fishes and catfishes.

The dragnet collections consisted of juveniles of mostly trash fish, apart from a stray occurrence of L.rohita and a few L.fimbritus, W.attu and O.bimaculatus. Majority of the collections consisted of Oxygaster spp. (67%), followed by R.corsula(11%), Channa sp.(6%), G.giuris(4%) and others (18%).

12. YIELD ESTIMATION

12.1 Landing Centres

Fishes are generally brought to three main landing centres - Srisailam and Sagar camp (Vijayapuri South) on right bank of the reservoir and Peddamungal bay catches are landed at Peddamungal village on left bank. Catches from lentic sector and adjoining Shunkishala bay are mainly landed at Sagar camp and to a lesser extent at Pylon and Hill Colony. However, the catches from Pylon and Hill colony are, generally, brought to Sagar Camp after local sales. The assembled catches at Srisailam and Peddamungal after local consumption in fresh condition to some extent are transported, generally to Hyderabad, while catches assembled at Sagar Camp are transported to Macherla on way to Calcutta. The intermediate sector is exploited only during winter/spring intermittently by the fishermen of Vijayapuri South, due to transportational difficulties and the catches are transported to Calcutta via Macherla. Lentic and lotic sectors and Peddamungal and Shunkishala bays are fished throughout the year.

In addition to the fresh fish trade smaller varieties of fish are generally dried and sold in neighbouring areas of Srisailam and Peddamungal. In summer even bigger catfishes are dried near Peddamungal for want of storage facilities. The extent of dry fish trade could not be estimated as the fishermen living in remote areas could not be approabhed for lack of transport facilities.

12.2 Yield

The estimates of fish yield for the years 1971-72 to 1979-80 are presented in Table 10. The first estimate of fish yield in 1971-72 soon after the complete filling of the reservoir in 1969, has amounted to 158.6 t. Subsequently, the catches declined gradually to 69.2t in 1974-75, and later got recovered to touch a maximum of 190.8 t in 1978-79. The poor yield (32.3 t) in 1972-73 was due to under exploitation during the civil disturbances in the State and do not reflect stock abundance. The increase in yields during 1977-78 and 1978-79 was to some extent due to the exploitation of intermediate sector. The catch per hectare steadily rose from 3.75 kg (1974-75) to 10.3 (1978-79).

Generally, the monthly landings were more or less uniform except during summer months of April and May, when the fishermen of Sagar camp (Vijayapuri South) usually operating in lentic sector migrate down below for riverine and canal fishing, However, sectoral variation was observed in yields as compiled for 1977-78 and 1978-79(Table- 11). Lentic sector with its bays contributed to more than 60% in both years, while lotic sector gave 18.59% and 19.20% and intermediate sector gave 20.34% and 15.95% during the two years respectively.

12.3 Trends in individual fishery :

The species composition for various years is presented in Table 12 and sector-wise for 1977-78 and 1978-79 in Table 11. Among the commercially important species observed C.catla, C.mrigala and L.rohita were stokked carps, while L.fimbriatus, L.calbasu and T.khudree were the indigenous carps. Among the miscellaneous P.taakree, B.bagarius, C.marulius and O.vogorsii were included.

L.fimbriatus was the most dominant in the initial years of 1971-72, contributing to about 56.3 t (35.51%). This declined gradually to a minimum of 5.3 t (7.6%) in 1974-75, but slightly recovered to 26.0 t (15.0%) and 21.7 t (11.4%) during 1977-78 and 1978-79 respectively. This recovery was mainly due to the exploitation of intermediate sector in the post-monsoon months.

L.calbasu fluctuated in a narrow range from 7.1 t in 1975-76 to 11.9 t in 1977-78, except for the low yield in 1972-73 the strike period. Improved catch in 1977-78 and 1978-79 was due to exploitation of intermediate sector.

T.khudree fluctuated in the range from 1.01 t in 1974-75 to 5.4 t in 1978-79. Improved catch in the last two years was due to exploitation in intermediate sector.

C.catla landing fluctuated from 1.4 t (1973-74) to 6.6 t (20.3%-1972-73). The catches dwindled from the earlier years and showed marginal improvements in later years.

L.rohita was negligible upto 1974-75. During the later years it fluctuated in a narrow range of 1.2 t (1977-78) to 1.4 t(1976-77). Stocking in recent years has improved the fishery to 4.8 t in 1979-80.

C.mrigala landings varied from 0.5 t (1976-77) to 6.7 t (1979-80). The improved catch in 79-80 is due to its stocking in recent years.

P.pangasius contributed to 30.6 t (19.3%) occupying second place in total catch in 1971-72. It fluctuated from 8.4 t (11.13% in 1973-74) to 63.4 t (36.2%) in 1977-78 occupying top place since 1974-75.

M.seenghala fluctuated from 5.5 t (1976-77) to 11.6 t (1971-72). The catch increased to 11.3 t in 1975-76 declining next year. The improved catches in 1977-78(7.1) and 1978-79(10.1 t) were due to exploitation of intermediate sector.

M.aor showed steady improvement from 8.3 t (1973-74) to 32.6 t (1979-80). From sixth position in catches in 1971-72, it gradually shifted to second position since 1976-77. It increased by more than four times.

S.childreni contributed 23.6 t in 1971-72, occupying third place. In 1973-74 it declined to 5.5 t and later improved reaching 22.1 t in 1975-76, occupying second place. Though it declined to 12.0 t in 1976-77, it reached 30.3 t in 1978-79. It is observed that more than 50% of its catch was obtained during monsoon months in lotic sector by drift nets, as it undertakes mass migration during this season to riverine portion. The increasing height of Srisailam dam, just above lotic sector, forming an effective barrier, its vulnerability seems to have increased during 1977-78 and 1978-79. It catch has declined during 1979-80 to 22.6 t and may further decline in the coming years, as the Srisailam dam may interfere with its breeding and recruitment.

W.attu fluctuated from 1.68 t (1973-74) to 4.2 t (1975-76). It steadily increased from 1973-74 to 1975-76, declined in 1976-77, again improving to 3.9 t by 1978-79.

12.4 Distribution of species in time and space

From the sector-wise landings, it is observed that L.fimbriatus and L.calbasu were caught more in the upper regions of the reservoir. Significant catches of L.fimbriatus were obtained during winter/spring in intermediate sector.

L.calbasu occurred significantly in lotic sector catches during post monsoon months of October-November. P.pangasius was abundant in lentic sector, where it formed about 50% of the sectoral catch, followed by intermediate sector and Peddamungal bay, M.aor was prevalent in bays along with M.seenghala. M.seenghala also occurred in good numbers in interemediate sector during winter months.

S.childreni was dominant in lotic sector during floods. Similarly W.attu, M.punctatus and P.taakree formed seasonal fisheries in lotic sector, while O.vigorsii in lotic sector and Peddamungal bay.

12.5 Dominance of catfishes and its effect on yield

From the perusal of data over the years it is indicated that the percentage of catfishes steadily increased over that of carps (Table 13) from 1974-75, though the dominance of carps-mainly the indigenous ones L.fimbriatus and L.calbasu was seen upto 1973-74. The absence of fast growing carps in the parental stock during the initial years, which could propagate themselves to give a firm carp base, was the reason for the shifting of the ratio in favour of catfishes. Added to this was the presence of indigenous catfishes of large size such as M.seenghala, M.aor, P.pangasius and S.childreni. As the indegenous carps were not adequate and not of fast growing type to utilize the favourable lower food chains during the initial impoundment stage and intensive stocking of favourable fast-growing carps was not done during the initial stages, the catfishes dominated taking advantage of the developed large trash fish population. As the catfishes are on higher food chain and poor converters of food to fish, they are not suitable for higher yields. However, from the data, it is observed that the catches of P.pangasius, M.aor and S.childreni increased substantially among catfishes. Of these P.pangasius, which emerged as the dominant species in later years, subsisted mainly on the abundant molluscan population and hence compatible with carps.

S.childreni which depends on riverine environment for its maturation and breeding is likely to decline in the coming years after the completion of Srisailam Dam. M.aor, which feed mainly on trash fish, prawns and insects, has firmly established in the reservoir and may be considered desirable for controlling of trash fish populations and is also expected to improve further. Other catfishes like P.taakree and M.cavasius are useful additions as they sustained on insects. The other bigger catfishes like M.punctatus and W.attu formed only a minor percentage and the former being a fluviatile form remains in upper reaches. Thus, there is every scope to augment the carp population and enhance the yield from the present level.

12.6 Effect of stocking on the productivity of Gangetic carps :

The stocking figures of major carps for different years indicated (Table 14) that only catla and mrigal were stocked during the formative years of the reservoir at a rate of less than one fingerling/hectare/annum. In the next five years, L.rohita and L.fimbritus were added to the above two species and the stocking rate of Gangetic carps was about 3.5 fingerlings per hectare. In the next four years the rate has increased to 19 fingerlings/ha/annum. The stocking of catla in the initial years has reflected on its increased catches during 1971-72 and 1972-73. In the succeeding years, however, their catches declined. The catches of mrigal were poor during different years and is yet to establish. The result of the increased stocking rate during the period 1975-76 to 1978-79 is reflected in the increased catches of rohu (4.9 t) and mrigal (6.7 t) in 1979-80.

Though C.carpio was stocked upto 5,00,000 and M.malcolmsonii upto 2,66,000 they failed to appear in catches.

12.7 Energy utilization and productivity efficiencies in Nagarjunasagar reservoir :

Studies in Nagarjunasagar reservoir have shown that the flow of energy is mainly through detritus chain.

The energy, represented by Microcystis the main primary producer in the reservoir, is not much utilized directly in the reservoir and is indirectly utilized through detritus chain.

The output of energy from the reservoir was 12,000 K cal/ha/yr which 20% was contributed by primary consumers, 35% by secondary consumers and the rest by tertiary consumers. It is important to note that P.pangasius the main secondary consumer in the reservoir, utilizes detritus energy through molluscs (gastropods and bivalves). The reservoir has very high energy resource of the bottom in the form of organic detritus but it is utilized properly. The utilization of this bottom energy is only through secondary consumers (mainly P.pangasius) causing greater loss of energy. Owing to the dominance of secondary and tertiary consumers the energy out put from the reservoir is very poor.

The visible radiant energy available on reservoir surface was 7480 x 10^6 K cal/ha/yr. The energy fixed by producers ranged between 19,577.49 x 10^3 to 24,674.03 x 10^3 K cal/ha/yr (0.26 to 0.33% of light) as oxygen and 20,437.72 x 10^3 to 25,750.21 x 10^3 K cal/ha/yr(0.27 to 0.34% of light) as carbohydrate. The fish yield from the reservoir varied from 3.75 to 10.35 kg/ha/yr with average at 6.61 kg/ha/yr. The energy out put from the reservoir was between 4,500 to 12,420 K cal/ha/yr. Comparison of energy output with energy fixed by producers shows that only 0.02 to 0.06% of energy fixed by producers was obtained as fish (0.0016% of light). The direct comparison of gross carbon synthesis to fish yield also showed low conversion ratio (0.19 to 0.48%). Based on primary production studies the reservoir ratio (0.19 to 0.48%). Based on primary production studies the reservoir can produce 113 kg of fish/ha/yr which is equivalent to 1,35,000 K calories/ha/yr of energy output. Thus only 8.9% of the potential is harvested at present.

The high values of aklainity, hardness, specific conductivity and presence of strong oxygen (Klinograde curve) and chemical stratification all point Nagarjunasagar to be a productive reservoir. From the above energy considerations, it is apparent that the energy fixed by the primary producers was quite high and is in accordance with the chemical deductions, but the energy obtained as fish was very low. The fishery of Nagarjunasagar is dominated by catfishes, which feed at higher trophic level, thus resulting in a greater loss of energy and poor energy harvest. Other probable reasons for the poor yield could be inadequate stocking of the reservoir with fishes feeding at a lower trophic level, low fishing effort and poor breeding and recruitment.

13. BIOLOGY OF FISHES

Commercial fishes

13.1 L.fimbriatus

Age and growth : Age and growth of the fish was calculated by using scales. The empirical growth equation obtained was $l_t = 812 \left[1-e^{-0.22(t+0.6922)} \right]$. Lengths obtained from scale studies and empirical growth equation are given below :

Age in years	Lengths(mm) estimated by		Average Wt.(g)	Increment in		Instatitaueous rate of growth
	Scales	Growth equation		length (mm)	Weight (g)	
1	265	252	189	-	--	-
2	370	363	565	105	376	1.0999
3	461	451	1165	91	500	0.7227
4	540	523	1958	79	793	0.5188
5	587	580	2571	47	613	0.2700

The length-weight relationship for the fishes in the size range 310-590 mm was estimated to be $\log W = -5.6851 + 3.2854 \log l$.

Size/Age groups in Fishery : Fishes of size 276 to 660 mm contributed to the commercial fishery and their numbers and weights of individual ages are shown in Table 15 . Age groups 2,3 and 4 formed the major portion in fishery. The average sizes in the catches were 439, 479 and 448 mm during the three years 1976-77 to 1978-79.

Maturity and breeding : Fully mature specimens generally occurred from May/June to September, stray mature individuals being noticed during January and February. The smallest mature male and female measured 383 and 420 mm respectively, when they crossed second year. Majority matured in fourth year and above.

The breeding season was during monsoon from June to September, with peak during July-August and the fish appeared to breed above Srisailam in the riverine stretch and also in Peddavagu during sufficient flood period. The Srisailam dam is likely to interfere with breeding in the main river in the years to come.

The sex ratio did not differ statistically from the 1:1 ratio. The fecundity was in the range of 1,56,000(423 mm) to 5,06,900(600 mm).

Food and feeding : Food mainly consisted of detritus along with diatoms, green and blue-green algae. Detritus component was relatively more during post-monsoon and less during summer. Diatoms also were more during post-monsoon and algae during winter and spring. Fragilaria, Cymbella, Melosira, Navicula were the main diatoms observed and were likely to have picked up along with detritus.

13.2 L.calbasu

Age and growth : Fishes examined ranged between 195 (90g) and 581 mm(2710gm). Scales were used to calculate the age and growth of the fish and the lengths obtained by scales and growth equation are given below:

	Length at ages(mm)					
	1	2	3	4	5	6
Scale·method	237	327	408	474	535	570
Growth equation	229	325	404	469	523	568

Length-weight relationships were found to be statistically different for immature males and others and they are described by the following equation :

Immature males : $\log W = -5.1765+3.10454 \log L (r = 0.98)$.

Others : $\text{Log } W = -5.8862+3.37829 \log L (r = 0.98)$.

<u>Maturity, breeding and fecundity</u> : The smallest mature male and female measured 278 and 309 mm respectively. Females above 420 mm were dominant in the fishery while males were dominant in small size of groups. Seasonal difference also was observed in sex ratio. Females dominated from August to October and males from May to July. From November to April the ratio did not deviate from 1 : 1. Female dominance during August to October may be due to their greater vulnerability during breeding season.

Gonado-somatic index reached its peak in July, extending from May to November and the precentage of mature ovaries was significant from May to September with peak in July and August. Thus, the breeding season seemed to be from July to September.

Ova diameter studies indicated the unimodal distribution pointing to a single and short spawning. The mature ova showed a mode at 1.25 mm. (Fig. 15).

Fecundity ranged between 67,500(345 mm) and 5,72,460 (533 mm). The relative fecundity ranged between 125 and 415 (average 201) ova. The relationship between fecundity and length of fish was calculated to be Log F = -6.20792 + 4.3681 log l (r = 0.85).

The exponent significantly deviated from '3'. Fecundity and body weight were related as :

F (in thousands) = -37.63286 + 0.23973 W (r=0.739).

Fecundity and gonad weight (Gw) were related by

F (in thousands) = -38.12246 + 2.153131 G.W.(r=0.96).

Food and feeding : Food mainly consisted of organic detritus (50.77 to 87.35%) and periphyton. Ingestion of detritus was lesser during January to March. With a peak in April, detritus continued to be high in the guts till December. Mud showed high percentages during May, June, August, September and January. Among the periphyton, diatoms observed were *Asterionella*, *Amphora* and *Cymbella* besides *Fragilaria* *Navicula*, *Tabellaria* and *Frustulia*. Among algae *Spirogyra*, *Anacystis*, *Merismopedia*, *Oscillatoria* and *Gloeotrichia* were represented. Among zooplankton, rotifers and copepods were observed. A poor feeding intensity during spawning was indicated by the low gastrosomatic index.

13.3 *T.khudree* :

Age and growth : The specimens examined ranged in length from 215 to 600 mm(110 to 2738 g). Age was estimated by scales. The length obtained from scales and Von Bertalanffy's growth equation at different ages are given below :

	Length at ages(mm)					
	1	2	3	4	5	6
by scales	188	283	356	422	482	528
growth equation	190	283	361	428	483	531

Length-weight relationship equation was estimated to be

Log W = -5.058885 +3.042 117 log l (r. 0.988).

Maturity and breeding : Spent specimens and mature females were not recorded. A few mature males occurred from June to August. The gonado-somatic index in males increased from July to September with a sudden fall in October. Similarly it increased from June to September in maturing females. The breeding season may be presumed to be during June to September. The condition factor also was lower during this period. Male to Female ratio was 1.5 : 1.0.

Food and feeding : Bivalves were found to be more frequent in males than in females. Gastropod shells were present almost throughout in both males and females. Gastropods (22.77%), bivalves (15.53%), organic matter (31.63%), mud (23.47%), macrovegetation (6.12%) and rotifers were the items found in guts. The molluscs are crushed by the pharyngeal teeth before swallowing.

13.4 *P.pangasius* :

Age and growth : From the growth rings formed generally around April -July period in the pectoral spines age was determined. The first ring got obliterated in specimens beyond 350 mm as the area around the central medulla became transparent. The relationship between the length of the fish and the spine radius was found to be:

$$Y = 2.018 + 0.0596\ X \quad (r = 0.8955)$$

(where Y = spine radius and X = fish length)

Von Bertalanffy's growth equation was estimated to be $l_t = 936 \left[1 - e^{-0.20\,(t + 0.85)}\right]$

The maximum length of the fish recorded in the reservoir was 810 mm. The lengths calculated from spines and growth equation were in proximity as shown below :-

Age in yagrs	Length(mm) as estimated by		Av.Wt. (g)	Increments in		Instantaneours rate of growth
	Spines	Growth equation		Length (mm)	Weight (g)	
1	-	187	42	-	-	-
2	302	289	184	115	142	-
3	415	407	494	113	310	0.9858
4	510	502	939	95	445	0.6419
5	595	581	1516	85	577	0.4700
6	658	645	2060	63	444	0.3001
7	704	698	2561	46	500	0.2151

Length increments were maximum during 1st year, where as the maximum weight increment was in 5th year.

The length-weight relationship was estimated to be Log W = -5.4457 + 3.1128 Log l.

Maturity and breeding : A few fully mature specimens of sizes 635-810 mm could be collected only during Mayto July in lotic sector. The fish seems to be not volunerable to the predominant surface drift nets used in this sector during floods probably due to its movement in deeper waters during migration to the riverine zone for breeding.

The males and females were equal in ratio. Ova diameters in fully mature ovary showed a single mode at 1.33 mm indicating single spawning. Presence of spent specimens in Srisailam (lotic sector) in July indicated breeding during June-July in riverine zone. The effect of Srisailam dam on its breeding and recruitment is to be assessed.

The fecundity was 73,300 in a fish of 640 mm and 1,54,800 in a fish of 726 mm.

Food and feeding : The food in lentic sector consisted of gastropods and bivalves in the size range (262-810 mm) studied. During its migration to lotic sector during monsoon, it subsisted on offal and dried leaves as molluscs were absent in lotic sector. Molluscs are devoured entirely and the empty shells are excreted after the flesh gets digested.

Size/Age group in fishery : Commercial size ranged between 190 and 810 mm. Contribution of different ages to the fishery from 1976-77 to 1978-79 is presented in Table 16. Age groups IV to VI contributed significantly to the fishery (by weight), while the age groups III to V formed major fraction of fishery (by numbers). The average sizes in the commercial catches during the three years were 538,547 and 497 mm respectively. The reduction of average size during 1978-79 may be due to the failure of a part of the spawning stock (of bigger size) to return to the reservoir due to the increase of the height of Srisailam dam.

Though annual mortality ratio were nearly equal a remarkable increase in the catch during 1978-79 was noticed. It is suspected that the catches may decline in coming years as the Srisailam dam may interefere with the recruitment of this species.

13.5 M.aor

Age and growth : Growth rings in pectoral spines formed generally during April-June period. The first ring got obliterated in the fishes measuring above 300 mm due to the expansion of central medullary layer of the spine. Hence, length at age could not be estimated. The relation of fish length to pectoral spine was Y = 8.134 + 0.0655 X (r = 0.9919) (where y = spine radius and X = fish length).

The von Bertalanffy's growth equation was estimated to be :

$$l_t = 860 \left[1 - e^{-0.23(t+0.551)}\right]$$

Lengths estimated from spines and growth equation were found to be close as given below :

Age in years	Lengths(mm)estimated by		Av. weight (g)	Increment in		Instantaneous rate of growth
	Spines	Growth equation		length (mm)	weight (g)	
1	-	257	80	-	-	-
2	382	381	262	125	182	1,1848
3	480	480	520	98	138	0.6831
4	558	558	819	78	299	0.4511
5	620	620	1125	62	306	0.2546

The length increment was maximum during 1st year and the weight increment during 4th and 5th years.

Maturity and breeding : Commencing from January, full maturity was attained by April/May and the mature were encountered upto October. The smallest mature male and female measured 456 and 485 mm respectively. The mature ovary occupied only 1/3rd of body cavity. Milting males could not be observed. Ova diameters showed 3 modes in mature ovary at 0.784 mm, 0.980 mm and 1.176 mm, indicating fractional and extended spawning.

Sex ratio was not significantly different from 1:1. Two spawning peaks were inferred during April-May and July-September. The fish appeared to breed in Paddamungal and Shinkishala bays. No evidence of breeding migration was noticed.

From the asymptotic length the maturity size (2/3 of l_∞) was estimated to be 573 mm, which may be the size at which majority of the population gets matured (at about 4th year).

Food and feeding : Food mainly consisted ~~in~~ of fish (50%), prawns, insects, molluscs and miscellaneous items. In many cases the foreguts contained a single item of food only. The fishes consumed generally were trash fishes like O.phulo, G.giuris, and O.cotio. A lone case of cannibalism was also noted. Prawns were mainly M.lamarrei. Nymphs of dragonfly and chironomid larvae formed the insect components of food. Molluscs were represented by small gastropods.

Size groups/Age groups in fishery: Commercial sizes ranged between 230 and 760 mm. Age group 3rd year contributed maximum to the landings during 1976-77 and 1977-78 and age group 4th year during 1978-79(Table 17). Average sizes during the above three years were 484, 544 and 528 mm respectively. Significant increase in landings during 1977-78 and 1978-79 over the previous years was observed. The annual survival rates for age 3 and above (age 4 and above in 1978-79) were calculated to be 33%, 30% and 25%. The heavy mortality rate was due to the concentration of maximum effort in lentic sector and especially in bays. The fish does not depend on the riverine portion for breeding and seems to be well established. Its catches are likely to improve further in the coming years.

13.6 M.seenghala :

Age and growth : Ages were calculated by length frequency method and the lengths were estimated to be 328, 478 and 619 mm at 1 to 3 age groups respectively. The minimum length in commercial catch was 235 mm. The fishes examined ranged between 284 and 822 mm and weights between 80 and 2650 g. It was caught more in Paddamungal bay.

Length-weight relationship was found to be significantly different in males and females and they were related by :

Male log W =-6.68787 +3.47545 log 1(r=0.99)

Female Log W = -5.43619+3.01815 log l(r=0.96)

Males were heavier above 546 mm and females of lesser length were heavier.

Maturity and breeding : Male and female ratio was 1 : 1.37. Mature specimens were observed from April to August and spent from June to August. The gonado-somatic index was at its peak from April to August. Presence of mature specimens and higher gonadosomatic index pointed the breeding season to be between April and August.

The multimodel frequency of ova diameters (Fig. 16) pointed to the fact that the fish has intermittent spawning. This was suggested by the presence of maturing and mature ova in spent fishes along with empty follicles.

Food and feeding : Seasonal variations were observed in the gut contents of males and females. In females fish formed major food item (33.34 to 100%) from May to January, while it was the dominant food in males (33.34 to 100%) from January to August. Prawns formed and important food item in males from September to December and in April, while they were recorded in females during February and November only. The fishes that could be identified in food were G.giuris, Chanda sp. Etroplus sp.,O.phulo and O.cotio. The prawn identified was M.lamarrei.

The intensity of feeding was found to be more in males from the comparison of gastro somatic indices of males and females. In females the gastro-somatic index was found to be low during spawning season.

13.7 S.childreni

Age and growth : Sizes of fishes examined ranged between 210 and 720 mm (65 to 2816 g). Using growth checks on claithrum bone lengths at ages were calculated to be 267,329, 375, 425, 516, 596 and 640 mm at ages 1 to 7 years respectively.

The length-weight relationship could be described by the equation :

$$\text{Log } W = -5.72721 + 3.20533 \log l (r = 0.98)$$

No differences were observed between males and females in length-weight relationship.

Maturity and breeding : Females dominated through out the year and the sex ratio was 1 : 9.31. A single mature female could be recorded in June. Spent specimens were recorded in February and from late June to September. Gonado-somatic index showed an increase in February with a peak in July. Hence, it is presumed that the main spawning season was from June to September. The ova diameter studies also showed a bimodal distribution (Fig. 17), with modes at 0.15 mm and 0.55 mm. In the spent specimens also maturing ova with mode at 0.15 mm were observed. Concentration of catches was observed during the breeding season in lotic sector indicating breeding migration.

Food and feeding : The guts were found to contain fishes (42.31%), prawns insects (7.87%), amphipods (4.25%) and semidigested matter (38.26%). Among fishes *Chanda* spp., *O. phulo*, *O. vigorsii*, *G. giuris*, *O. clupeioides*, *P. sophore* were observed.

Fishes were found throughout the year as main food item except in June, when prawns dominated. Insects were maximum (14.28%) in August. From the gastro-somatic index, it was observed that the feeding intensity increased from September to January and declined in February. It did not fluctuate much during March to August. Thus, there was a trend of decrease in gastro-somatic index during the spawning season.

Non-commercial fishes :

13.8 *R. corsula* :

Length-weight relationship : Length-weight relationship was found to be significantly different in juveniles and adults (adult males and females being not different). The relationship could be described by:

Juveniles : Log W = -2.375946 + 3.220132 log l

adults log W = -1.9632803 + 2.950850 log l.

Food and feeding : Bulk of the gut contents was detritus dominated by mud particles (index of preponderance) 86.04), followed by diatoms (i.p.-10.16), zooplankton, Chlorophyceae, Myxophyceae, and other-benthic organisms.

Food of juveniles (20-109 mm) was similar to adults but the feeding intensity was much higher as evidenced by the gastro-somatic index.

Maturity and breeding : Fishes of IV stage of maturity and above were available almost throughout the year with more incidence from June to September and in February. Also young specimens of sizes between 11 and 65 mm were available throughout the year except in March. Ova diameter studies showed unimodal distribution of eggs indicating a single spawning by individual fish (Fig.18). Hence, it may be tentatively presumed that the individual fish spawns only once in a year but the population has an extended spawning period almost throughout the year.

13.9 P.taakree

It formed a seasonal fishery being caught by castnets in large numbers during monsoon in lotic sector, to where they migrate for breeding. It matures during April to September, breed during early monsoons. In adults food mainly consisted of insects (aquatic and terrestrial beetles and chironomid pupae) besides fish and prawns.

13.10 O.vigorsii

It formed a minor fishery during summer and monsoon months in lotic sector and Peddamungal bay and is generally dried. It is also a monsoon breeder with mature specimens of sizes 165-315 mm available during April-September. Insects were beetles and tendipes larvae and molluscs included small gastropods and bivalves.

13.11 M.cavasius:

This occurred during summer and monsoon months especially in Peddamunagal bay. Mature specimens (200-280 mm) were available from April to September. Adults mainly fed on insects and insect larvae (beetles, tendipes larvae and caddisworms) during monsoons and on tiny bivalves and gastropods during summer.

Food and feeding habits of trash fishes :

Among the detritophagus fishes can be mentioned O.phulo, O.melastigmus (17-40 mm), P.sophore (17-40mm), Barilis evezardi (12-83 mm), O.cotio (30-135 mm), C.atpar (35-57 mm) and D.equipinnatus (40-49 mm). They were also feeding on zooplankton, Chlorophyceae, Bacillariophyceae and Myxophyceae. Planktonic crustaceans and insects formed more than 70% in the guts of Chanda spp. (13-73 mm) and R.ogilbii (31-65 mm), G.giuris (13-130 mm) and G.itahkeea (22-33 mm) were carnivorous.

The major population of trash fishes are detritus feeders, the feeding habits being similar to commercial carps like L.fimbriatus and L.calbasu. The reservoir seem to favour the breeding and proliferation of trash fishes.

13.12 Growth of some stocked fishes :

Ages of catla, rohu and mrigal were estimated from scales. About 21 scales of C.catla (868-1155 mm), 32 of L.rohita (432-967 mm) and 14 scales of C.mrigala (485-960 mm) were used.

13.12.1 C.catla

This was one of the species stocked (in 1967) just before the completion of the dam. In September, 1971 specimens measuring 895-992 mm(15 to 16 kg) were collected from the reservoir. Based on scales lengths at different ages were calculated, which more or less coincided with the lengths estimated by Von Bertalanffy's growth equation. The lengths at ages estimated are given below :

	Lengths at ages in years						
	1	2	3	4	5	6	7
by scales	520	690	830	910	980	1040	1100
by equation	446	632	777	886	971	1033	1082

The growth equation was $l_t = 1239 \, [1 - e^{-0.27(t+0.65)}]$

13.12.2 C.mrigala

The lengths estimated by from scales and by growth equation

$$l_t = 1202 \, [1 - e^{-0.22(t+0.83)}]$$

at different ages are given below :

	Lengths at ages in years					
	1	2	3	4	5	6
by scales	390	554	665	772	848	924
by equation	399	557	687	787	869	935

13.12.3 L.rohita

The lengths estimated for different ages from scales and the growth equation -

$$l_t = 1119 \, [1 - e^{-0.24(t + 0.008)}]$$

are given below :

	Lengths at ages in years						
	1	2	3	4	5	6	7
by scales	331	497	627	750	835	876	933
by equation	241	428	575	691	783	854	910

14. SURVEY OF FISHERMEN POPULATION

Fishermen of Nagarjunasagar are concentrated in Peddamungal, Hill Colony, Pylon, Vijayapuri South and Srisailam. Fishermen based at Srisailam venture upto about 20 km down stream from Srisailam in the lotic sector. At Srisailam there are about 30 fishermen owning 15 coracles. In Peddamungal bay about 50 fishermen families, having about 35 coracles live in about half-a-dozen settlements around the bay. In the three Colonies along the dam-Hill Colony, Pylon and Vijayapuri South (including Sagar camp) about 180 fishermen with 85 coracles are engaged in fishing.

The gear used was mostly surface (100'x12' each) and bottom set (110' x 3' each) gill net and long lines (75 in number).

The details of fishing units in the reservoir during different months in 1971 are given below. Each unit consisted of 2 fishermen, 1 coracle and 4 to 5 surface gill nets of mesh bar 90-150 mm.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
40	40	30	30	25	25	40	80	90	100	60	50

However, the present effort could not be estimated. The fishing effort with 53,550 units(in terms of 50 m length nets) was presumed to have remained almost the same during the entire period of 9 years from 1971-72 to 1979-80. The catch (kg)/50 m net of the reservoir, fluctuated in a range of 1.29 kg in 1974-75 to 3.56 kg in 1978-79.

15.. STOCKING

The stocking was inadequate upto 1974-75, while it improved from 1975-76 in that about 19 fingerlings/ha/annum were reported to have stocked in the reservoir. The stocking programme did not yield encouraging results probably due to inadequacy of stocking and improper stocking in the earlier years in the sense that they were stocked in deeper areas near the dam.

16. ACKNOWLEDGEMENTS

The Project Coordinator, AICRP on Ecology and Fisheries of Freshwater Reservoirs wishes to record his deep sense of gratitude to the Department of Fisheries, Government of Andhra Pradesh for the kind help and co-operation extended to the Research Sub-centre at Nagarjunasagar throughout the course of present studies. Thanks are also due to the Public Works Department for supplying the data on reservoir morphometry and meteorology respectively.

SUMMARY

1 Nagarjunasagar is a large impoundment on the mainstream of river Krishna, came into existence in the year 1969, has a water spread of 28,475 ha (at FRL) and an extensive catchment covering an area of 2,15,194 km^2.

2 The shore line is highly irregular (shore development 7.89) and the mean depth is also high (40.5 m). The basin wall is concave towards water (volume development index 1.13).

3 The basin soil is poor in nutrients while the water is rich indicating the importance of drainage basin in the nutrient loading of the reservoir.

4 Reservoir water is alkaline with pH 8.4. Bicarbonateis (51-163.0 ppm). Hardness (70-200 ppm), hardness (70-200 ppm), Calcium (9.2 to 42.8 ppm) and specific conductivity (172.5 to 1114.7 micro-mhs) are at productive levels.

5 Phosphates (traces to 0.02 ppm) are poor while nitrates (0.1 to 3.2 ppm) are rich.

6 A feeble thermal stratification has been observed in some years during summer at depth 3 to 16 m with a difference in temperature of 4°C.

7 Strong oxycline, characteristic feature of productive waters observed in Nagarjunasagar during summer in lentic sector and in October in bays when the water levels are high.

8 Influx of flood water breakes summer chemical stratification bringing the locked up nutrient at the bottom to the euphotic zone.

9 Primary production values are quite high in the range 220 to 915 $mgC/m^2/12$ hrs (gross). Peddamunagal bay showes high rate of energy fixation (Gross 9,400 cal/ m^2)

10 Three plankton pulses are observed during winters (December-January) and summer (March-April), contributed by copepods, diatoms and Myxophyceae respectively.

11 Bays are richer in plankton and littoral regions than limnetic regions. Myxophyceae (*Microcystic*) is the dominant element in phytoplankton and copepods in zooplankton.

12 The reservoir is rich in benthos, mainly contributed by molluscs. The high calcium content seems to have favoured the establishment of molluscs. Peddamungal bay and lentic sector are rich in benthic faunna.

13 Higher aquatic plants could not establish permanently due to high water level fluctuations.

14 Rich periphyton deposits were noted between 1 to 3 m depth.

15 Sixtynine species of fishes belong to 16 families have been recorded.

16 There are limited carp breeding grounds in the reservoir. Srisailam dam on the upper reaches of Nagarjunasagar, which has just been completed, sealed off the only migratory route for breeding of several carps and cat fishes.

17 The fish yield fluctuates in the range 69 t (74-75) to 190.8 t (1978-79) and the per hectare yield in the range 3.75 to 10.3 kg. The fishery is mainly contributed by indigenous carps (*L.fimbriatus*, *L.calbasu*) and cat fishes (*P.pangasius*, *M.aor*, *M.seenghala*, *S.childreni*).

18 There has been a gradual shift in the species abundance from an initial carp dominances to catfish dominancee.

19 The major carp stocking in the initial years have been rather poor (less than a fingerling/ha/year) and they failed to establish in the reservoir.

20 The dense molluscan population contributed a rich fishery of P.pangasius which forms about 30-35% of the landings.

21 Fishes of age groups III to V predominantly contributed to the commercial fishery.

22 Srisailam dam is expected to adversely affect the productivity of the reservoir as it reduces the detritus loading besides interfering with the breeding and recruitment of several species.

23 On limnological evidence the reservoir is capable of a fish yield of about 119 kg/ha/annum. The low yield (9- 10 kg) at present is due to the dominances of catfish feeding at higher levels of food chain and under exploitation.

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RECOMMENDATIONS

In capture fishery management monitoring of catch and fishing effort is a must. The present system of free fishing may be replaced by a system of licencing the nets and boats. This will enable regulation of fishing effort.

Many areas in the upper reaches (Intermediate sector) is by and large unexploited for want of communication facilities. A mechanical boat may be arranged to transport the fishermen to these areas and the catches to the landing centres.

Cooperative societies may be organises for production and marketing.

At present there is large scale fishing of brood fish migrating into the shallow 'Peddavagu' at Peddamunnagal during the first floods. This should be stopped and closer season enforced.

The stocking of Gangetic carps in the initial period of reservoir formation has been very poor. The poor stocking coupled with the availability of limited breeding grounds for carps, led to the emergence of catfishes to the dominant position. To develop a carp fishery at this stage will entail lot of effort and expenditure. The present fish farm at Nagarjunasagar is ill equipped to meet the stocking demands of the reservoir. Considering all these aspects, it would be worth while to develop the reservoir as a catfish reservoir, though it may mean reduced productivity.

Intensive cropping (fishing effort) would increase the productivity (yield) of cat fishes as has happened in Bhavanisagar. The fishing effort needs to be enhanced.

Stocking of C.carpio may be discontinued. It failed to appear in the catches inspite of stocking probably due to its sluggish nature forming an easy prey to catfishes and also due to its food habits over lapping with L.calbasu.

It has been reported that crocodiles have been stocked in the upper reaches of the reservoir. This clash with fisheries interest posing problems of exploitation. Besides producing much needed protein food, fishing provides employment to hundreds of fishermen. Nothing should be done to alter this situation by encouraging crocodile farming.

Suggestions for future work :

Srisailam dàm is bound to affect the fishery structure and productivity of the reservoir. Studies may be undertaken monitoring the catches and species composition to undertake remedial measures.

Experimental fishing may be conducted with different nets having mesh bar ranging from 25-180 mm to identify areas ôf fish dispersal in time and space.

TABLE - I

Minimum (Min.), Maximum (Max.) and Average (A) levels of Nagarjunasagar (in ft. above MSL) and yearly fluctuation in water level (in ft.) during 1971-72 to 1979-80

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
	Min.	496.00	493.20	490.90	518.80	518.10	510.10	510.10	533.60	508.90
APR.	Max.	504.00	500.20	502.80	526.60	534.40	519.20	518.00	547.60	519.20
	A	499.20	496.80	499.10	521.50	525.10	513.11	513.50	540.09	513.36
	Min.	497.00	490.50	497.70	518.70	514.80	510.30	510.30	530.90	506.20
MAY	Max.	500.40	495.20	498.00	522.50	517.70	512.80	514.00	533.50	524.60
	A	498.20	492.40	497.90	519.30	515.90	511.64	512.05	532.16	515.49
	Min.	500.60	490.10	497.00	523.10	512.60	512.80	514.20	530.90	517.00
JUN	Max.	539.40	495.50	507.20	529.40	519.60	548.00	533.70	555.50	524.00
	A	514.60	493.10	500.40	526.70	515.00	529.24	521.25	538.01	521.15
	Min.	545.80	488.40	507.70	527.40	522.20	548.80	533.00	558.10	515.80
JUL	Max.	561.40	557.80	569.80	567.00	564.10	564.00	575.90	579.00	534.00
	A	554.30	531.20	542.80	549.40	550.80	556.45	554.20	569.62	526.80
	Min.	551.70	543.90	556.10	567.80	554.40	560.60	574.70	574.80	534.10
AUG.	Max.	557.80	550.10	577.10	575.00	567.80	571.50	579.80	580.40	580.50
	A	554.20	547.60	566.20	570.50	559.30	562.40	576.26	576.64	564.28

Contd....2/-

Table-I (Contd....)

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
	Min.	550.00	548.90	554.60	574.50	559.00	562.20	580.30	580.20	580.50
SEP.	Max.	561.70	552.60	560.00	585.00	588.30	573.70	587.20	589.70	589.40
	A	554.30	550.10	556.40	579.30	573.00	570.30	604.30	585.43	585.66
	Min.	549.90	540.30	556.00	584.00	580.20	556.40	584.10	587.60	586.60
OCT.	Max.	557.70	548.50	561.90	590.00	590.00	573.20	590.00	590.10	590.00
	A	554.30	545.67	557.60	586.70	584.50	565.84	588.73	589.67	589.10
	Min.	543.60	540.70	556.60	584.90	580.10	549.70	582.70	589.00	584.60
NOV.	Max.	549.60	543.00	560.20	587.50	580.80	555.80	587.10	590.00	587.40
	A	546.30	542.20	558.20	586.70	580.50	551.47	584.74	589.75	585.96
	Min.	536.30	538.70	555.50	584.10	575.00	549.10	583.10	565.40	583.40
DEC.	Max.	543.30	543.80	559.40	587.00	580.00	553.30	590.00	589.60	590.00
	A	540.40	542.10	558.30	586.30	577.70	552.00	588.11	578.73	586.9+
	Min.	524.90	527.40	547.80	571.50	556.40	540.10	577.00	541.50	573.50
JAN.	Max.	536.00	538.50	555.30	583.90	574.70	548.80	587.10	564.70	583.60
	A	530.40	533.30	551.50	578.00	567.50	544.84	528.63	533.91	578.71
	Min.	512.80	515.80	539.40	557.90	538.40	530.00	564.10	530.60	560.00
FEB.	Max.	524.50	527.00	547.40	571.10	555.30	539.70	576.50	540.00	573.10
	A	519.20	521.50	543.70	565.10	546.10	534.70	570.45	534.94	567.00

Contd....3/-

Table-I (Contd...)

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
	Min.	500.60	503.10	527.00	536.00	519.90	518.40	547.90	520.00	544.00
MAR.	Max.	513.60	515.40	539.10	557.40	537.80	529.60	563.60	530.20	559.40
	A	507.60	504.28	535.00	546.50	528.90	523.90	555.72	525.98	552.01
Range of yearly Fluctuations		65.70	69.40	86.20	71.30	77.40	63.60	79.90	70.10	83.80

Note : The minimum and maximum levels of each year are underlined.

TABLE - 2

Extent of shallow Areas of the Nagarjunasagar in Relation to Reservoir Levels between 480' and 590' (FRL)

Reservoir Level (ft.)	Total water spread area		Area under 5'		Area under 10'		% of area in total area under	
	M Sq ft	ha	M Sq ft	ha	M Sq ft	ha	5 ft	10 ft
590	3,065.00	28,474.8	28.16	261.6	56.32	523.3	0.9	1.8
585	3,036.84	28,213.2	28.16	261.7	125.688	1,167.6	0.9	4.1
580	3,008.68	27,951.5	97.52	905.9	195.04	1,811.9	3.2	6.5
575	2,911.16	27,045.6	97.52	906.0	172.24	1,600.2	3.3	5.9
570	2,813.64	26,139.6	74.72	694.2	149.44	1,388.4	2.7	5.3
565	2,738.92	25,445.4	74.72	694.2	155.85	1,447.9	2.7	5.7
560	2,664.20	24,751.2	81.13	753.7	162.26	1,507.4	3.0	6.1
555	2,583.07	23,997.5	81.13	753.7	161.64	1,501.7	3.1	6.3
550	2,501.94	23,243.8	80.51	748.0	161.03	1,496.0	3.2	6.4
545	2,421.43	22,495.8	80.52	748.0	140.03	1,301.0	3.3	5.8
540	2,340.91	21,747.8	59.51	553.0	119.02	1,105.8	2.5	5.1
535	2,281.40	21,194.8	59.51	552.8	117.01	1,087.0	2.6	5.1
530	2,221.89	20,642.0	57.50	534.2	115.00	1,068.4	2.6	5.2
525	2,164.39	20,107.8	57.50	534.2	110.83	1,029.6	2.7	5.1
520	2,106.89	19,573.6	53.33	495.4	106.66	990.9	2.5	5.1
515	2,053.56	19,078.2	53.33	495.5	115.33	1,071.5	2.6	5.6

Contd...2/

(Table No.2 Contd..)

Reservoir Level (ft.)	Total water spread area		Area under 5'		Area under 10'		% of area in total area under	
	M Sq ft	ha	M Sq ft	ha	M Sq ft	ha	5 ft	10 ft
510	2,000.23	18,582.7	62.00	576.0	124.00	1,152.0	3.1	6.2
505	1,938.23	18,006.7	62.00	576.0	132.58	1,231.7	3.2	6.8
500	1,876.23	17,430.7	70.58	655.7	141.16	1,311.4	3.8	7.5
495	1,805.65	16,775.0	70.58	655.7	116.12	1,078.8	3.9	6.4
490	1,735.07	16,119.3	45.54	423.1	91.09	846.2	2.6	5.2
485	1,689.53	15,696.2	45.55	423.1	-	-	2.7	-
480	1,643.98	15,273.1	-	-	-	-	-	-

T A B L E - 3

Monthly total Inflow (I) and Outflow (O) of water (in thousand cusecs) in and from Nagarjunasagar

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
APR	I	39	59	18	24	46	103	57	72	20
	O	211	228	125	251	514	335	239	478	284
MAY	I	96	112	11	112	53	61	111	72	480
	O	nil	45	nil	nil	76	nil	19	152	117
JUN	I	1,440	114	537	309	438	1,167	863	922	218
	O	296	225	233	245	308	251	396	251	384
JUL	I	3,488	3,170	4,331	2,428	4,924	3,374	2,750	3,064	1,507
	O	3,074	1,454	2,986	1,890	3,653	3,076	1,491	2,614	1,100
AUG	I	2,972	1,181	4,160	3,849	6,045	6,652	3,852	7,949	6,028
	O	3,091	1,146	4,325	3,843	5,759	6,622	3,689	7,619	4,544
SEPT	I	3,025	1,330	3,093	2,931	4,723	2,750	3,110	5,467	4,021
	O	3,085	1,193	3,043	3,210	4,480	2,301	2,973	5,189	4,008

(Contd....

(Table No.3 Contd...)

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
OCT	I	2,730	355	3,288	4,761	8,705	634	2,373	3,095	2,915
	O	3,245	644	3,181	5,206	9,640	1,178	2,280	2,836	2,995
NOV	I	320	241	942	866	3,580	248	327	1,101	784
	O	555	237	1,000	696	3,675	592	479	1,142	885
DEC	I	120	69	173	298	417	94	600	361	626
	O	345	126	243	480	557	178	502	1,386	740
JAN	I	74	not available	120	235	182	109	145	202	208
	O	433	199	354	594	824	354	547	949	549
FEB	I	68	not available	70	181	141	83	124	113	123
	O	365	194	332	582	612	353	530	399	559
MAR	I	36	not available	44	80	82	73	118	106	88
	O	369	124	414	724	601	345	129	354	554
TOTAL	I	14,414		16,792	16,081	29,342	15,355	14,436	22,529	17,024
	O	15,073	5,821	16,240	17,725	30,702	15,591	13,278	23,374	16,725

T A B L E - 4

Average minimum (Min.) and maximum (Max.) air temperature in C° and total rainfall (R) in mm at Nagarjunasagar

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
	Min.	25.94	26.98	27.02	26.72	26.91	26.00	26.40	26.65	28.54
APR	Mix.	40.06	40.36	42.33	41.41	41.27	40.68	40.45	41.70	41.21
	R	3.7	23.3	nil	7.4	nil	4.1	12.1	nil	3.2
	Min.	28.43	28.75	30.12	27.77	29.55	30.09	27.21	28.78	29.68
MAY	Mix.	40.62	41.23	43.51	40.33	42.56	43.06	40.31	41.61	39.54
	R	22.8	1.4	4.3	27.3	11.2	32.4	70.0	18.4	37.8
	Min.	26.42	28.43	27.15	26.78	26.24	27.68	27.74	26.74	30.20
JUN	Mix.	34.26	39.70	37.57	35.49	35.58	37.52	37.38	35.57	38.05
	R	34.7	28.7	143.5	66.3	55.6	139.1	56.3	83.4	23.6
	Min.	27.15	26.20	25.90	26.41	24.96	25.80	26.03	26.07	27.99
JUL	Mix.	33.55	34.68	34.46	35.10	32.94	33.11	34.23	32.90	35.22
	R	70.8	33.3	34.6	70.4	276.8	84.7	120.8	105.2	30.6
	Min.	26.20	27.47	25.66	25.88	25.25	24.78	25.43	25.58	27.33
AUG	Mix.	33.60	35.33	32.96	33.15	32.33	31.68	32.69	31.46	33.59
	R	80.5	25.1	65.6	40.6	263.3	235.7	150.8	190.6	35.1

(Contd...)

(Table No.4 Contd.)

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
	Min.	26.66	25.80	25.63	25.04	24.27	25.35	25.71	25.92	25.85
SEP.	Max.	33.80	35.91	34.45	33.66	31.84	33.97	34.80	32.23	33.87
	R	156.2	130.8	135.3	301.7	216.5	37.2	46.6	185.2	318.3
	Min.	24.16	23.25	23.90	24.14	23.31	23.74	23.17	25.61	25.83
OCT.	Max.	31.87	33.60	32.59	31.98	31.81	35.42	34.09	32.98	33.71
	R	125.2	131.9	185.6	159.6	366.3	16.2	101.9	56.1	5.8
	Min.	19.75	21.10	20.59	20.31	19.56	22.00	22.14	23.34	23.77
NOV.	Max.	31.01	30.81	31.03	31.27	30.17	31.11	32.67	31.47	30.97
	R	nil	66.5	26.1	45.2	27.6	126.1	42.9	57.4	100.9
	Min.	17.92	Not availabe	18.69	17.57	16.39	18.43	18.00	21.32	21.50
DEC.	Max.	29.51	Not available	30.29	29.58	29.93	31.42	31.39	29.96	30.67
	R	nil	Not available	nil	nil	nil	nil	nil	3.2	2.00
	Min.	17.12	19.74	18.08	18.28	16.98	17.90	19.10	21.04	21.23
JAN.	Max.	30.35	33.11	32.14	30.77	29.88	32.25	31.65	31.32	32.29
	R	nil	nil	nil	nil	nil	nil	nil	nil	nil
	Min.	22.22	22.07	20.30	22.05	19.71	20.85	20.56	24.31	22.91
FEB.	Max.	33.50	35.05	35.04	34.08	34.59	34.22	33.57	33.59	35.01
	R	74.3	nil	nil	3.5	nil	nil	2.0	22.4	nil

(Contd...

(Tanle No.4 Contd..)

Year/ Month		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
	Min.	23.35	24.09	24.12	24.53	23.52	23.31	23.81	24.24	25.88
MAR.	Mix.	38.22	38.69	39.73	38.13	38.65	38.10	38.03	37.38	38.46
	R	nil	nil	nil	2.0	nil	nil	33.5	nil	nil
TOTAL RAIN FALL:		568.2	440.8	595.0	724.0	1,217.3	675.5	636.9	721.9	557.3

TABLE - 5

SECTORWISE PHYSICO-CHEMICAL CHARACTERISTICS (RANGE & AVERAGE)*
OF NAGARJUNASAGAR RESERVOIR DURING 1971 TO 1979

Parameters	Lentic Sector Range/ Average	Intermediate Sector Range/ Average	Lotic Sector Range/ Average	Peddamunagal Bay Range/ Average	Shunkishala Bay Average	Dihdi Bay Average
1	2	3	4	5	6	7
Water Temperature (°C)	23.3-31.0 (27.63)	25.0-30.5 (27.2)	22.5-29.0 (27.12)	24.5-33.5 (28.2)	28.02	26.0
Transparency (cm)	21.0-545.5 (199.50)	27.7-514.0 (172.80)	5.8-961.75 (54.35)	26.2-212.0 (78.97)	182.4	194
pH	8.0-8.8 (8.4)	7.7-8.7 (8.3)	7.6-8.8 (8.3)	8.0-8.8 (8.5)	8.4	8.4
Free Carbon-dioxide (ppm)	nil-8.8	nil-7.5	nil-6.6	nil-3.15(Jul.'77)	0.35	nil
Carbonate(ppm)	nil-19.80 (9.08)	nil-19.20 (11.32)	nil-34.56 (15.84)	nil-32.32 (11.89)	9.86	15.96
Bicarbonate(ppm)	58.58-125.0 (87.12)	65.84-120.32 (91.00)	51.0-163.35 (104.14)	61.0-138.18 (97.04)	82.78	100.32
Calcium (ppm)	12.0-36.4 (24.61)	21.6-31.6 (26.1)	9.30-42.8 (26.82)	17.2 - 38.4 (25.29)	24.8	24.0

(Contd...)

(Table No.5 Contd..)

1	2	3	4	5	6	7
Magnesium (ppm)	3.6-15.0 (7.21)	2.64-14.64 (6.93)	1.44-27.6 (11.21)	3.36-12.48 (7.93)	6.98	7.92
Total hardness (ppm)	72.0-128.0 (97.17)	71.0-133.0 (96.60)	70.0-200.0 (122.90)	81.0-128.0 (102.30)	93.5	-
Dissolved Org. matter (ppm)	0.20-2.25 (0.813)	0.09-1.55 (0.558)	0.14-2.22 (0.685)	0.06-4.87 (0.906)	0.959	0.412
*Dissolved Oxygen (ppm)	5.12-9.91 (7.10)	5.12-7.83 (6.18)	5.10-9.49 (7.35)	5.10-11.0 (7.58)	7.52	6.60
Ammonium Nitrogen (ppm)	0.04-0.60 (0.147)	0.06-0.25 (0.12)	0.03-0.40 (0.173)	0.05-0.35 (0.145)	0.213	0.09
Nitrate nitrogen (ppm)	0.10-1.20 (0.472)	0.16-0.70 (0.45)	0.13-1.2 (0.586)	0.14-3.2 (0.485)	6.450	0.73
Phosphorus (ppm)	Traces-0.02	Traces-0.003	Traces-0.01	Traces-0.01	Traces-0.02	0.0015
Iron (ppm) Fe^{+++}	0.05-0.63 (0.147)	0.04-0.60 (0.172)	0.08-3.2 (0.671)	0.04-0.60 (0.219)	0.204	0.08
Silicon (ppm)	19.0-48.0 (30.3)	19.0-40.0 (28.15)	19.0-50.0 (33.68)	22.0-53.0 (36.2)	32.39	39.2
Sp. conductivity (micromhos)	216.6-600.0 (379.36)	189.9-657.8 (372.1)	172.53-1114.7 (515.36)	258.8-614.10 (416.48)	360.0	387.3

*Average values in Brackets.

TABLE - 6(A)

SEASONAL VARIATION OF PHYSICO-CHEMICAL-CHARACTERISTICS IN DIFFERENT SECTORS OF NAGARJUNASAGAR RESERVOIR (Seasonwise average values in different sectors during 1974 to 1979).

Sectors	Seasons	Temperatures(°C)	Transparency (cm)	pH	Free Carbon-dioxide (ppm)	Carbonate (ppm)	Bicarbonate (ppm)
1	2	3	4	5	6	7	8
LOTIC SECTOR	Jan. - March	27.5	88.84	8.4	nil	19.99	123.86
	April- June	27.3	18.78	8.1	3.23	nil	91.35
	Jul.- Sept.	28.1	12.25	7.9	4.01	nil	81.70
	Oct. - Dec.	23.3	51.32	8.3	nil	13.48	127.42
INTERMEDIATE SECTOR	Jan. - March	25.4	258.0	8.5	nil	12.61	95.40
	April- June	29.5	185.0	8.6	nil	13.07	100.85
	Jul. - Sept.	27.2	34.78	7.9	4.25	nil	69.81
	Oct. - Dec.	26.9	214.0	8.3	1.416 (absent in 76,78)	3.03 (present in 76,78)	97.95
LENTIC SECTOR	Jan. - March	25.5	420.80	8.4	nil	8.38	95.96
	April- June	28.9	224.50	8.6	nil	13.83	98.69
	Jul. - Sept.	28.3	144.20	8.3	7.0 (in 1975)	5.79 (absent in 75)	92.98
	Oct. - Dec.	28.5	102.0	8.2	2.125 (absent in 74,76, 79)	3.01 (present in 74, 76,79)	80.49

Contd...

Contd. Table No. 6(A)

1	2	3	4	5	6	7	8
PEDDAMUNA-GAL BAY	Jan. - March	25.4	131.64	8.6	nil	12.83	100.05
	April- June	30.3	79.51	8.6	nil	12.28	111.84
	Jul. - Sept.	26.6	98.43	8.2	nil	5.09	110.08
	Oct - Dec.	29.0	99.65	8.5	3.15 ('77)	14.32 (absent in 77)	91.22

TABLE - 6(B)

SEASONAL VARIATION OF PHYSICO-CHEMICAL- CHARACTERISTICS IN DIFFERENT SECTORS OF NAGARJUNASAGAR RESERVOIR(Seasonwise average values in different sectors during 1974 to 1979).

Sector	Seasons	Calcium (ppm)	Magnesium (ppm)	Total hardness (ppm)	Dissolved Organic matter(ppm)	Dissolved Oxygen (ppm)	Nitrate (ppm)	Iron (ppm)	Silicon (ppm)	Sp. conductivity (micr
1	2	3	4	5	6	7	8	9	10	11
LOTIC SECTOR	Jan.-Mar.	32.8	16.13	166.25	0.646	7.15	0.45	0.43	31.0	824.45
	Apr.-Jun.	23.8	7.26	91.00	0.720	6.53	0.63	1.176	26.2	394.35
	Jul.-Sept.	23.3	6.76	79.00	0.352	6.36	0.41	1.476	24.2	251.97
	Oct.-Dec.	33.5	15.31	155.50	0.623	6.96	0.975	0.12	28.0	609.38
INTER-MEDIATE SECTOR	Jan.-Mar.	27.44	7.38	102.75	0.674	6.87	0.484	0.198	31.5	413.26
	Apr.-Jun.	27.52	9.27	112.75	0.737	6.24	0.386	0.128	29.8	505.78
	Jul.-Sept.	22.48	4.61	74.0	0.397	6.21	0.474	0.28	23.4	223.04
	Oct.-Dec.	26.96	6.48	96.75	0.425	6.00	0.45	0.085	25.2	346.02
LENTIC SECTOR	Jan.-Mar.	26.7	7.76	101.40	0.682	6.21	0.605	0.087	32.0	343.05
	Apr.-Jun.	29.07	7.96	108.80	1.125	6.63	0.421	0.083	27.8	474.36
	Jul.-Sept.	25.44	8.03	95.60	0.520	6.33	0.432	0.146	24.8	414.22
	Oct.-Dec.	21.67	6.24	81.50	0.547	6.54	0.47	0.26	26.0	272.64

Contd...

(Contd. Table No.6(B)

1	2	3	4	5	6	7	8	9	10	11
PEDDA-MUNAGAL BAY	Jan.-Mar.	25.96	8.16	103.0	0.955	7.28	0.454	0.096	32.0	373.66
	Apr.-Jun.	28.60	8.45	110.0	1.005	5.79	0.820	0.311	32.1	492.30
	Jul.-Sept.	30.26	8.87	108.5	0.488	5.77	0.496	0.096	24.0	460.80
	Oct.-Dec.	24.5	6.36	90.0	0.911	6.35	0.20	0.13	24.6	311.92

TABLE - 7

Percentage composition of different planktonic genera in their respective groups from 1971-72 to 1979

(PHYTOPLANKTON)

Genera	Lotic Sector	Intermediate Sector	Lentic Sector	Peddamunigala	Shunkishala	Reservoir
MYXOPHYCEAE						
Microcystis	65.54%	99.89%	99.80%	99.33%	95.42%	99.274%
Nostoc	0.07	-	-	-m-	-	0.003
Phormidium	0.12	-	0.01	-m-	-	0.001
Oscillatoria	10.48	0.10	0.12	0.07	4.58	0.100
Anabaena	19.42	-	0.04	0.50	-	0.520
Coelospherium	0.34	-	-	-	-	0.001
Aphanocapsa	2.04	-	-	-	-	0.005
Spirulina	0.65	-	-	-	-	0.002
Merismopedia	0.51	0.01	0.01	0.09	-	0.090
Lyngbya	0.29	-	-	-	-	0.001
Rivularia	0.54	-	0.02	-m-	-	0.003
CHLOROPHYCEAE						
Hormidium	0.01%	-		0.35%	-	0.22%
Pediastrum	86.34	60.65%	63.81%	19.15	27.89%	40.91

(Contd....

Table No.7 Contd...)

Genera	Lotic Sector	Intermediate Sector	Lentic Sector	Peddamu-nigala	Shunki-shala	Reservoir
Oedogonium	0.02	-	3.63	-	-	0.31
Spirogyra	12.34	38.24	28.78	78.58	72.11	56.70
Tetraspora	-m-	0.23	0.02	0.01	-	0.01
Ulothrix	0.09	-	0.03	-	-	0.02
Botryococcus	1.20	0.88	3.73	1.79	-	1.76
Volvox	-			0.12	-	0.07
<u>BACILLARIOPHYCEAE</u>						
Navicula	10.83%	0.42%	0.31%	0.45%	23.84%	0.413%
Tabellaria	28.10	0.02	0.01	0.07	73.52	0.124
Gyrosigma	2.11	-m-	-m-	-m-	-	0.008
Amphora	0.65		-m-	-m-	-	0.003
Synedra	9.32		-m-	-m-	-	0.034
Nitzchia	0.64		-m-	-m-	-	0.002
Fragilaria	25.49	98.97	94.39	90.94	2.64	95.138
Melosira	22.48	0.59	5.28	8.53	-	4.276
Surirella	0.38	-m-	-m-	-	-	0.002
Pinnularia	-	-m-	-m-	-	-	-m-
<u>DINOPHYCEAE</u>						
Ceratium	100.00	100.00	100.00	100.00	-	100.00

m = meagre

TABLE - 8

Percentage composition of different planktonic genera in their respective groups from 1971-72 to 1979

(ZOOPLANKTON)

	Lotic	Intermediate	Lentic	Peddamunigala	Shinkisella	Reservoir
PROTOZOA						
Arcella	94.26%	100.00%	36.17%	100.00%	100.00%	94.88%
Difflugia	4.05		4.25			1.06
Actinosphaerium	1.69		59.58			4.06
ROTIFERA						
Lecane	7.33%	3.16%	7.62%	14.78%	18.62%	12.82%
Asplanchna	0.02	-	0.01	0.75	-	0.54
Brachionus	9.22	2.16	2.28	10.70	0.43	8.50
Keratella	74.54	65.64%	54.86	58.28	80.23	59.19
Monostyla	0.02	-	-	-	-	-m-
Filina	0.45	0.51	2.55	2.81	0.52	2.50
Conochilus	5.91	16.08	15.03	3.38	0.20	6.03
Trichocerca	0.08	0.09	0.27	0.36	-	0.31
Mytilina	0.06	0.44	0.32	0.18	-	0.21
Noteus	1.74	11.27	16.45	5.82	-	7.61
Schizocerca	0.52	0.41	0.57	0.75	-	0.68
Kellicottia	0.11	-	0.02	0.19	-	0.14
Notholca	-	0.24	-	-	-	0.01
Polyarthra	-	-	0.02	2.00	-	1.46

(Contd..)

(Table No.8 Contd...)

	Lotic	Intermediate	Lentic	Peddamunigala	Shinkisella	Reservoir
CLADOCERA						
Chydorus	90.40%	25.87	21.35%	17.11%	29.22%	40.98%
Diaphanosoma	1.19	2.21	1.10	1.23	10.67	1.56
Ceriodaphnia	3.54	23.03	18.26	30.59	-	18.33
Daphnia	4.87	65.58	59.29	51.07	57.09	39.13
Sida	-	-	-	-	3.02	-m-
COPEPODA						
Cyclops	45.05%	52.35%	53.26	33.74	47.81%	40.23%
Diaptomus	3.97	10.10	6.63	9.31	13.98	8.91
Nauplii	50.98	37.55	40.11	56.95	38.21	50.86

TABLE - 9

Sectorwise qualitative (units/m^2) and quantitative (ml and g/m^2) variations in bottom macrofauna of Nagarjunasagar

	Lotic Sector Numerical (no/m^2)	%	Intermediate Sector Numerical (no/m^2)	%	Lentic Sector Numerical (no/m^2)	%	Bays Peddamunigala & Shunkishala Numerical (no/m^2)	%
Gastropods	1	(1.06)	76	(21.48)	111	(48.46)	530	(74.97)
Bivalves	9	(9.47)	12	(3.40)	10	(4.37)	65	(9.19)
Chironomus larva	9	(9.47)	131	(37.00)	25	(10.92)	29	(4.10)
Other Insect larvae	36	(37.89)	123	(34.79)	66	(28.82)	58	(8.21)
Nymphs	1	(1.06)	10	(2.82)	4	(1.75)	24	(3.39)
Oligochaetes	39	(41.05)	2	(0.56)	13	(5.68)	1	(0.14)
Total (no/m^2)	95		354		229		707	
Volumetric (ml/m^2)	4.4		5.0		4.7		12.4	
Gravimatric (g/m^2)	3.2		3.7		7.5		11.7	

TABLE - 10

Annual yield, fishing effort and Catch/Unit effort during the period 1971-72 to 1979-80

Year	Total yield (t)	Catch(Kg)/ ha	Fishing effort (50 m unit)	Catch(Kg)/ 50 m	% increase/ decrease in catch
1971-72	158.65	8.60	53,550	2.96	-
1972-73	32.32	1.75	#	0.60	- 79.63
1973-74	76.33	4.14	53,550	1.42	- 51.89
1974-75	69.15	3.75	"	1.29	- 56.41
1975-76	111.94	6.04	"	2.09	- 29.44
1976-77	78.30	6.00	"	1.46	- 50.65
1977-78	173.01	9.38	"	3.23	+ 9.05
1978-79	190.77	10.35	"	3.56	+ 20.24
1979-80	178.64	9.69	"	3.33	+ 12.60

Fishing effort was highly reduced

Average area of reservoir = 18,429 ha.

TABLE - 11

Sector-wise fish landing (Kg) during 1977-78 & 1978-79

	Lentic		Lentic Bay (Peddamunagal)		Intermediate		Lotic	
	1977-78	1978-79	1977-78	1978-79	1977-78	1978-79	1977-78	1978-79
L. fimbriatus	6,202	5,251	2,045	3,945	12,558	8,017	5,204	4,446
L. calbasu	3,650	4,231	1,177	951	1,165	2,474	5,880	2,582
C. catla	330	-	1,480	1,385	408	-	820	1,246
C. mrigala	355	886	450	543	260	1,393	90	34
L. rohita	375	147	408	957	148	294	248	-
T. khudree	1,883	2,715	387	341	780	1,529	730	853
P. pangasius	32,950	41,227	10,932	4,816	13,335	6,214	6,215	5,249
M. aor	9,872	17,209	17,800	11,709	408	940	910	979
M. seenghala	1,450	1,412	3,952	5,240	1,360	3,025	338	413
S. childreni	4,446	7,743	1,026	3,339	3,155	4,750	5,330	14,504
W. attu	636	1,388	548	988	570	720	1,212	763
M. punctatus	992	1,235	139	481	470	767	1,400	1,366
Misc.	470	997	1,703	4,555	570	316	3,790	4,206
Total	63,611	84,441	42,047	39,250	35,187	30,439	32,167	36,641
%	36.77	44.26	24.30	20.57	20.34	15.95	18.59	19.20

TABLE- 12(A)

Fish yield (Kg) and species composition during 1971-72 to 1979-80

	1971-72		1972-73*		1973-74		1974-75		1975-76		1976-77		1977-78	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
L. fimbriatus	56,300	35.49	9,906	30.65	22,436	29.28	5,262	7.61	8,631	7.71	10,240	9.27	26,009	15.03
L. calbasu	8,880	5.60	1,588	4.81	8,265	10.83	11,808	15.92	7,086	6.33	7,571	6.85	11,872	6.86
L. rohita	640	0.40	50	0.15	-	-	-	-	1,332	1.19	1,414	1.28	1,179	.68
C. catla	6,530	4.12	6,610	20.25	1,408	1.95	1,938	2.80	2,160	1.93	2,200	1.99	3,038	1.76
C. mrigala	890	0.56	729	2.26	-	-	1,761	2.55	660	0.59	542	0.49	1,155	.67
T. Khudree	2,120	1.34	500	1.56	3,888	5.09	1,074	1.58	2,015	1.80	2,631	2.38	3,780	2.18
M. aor	8,550	5.39	4,142	12.51	8,356	10.95	9,457	13.67	18,112	16.18	12,854	11.63	28,990	16.76
M. seenghala	11,590	7.31	727	2.21	7,267	9.52	6,233	9.01	11,295	10.09	5,515	4.99	7,100	4.10
P. pangasius	30,630	19.31	2,290	7.09	8,493	11.13	13,043	18.66	23,654	21.13	37,525	33.95	63,432	36.66
S. childreni	23,590	14.87	1,727	5.34	5,535	7.25	8,492	12.88	22,089	19.74	12,048	10.90	13,957	8.07
W. attu	1,970	1.24	934	2.89	1,679	2.20	2,416	3.49	4,164	3.72	2,457	2.22	2,966	1.71
Misc.	4,270	4.37	3,134	10.28	9,009	11.80	8,451	11.83	10,736	9.57	15,534	14.05	9,534	5.51
Total Catch	1,58,650		32,318		76,328		69,155		1,11,934		1,10,531		1,73,012	
Catch/ha	8.6		1.75		4.14		3.75		6.04		6.00		9.4	

* Fishing effort was low due to civil strife in the state.

TABLE - 12(B)

Fish yield (Kg) and species composition during 1971-72 to 1979-80

	1978-79		1979-80	
	Catch	%	Catch	%
L. fimbriatus	21,659	11.35	18,631	10.43
L. calbasu	10,238	5.37	11,104	6.22
L. rohita	1,398	0.73	4,877	2.73
C. catla	2,631	1.38	1,696	0.95
C. mrigala	2,855	1.50	6,668	3.73
T. khudree	5,438	2.85	3,122	1.75
M. aor	30,837	16.16	30,624	18.26
M. seenghala	10,090	5.29	11,337	6.35
P. pangasius	57,506	30.14	48,338	27.06
S. childreni	30,336	15.90	22,615	12.66
W. attu	3,859	2.02	3,158	1.77
Misc.	13,921	7.30	14,469	8.10
Total Catch	1,90,771		1,78,641	
Catch/ha	10.3		9.70	

TABLE - 13

Percentages of carps and cat fishes during 1971-72 to 1978-79

Year	1971-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79
Carps	47.50	60.19	47.15	30.46	19.55	22.26	27.18	23.66
Cat fishes	48.11	38.98	41.05	57.71	70.86	63.69	67.30	72.80
Cat fishes without *P. pangasius*	34.81	30.89	28.92	37.05	49.73	29.74	30.64	38.66

N.B.: Other carps and catfishes from miscellaneous item also are added wherever separately know.

TABLE-14

Details of stocking in Nagarjunasagar Reservoir

Year	*C. Catla*	*L. rohita*	*C. mrigala*	*C. carpio*	*L. fimbriatus*	Total
1964-65	-	-	-	-	690	690
1965-66	-	-	-	-	-	nil
1966-67	150	-	-	2,075	730	2,955
1967-68	41,630	-	-	-	-	41,630
1968-69	-	-	26,770	17,100	-	43,870
1969-70	-	-	9,326	-	-	59,326
1970-71	6,900	12,700	26,350	1,01,535	1,000	1,48,485
1971-72	16,750	8,250	1,29,244	47,950	-	2,02,194
1972-73	-	-	-	80,254	-	80,254
1973-74	2,000	23,950	500	21,800	1,850	50,100
1974-75	-	-	93,000	-	-	93,000
1975-76	67,000	1,85,000	4,07,200	1,24,500	-	8,33,700*
1976-77	4,000	1,03,000	75,000	1,00,000	4,000	4,22,000*
1977-78	1,12,000	1,21,700	24,200	41,700		4,15,600*
1978-79	9,500	1,48,250	1,54,250	-	-	3,12,000

*Total included 50,000 in 1975-76, 1,00,000 in 1976-77 and 1,16,000 in 1977-78 of *M. malcolmsonii*.

TABLE - 15

Catch (No&Wt.) in relation to age in L. fimbriatus during 1976-77 to 1978-79

Age in years	1976 - 77				1977 - 78				1978 - 79			
	No	%	wt. (Kg)	%	No	%	wt. (Kg)	%	No	%	wt. (Kg)	%
1	143	1.58	29	0.28	111	0.61	21	0.08	104	0.64	198	0.91
2	3731	41.14	2108	20.59	2611	14.42	1475	5.67	5457	33.82	3083	14.23
3	2869	31.63	3342	32.64	7622	42.31	8926	34.32	3884	24.07	4525	20.89
4	2026	22.34	3966	88.73	7071	39.05	13,845	53.23	5702	35.34	11166	51.55
5	262	2.89	675	6.59	546	3.05	1404	5.40	740	4.59	1903	8.78
6	38	0.42	120	1.17	106	0.59	338	1.30	246	1.52	784	3.62

TABLE - 16

Catch (No.&Wt.) in relation to age in P. pangasius during 1976-77 to 1978-79

Age in years	1976 - 77				1977 - 78				1978 - 79			
	No	%	wt. (Kg)	%	No	%	wt. (Kg)	%	No	%	wt. (Kg)	%
2	1079	3.73	195	0.52	1270	2.72	235	0.37	3,277	5.96	603	1.05
3	5970	21.04	2949	7.86	9798	21.01	4840	7.63	16,156	29.38	7981	13.88
4	6042	21.30	5674	15.12	10875	23.32	10212	16.10	17,918	32.59	16825	29.26
5	7854	27.68	11907	31.73	11460	24.58	17374	27.39	10,864	19.76	16470	28.64
6	4985	17.57	10271	27.37	8074	17.32	16632	26.22	4,662	8.48	9603	16.70
7	1963	8.92	5028	13.40	3351	7.18	8582	13.53	1,102	2.00	2823	4.91
8	497	1.75	1493	3.98	1437	3.08	4313	6.80	630	1.15	1892	3.29
9	–				359	0.77	1243	1.96	378	0.69	1310	2.28
i		.921				.866				.837		
a		.602				.579				.567		

i = Instantaneous mortality rate

a = Total mortality rate.

TABLE - 17

Catch (No.&Wt.) in relation to age in *M. aor* during 1976-77 to 1978-79

Age in years	1976 - 77				1977 - 78				1978 - 79			
	No	%	wt. (Kg)	%	No	%	wt. (Kg)	%	No	%	wt. (Kg)	%
1	663	3.08	53	0.41	175	0.45	14	0.05	37	0.09	3	0.01
2	3,179	14.77	833	6.48	2,656	6.89	696	2.40	2,473	6.09	648	2.10
3	11,146	51.77	5,796	45.09	14,065	36.51	7,314	25.23	14,327	35.28	7,450	24.16
4	4,483	20.82	3,672	28.57	13,459	34.94	11,023	38.02	15,260	37.58	12,498	40.53
5	1,544	7.17	1,737	13.51	5,779	15.00	6,502	22.43	6,439	15.86	7,244	23.49
6	413	1.92	585	4.55	2,177	5.65	3,079	10.62	1,827	4.50	2,584	8.38
7	55	0.26	93	0.72	180	0.47	301	1.04	245	0.60	410	1.33
8	45	0.21	86	0.67	33	0.09	61	0.21	-	-	-	-
i	1.098				1.213				1.377			
a	.667				.703				.748			

i = Instantaneous mortality rate

a = Annual mortality rate

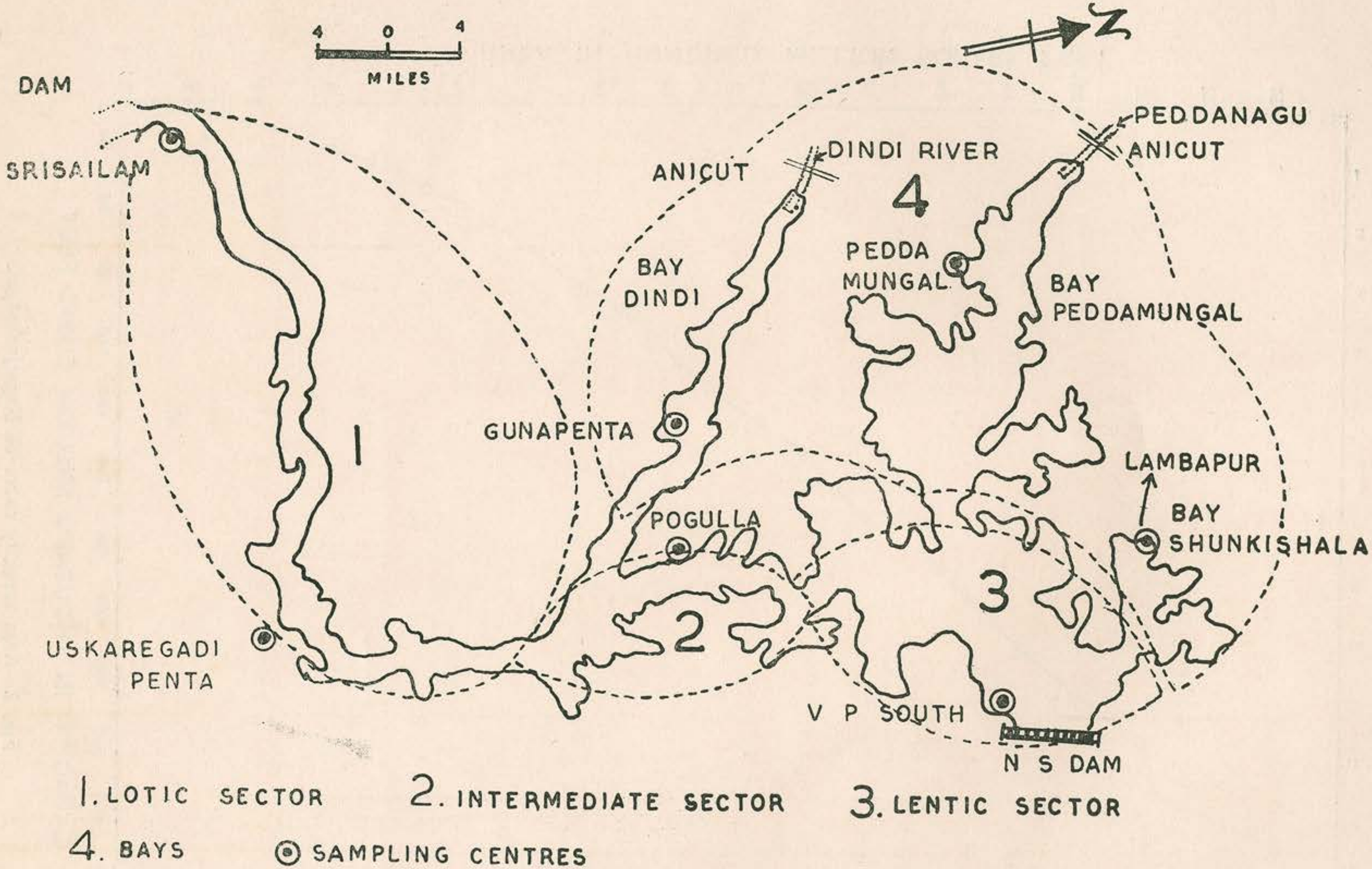

Fig. 1 Nagarjunasagar Reservoir.

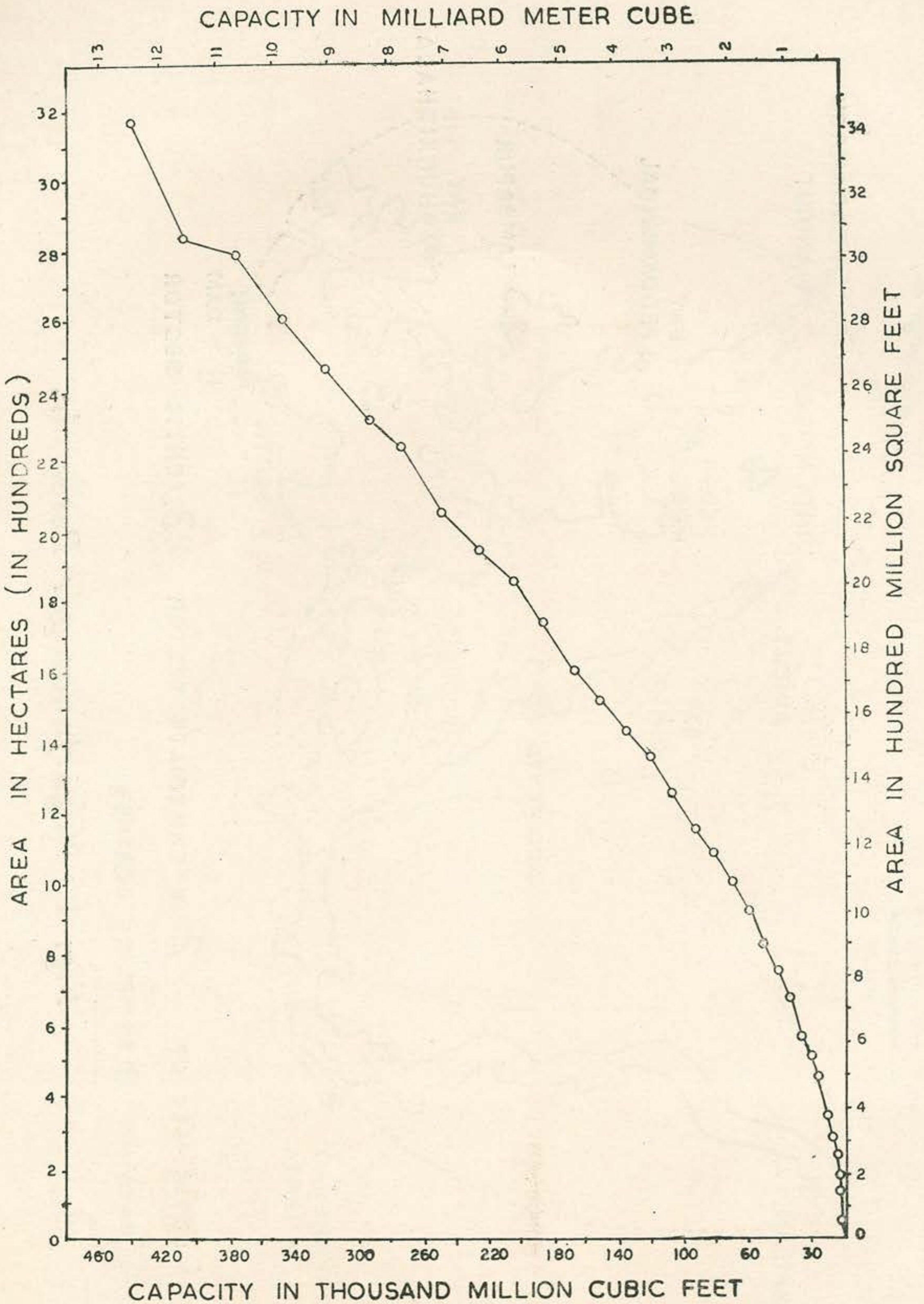

Fig. 2 Area capacity curve of Nagarjunasagar.

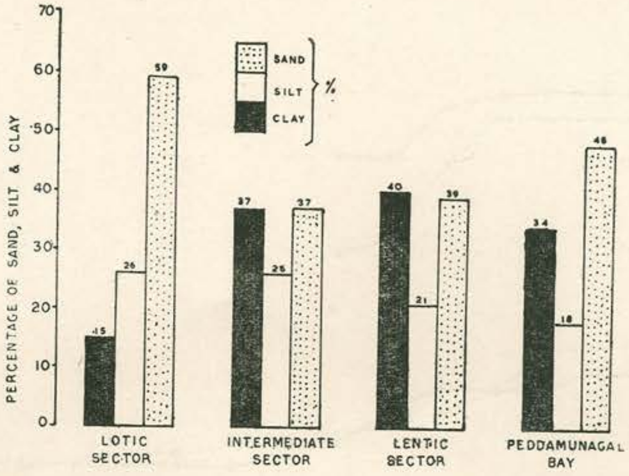

Fig. 3 Physical features of bottom soil in different sectors.

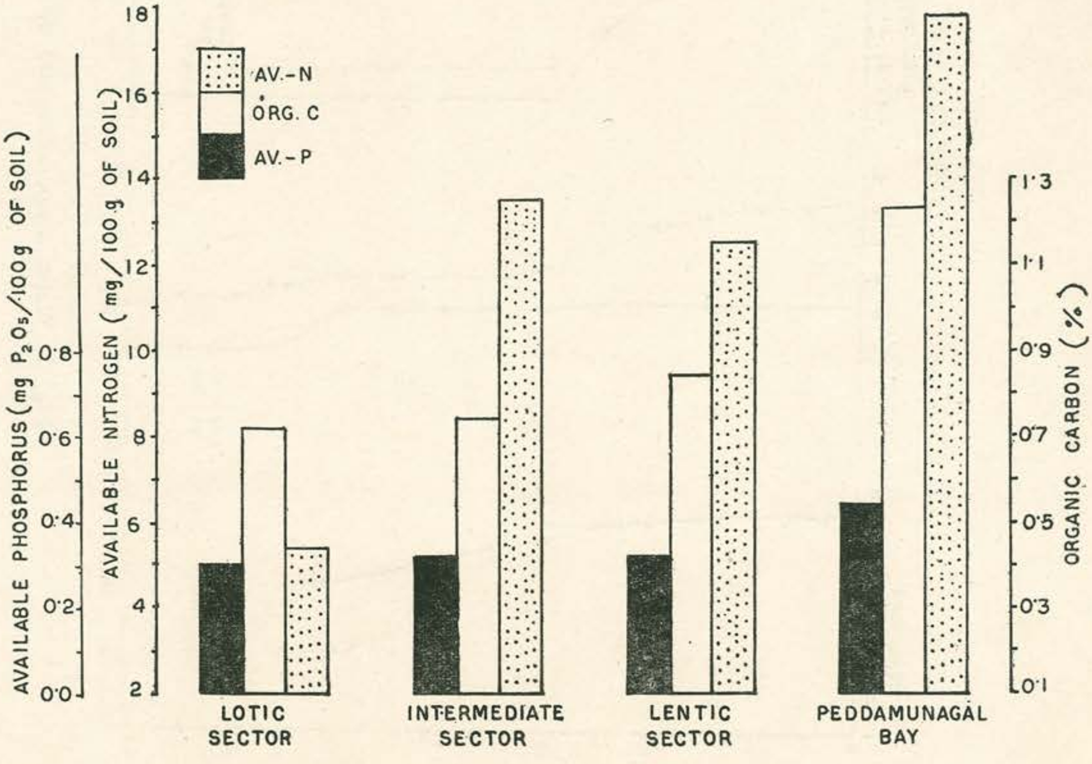

Fig. 4 Fertility status of bottom soil in different sectors.

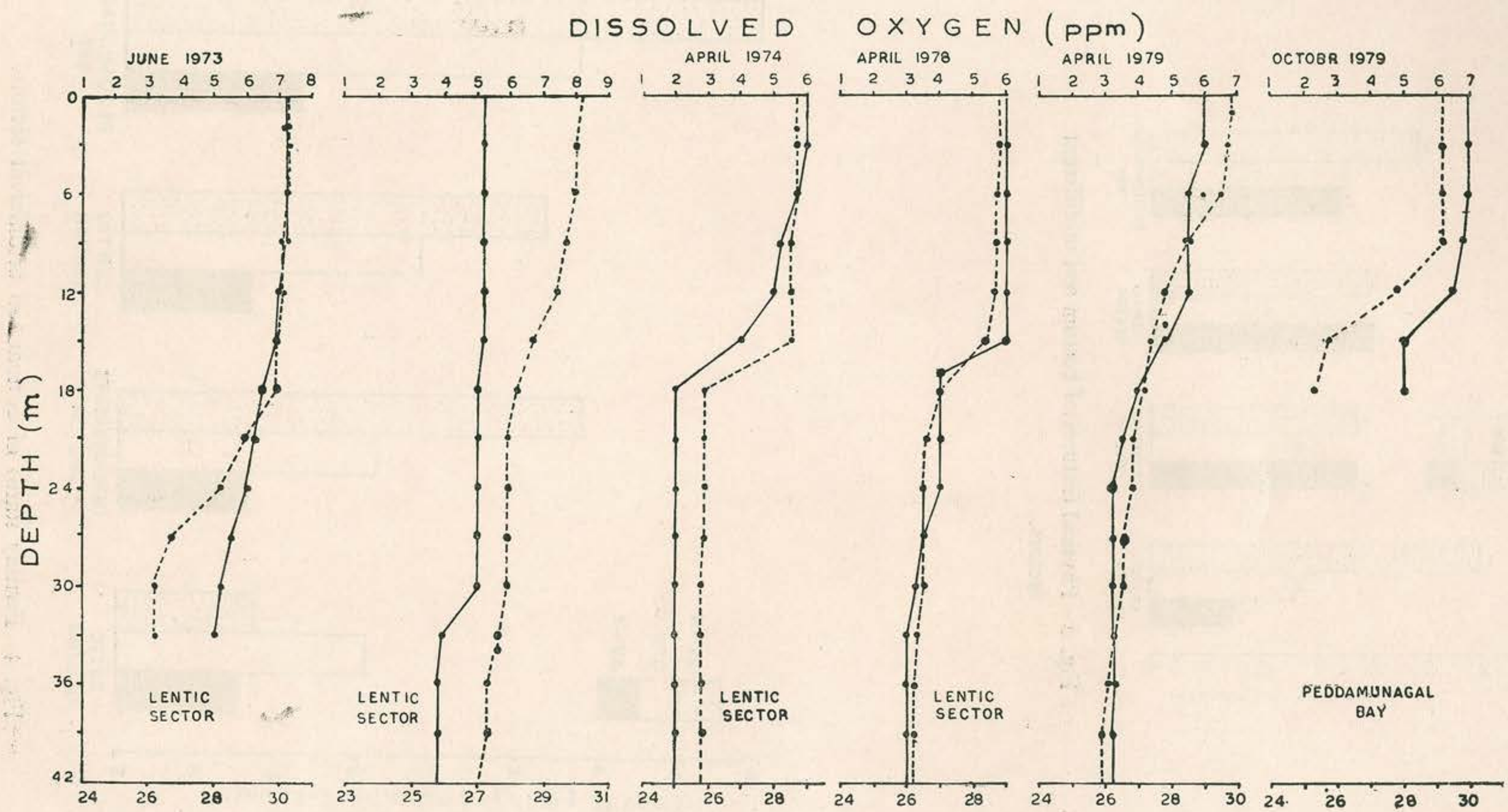

Fig. 5 Water temperature and dissolved oxygen at different depths.

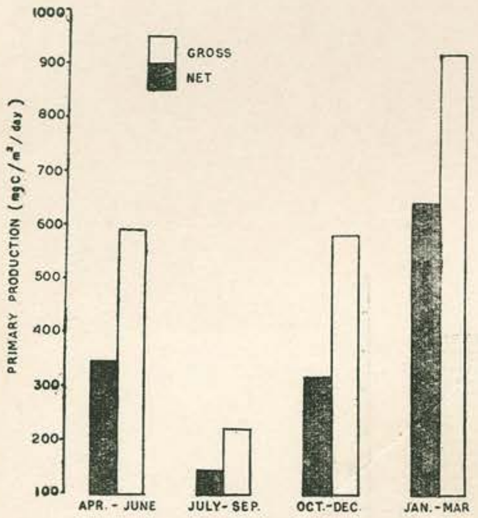

Fig. 6 Seasonal variation of primary production.

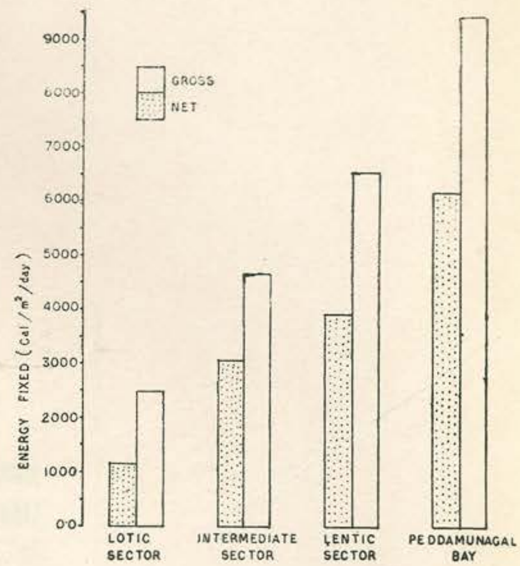

Fig. 7 Rate of energy fixation by primary producers (calories/m^2 day) in different sectors. (Averages of five years) (1974-75 to 1978-79)

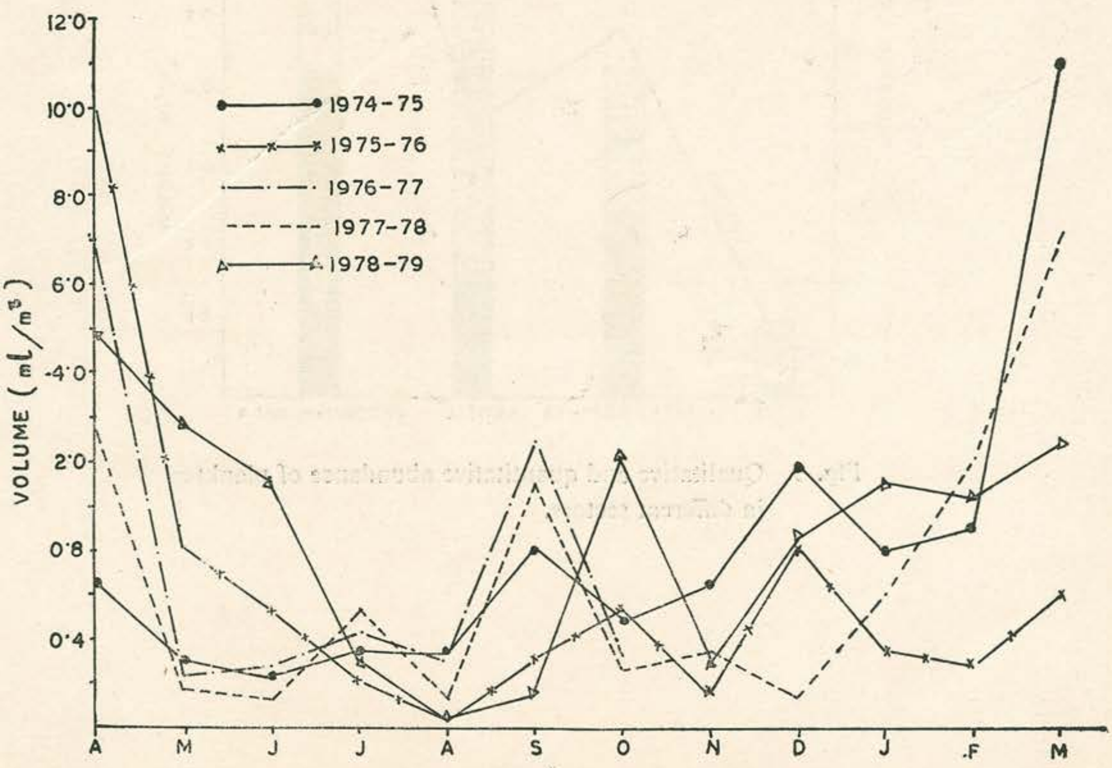

Fig. 8 Seasonal trends in the standing crop of plankton.

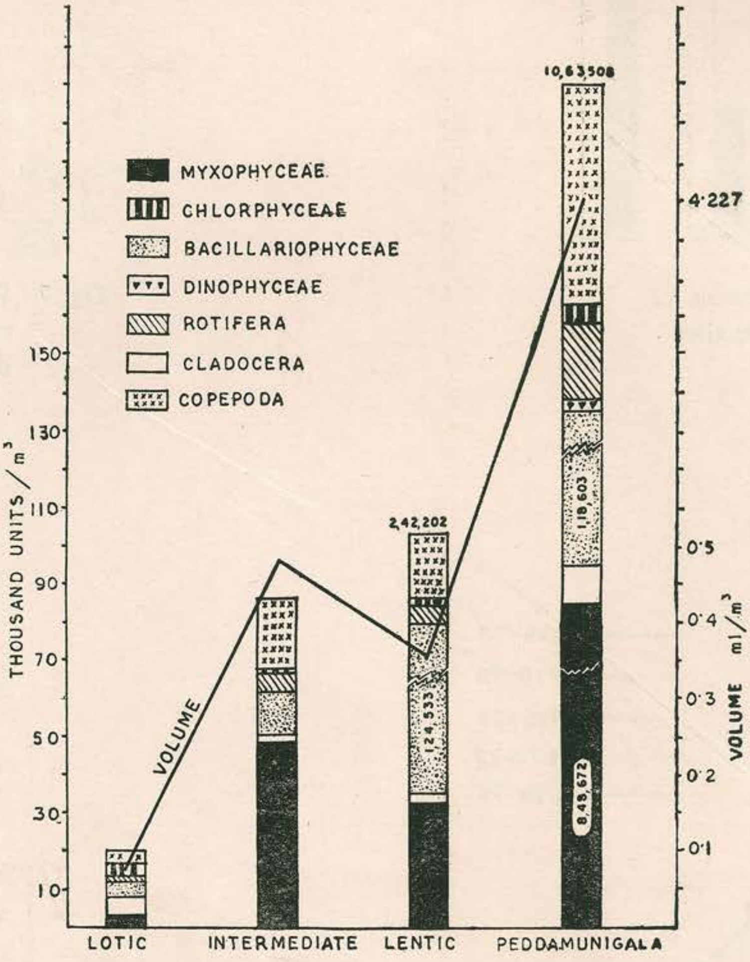

Fig. 9 Qualitative and quantitative abundance of plankton in different sectors.

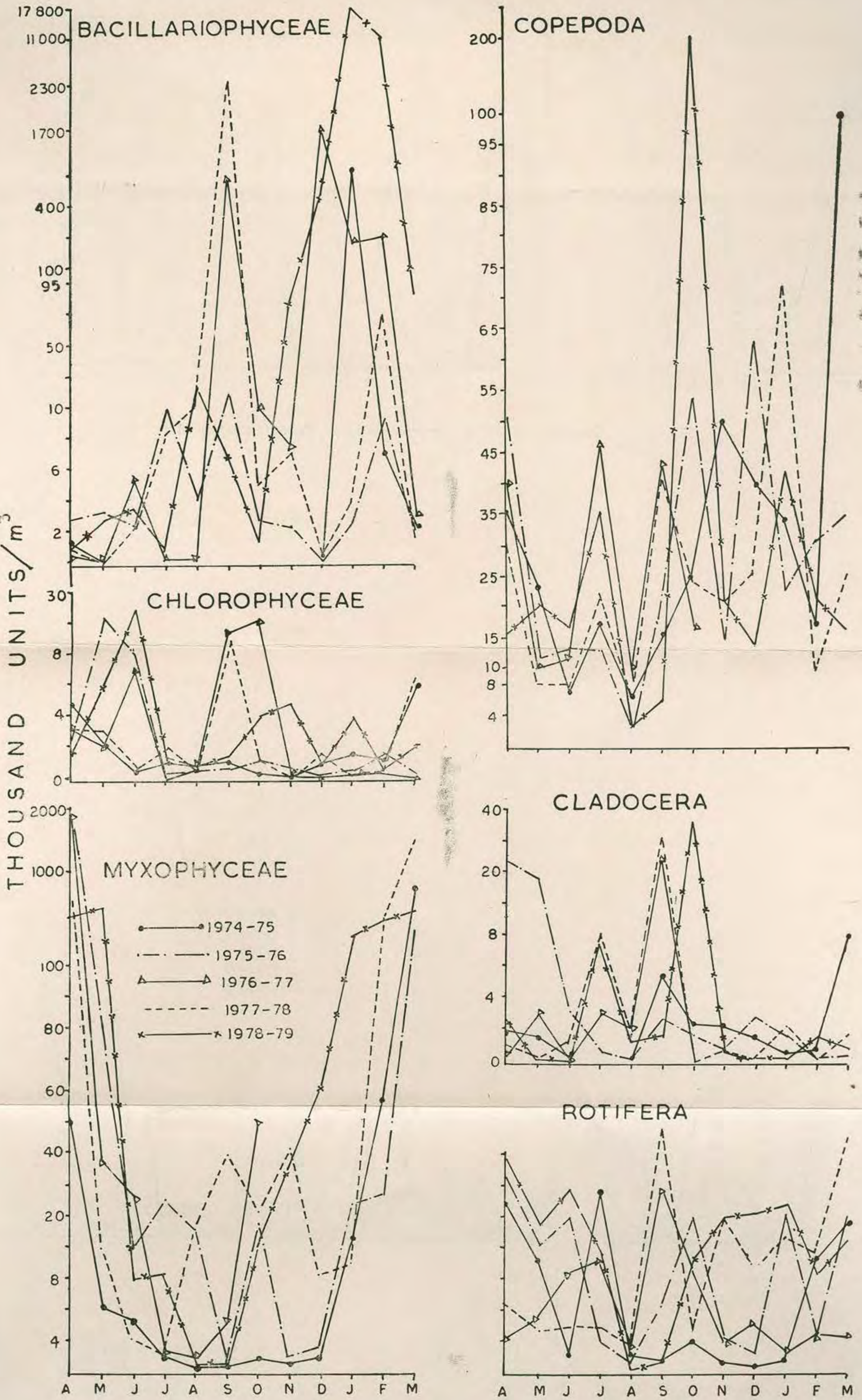

Fig. 10 Seasonal fluctuations of plankton in Nagarjunasagar Reservoir.

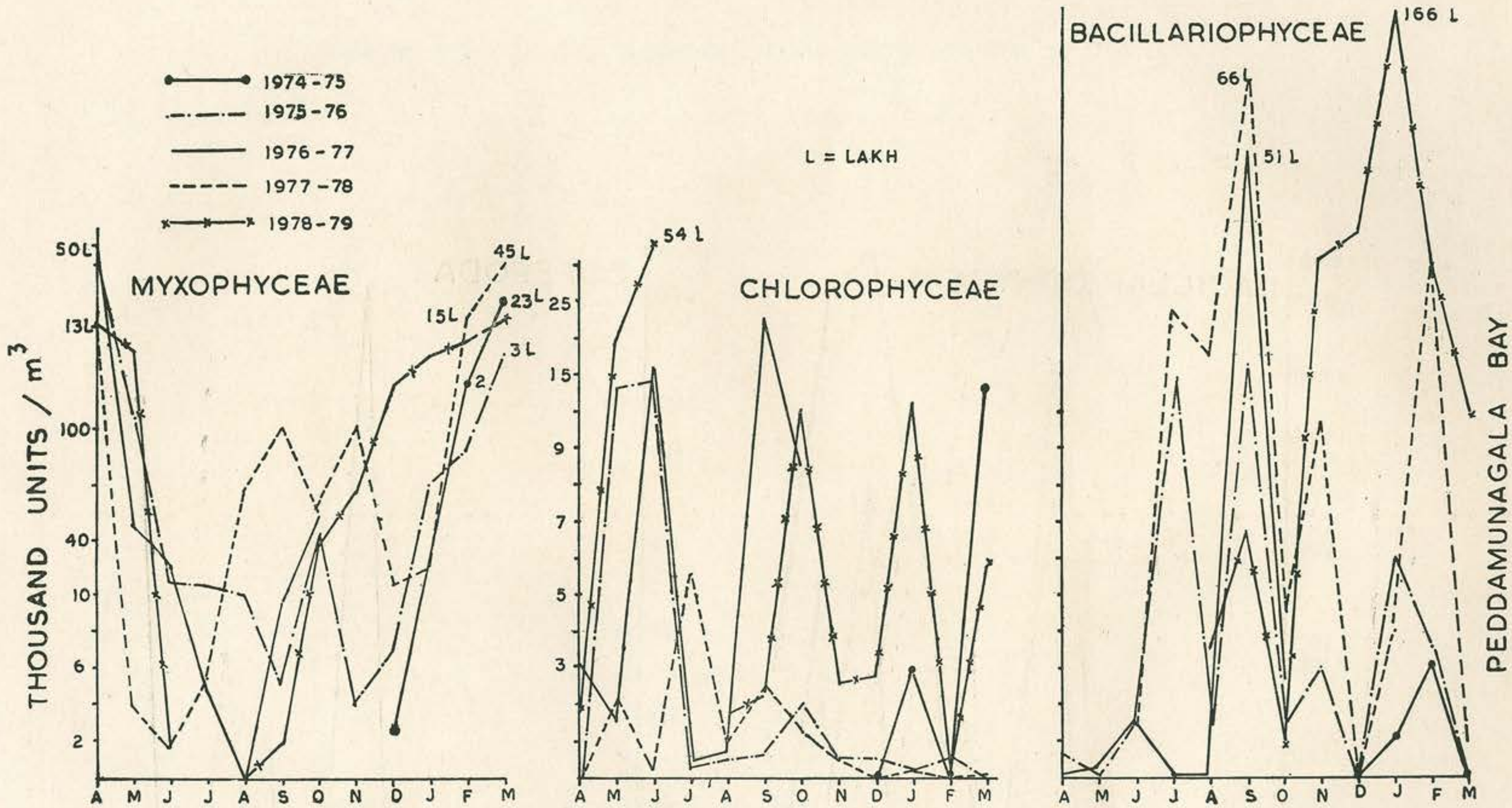

Fig. 11 b. Seasonal trends in phytoplankton in Peddamunagala Bay.

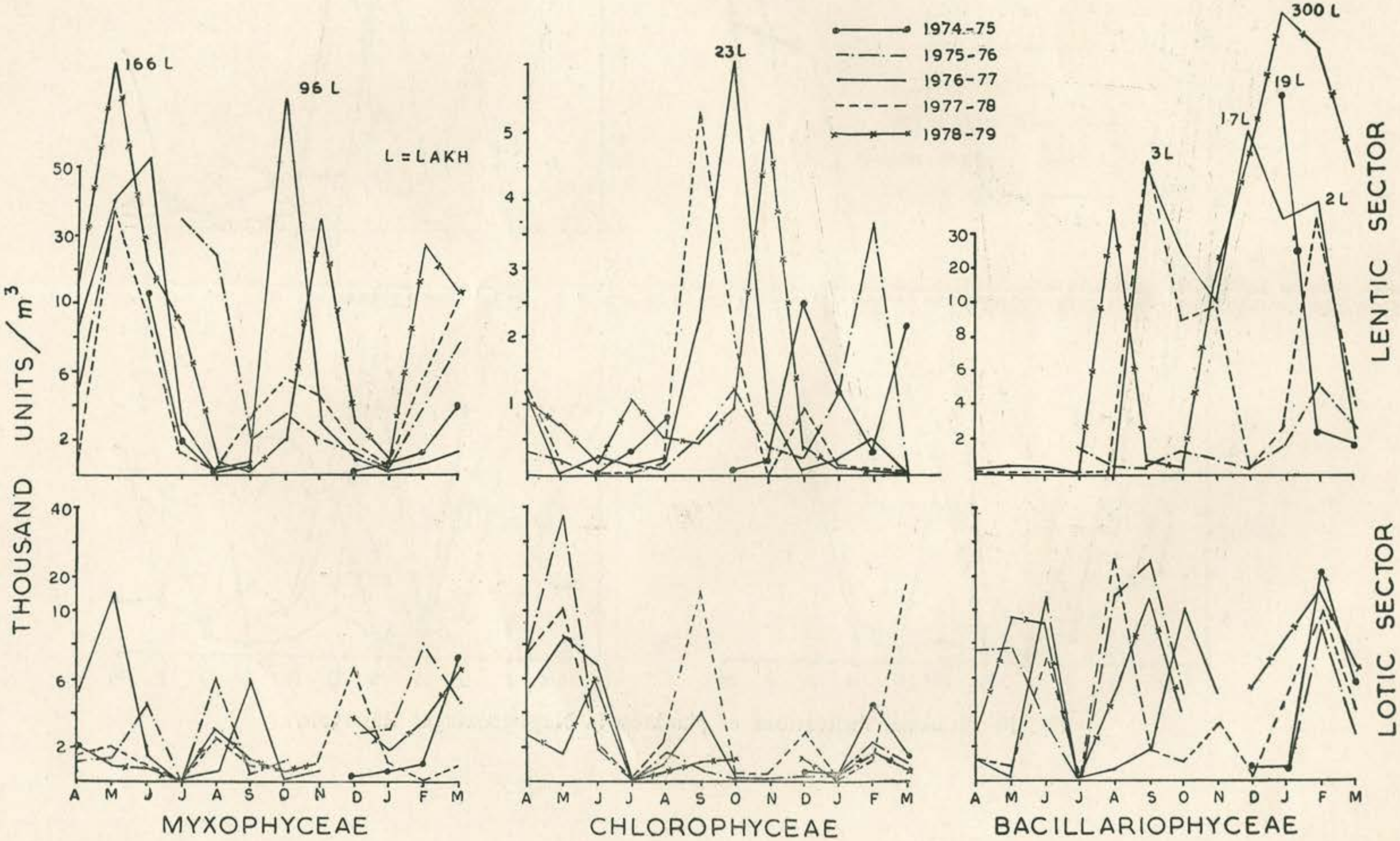

Fig. 11 a. Seasonal trends in phytoplankton in lotic and lentic sectors.

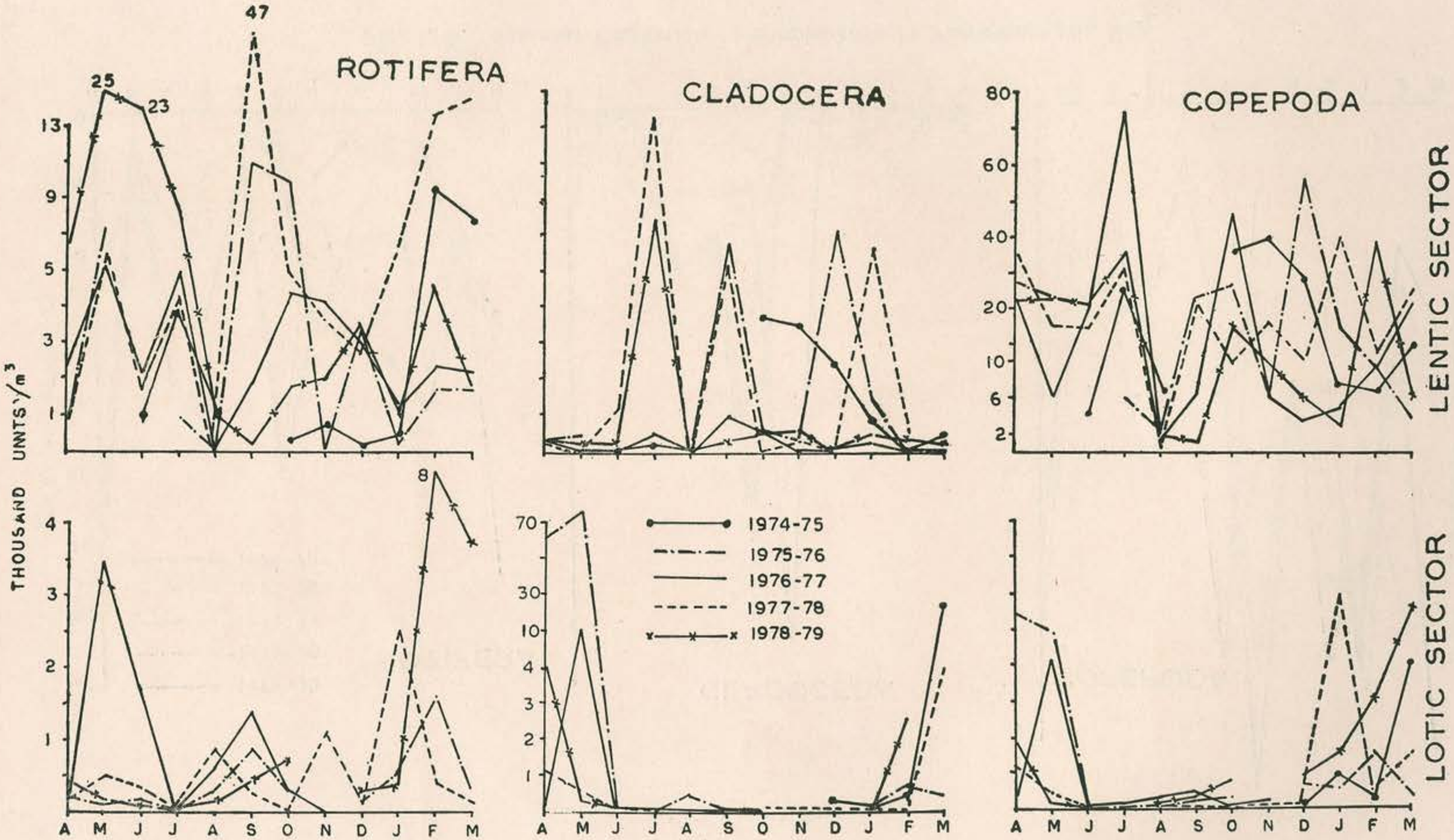

Fig. 12 a Seasonal fluctuation of zooplankton in lotic and lentic sectors.

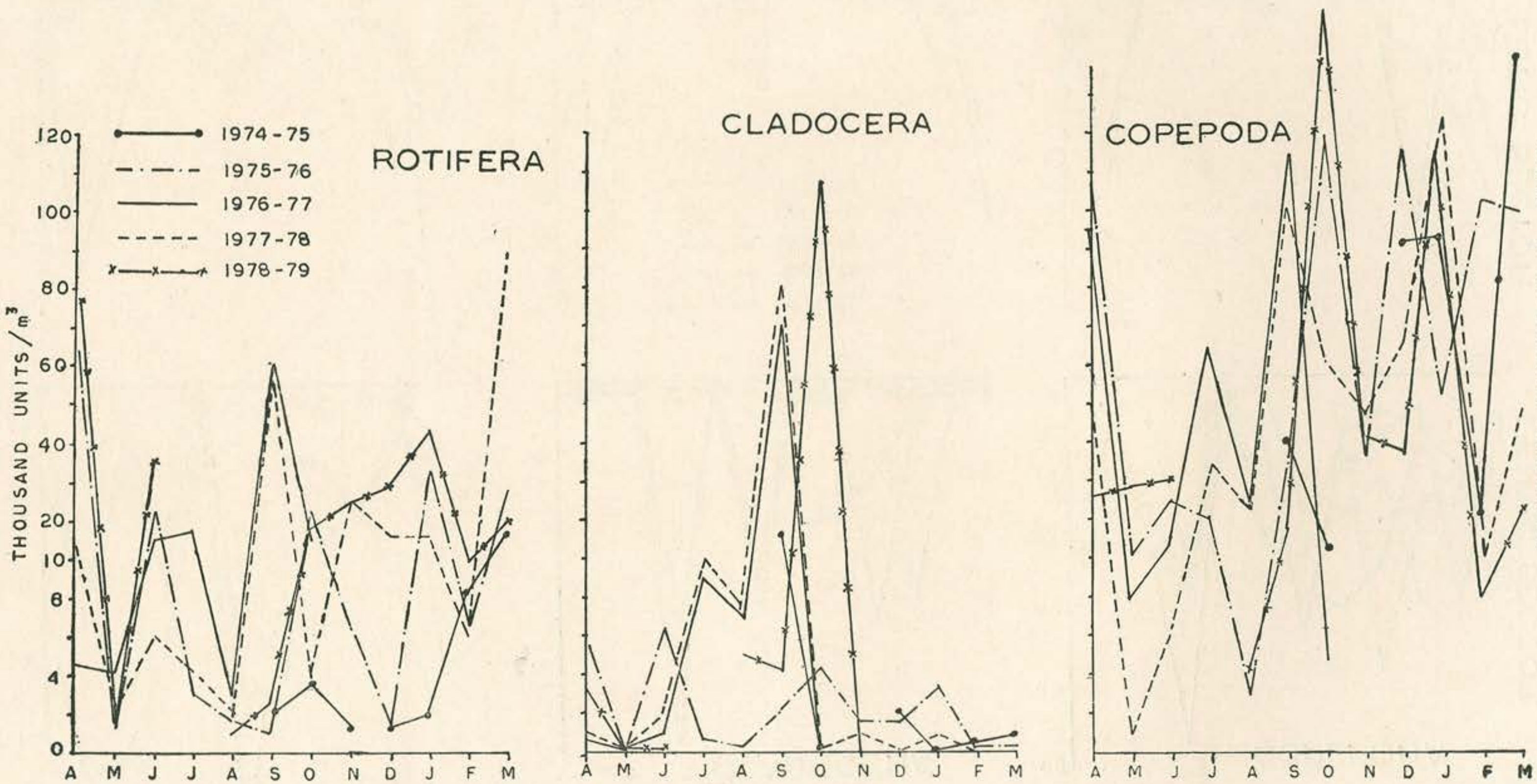

Fig. 12 b. Seasonal fluctuation of zooplankton in Peddamunagala Bay.

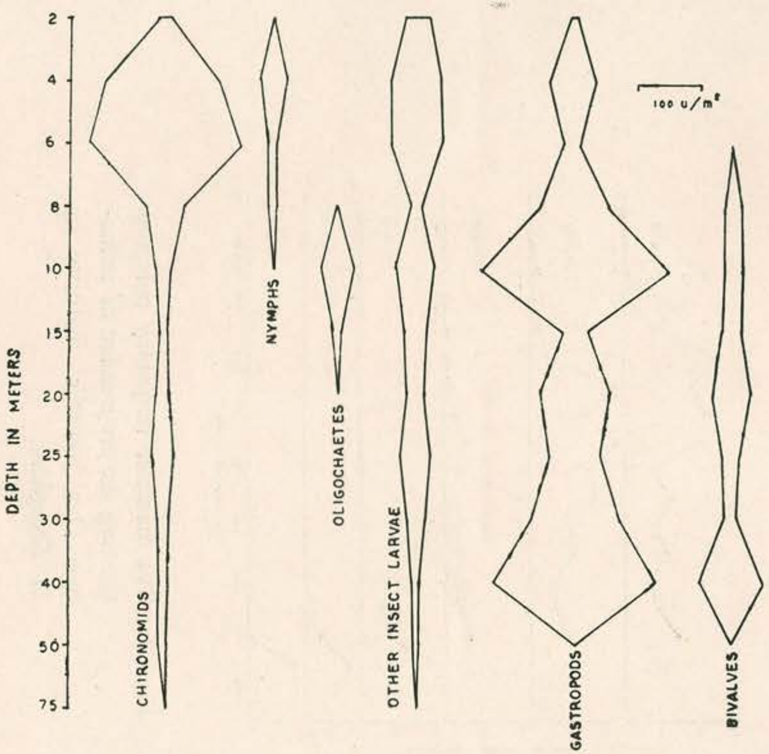

Fig. 13 Bathymetric distribution of Benthic Macro Fauna during 1974-75.

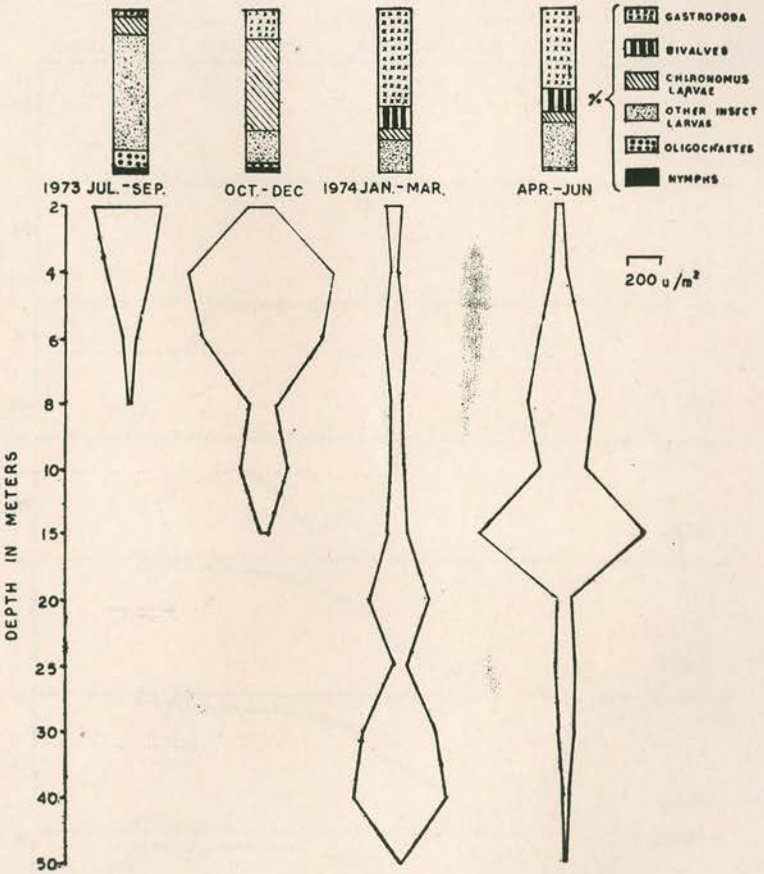

Fig. 14 Seasonal variations in the bottom macrofauna of Nagarjunasagar Reservoir.

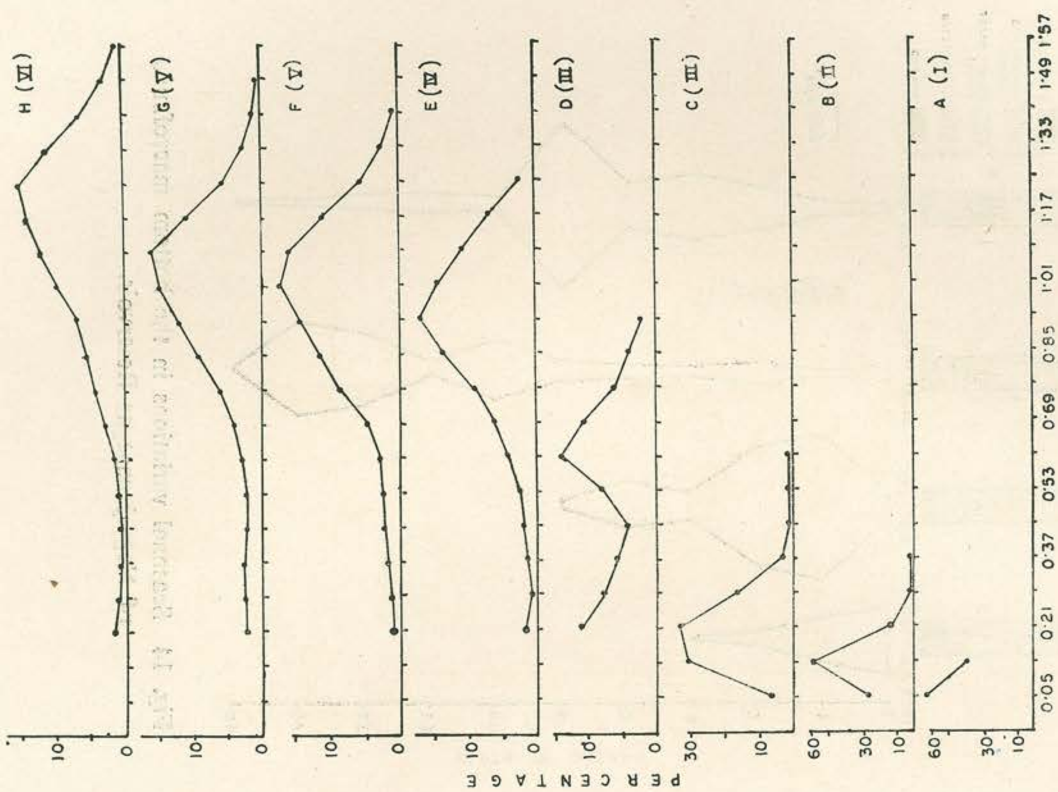

Fig. 15 Ova Diameter Frequency Polygons in *L. Calbasu.*

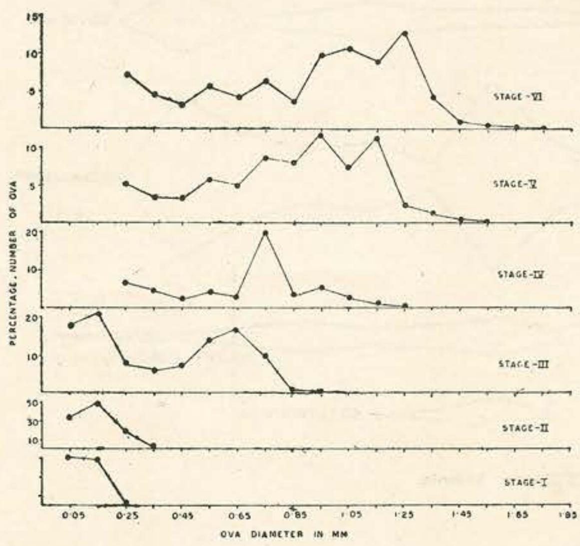

Fig. 16 Ova diameter frequency polygons showing the progression of immature Ova towards maturity in *M. Seenghala.*

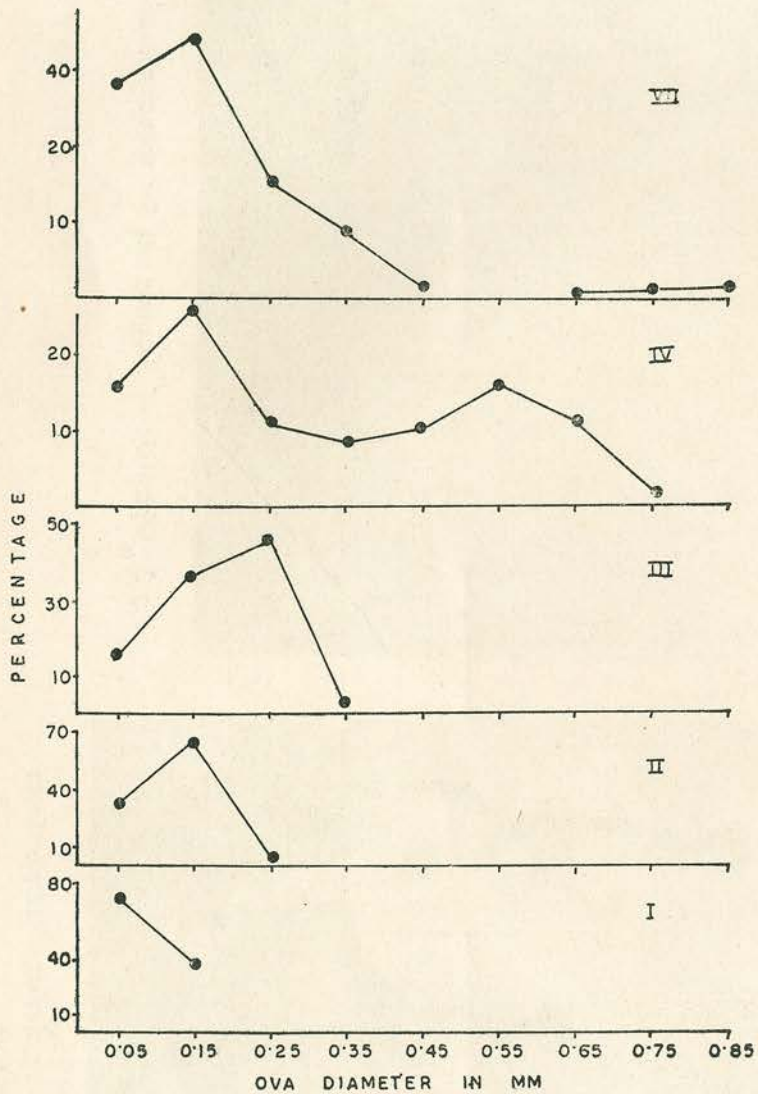

Fig. 18 Ova diameter frequency distribution of different stages of ovaries of *R. Corsula*.

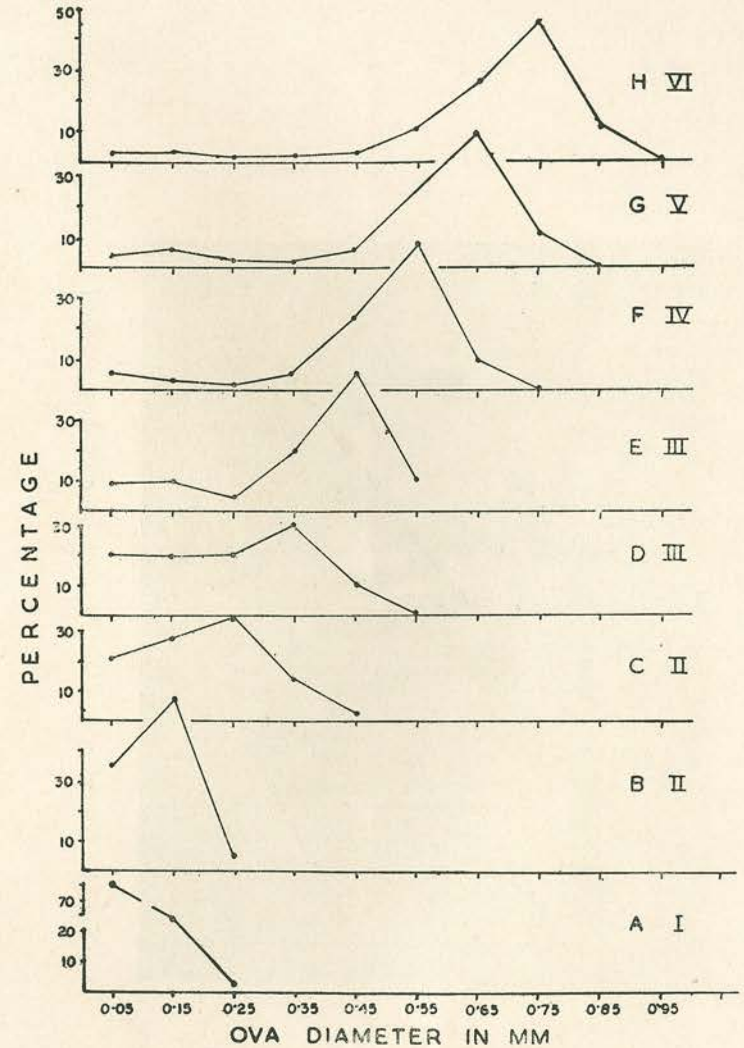

Fig. 17 Ova diameter frequency polygons of *S. Childrenii*.

Fig. 1 Carrying out the Primary productivity studies.

Fig. 2 Collecting plankton samples from the reservoir.

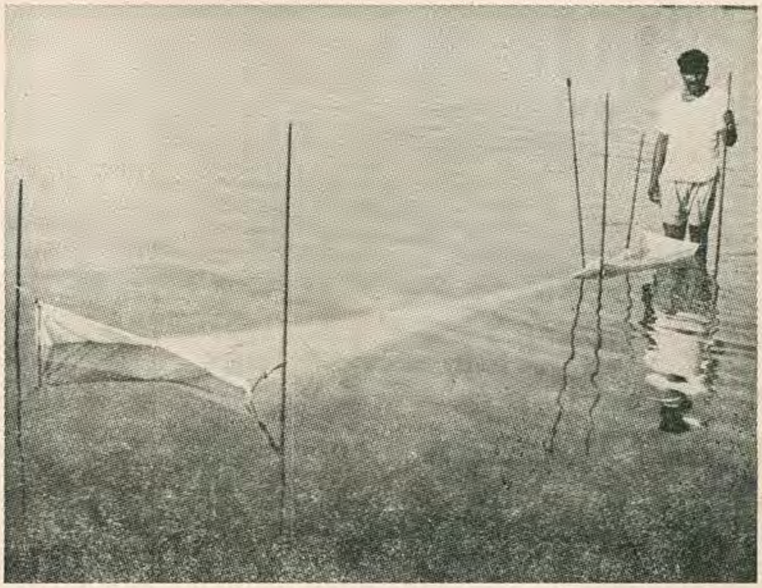

Fig 3 Operation of shooting net for spawn collection.

Fig. 4 Gill net fishing in the reservoir.

Fig. 5 A catch from the lotic sector.

Fig. 6 Srisailam Dam under Construction.

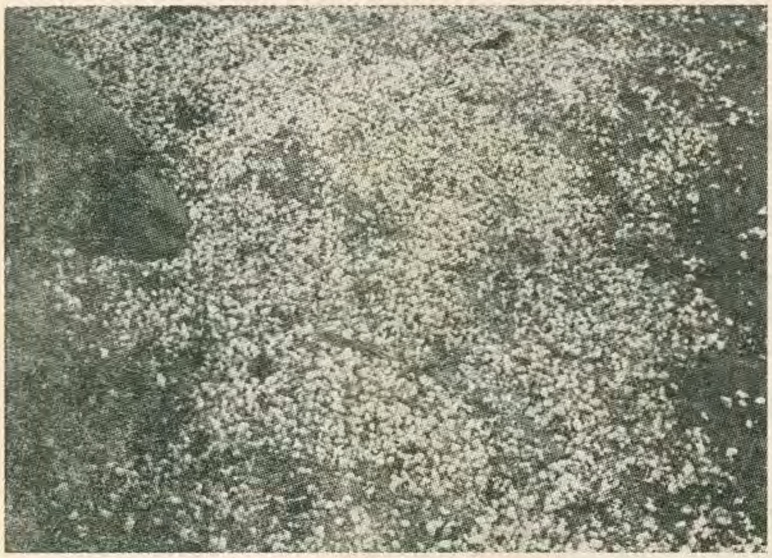

Fig. 7 Molluscan shells exposed during summer at Peddamunagala bay.

Fig. 8 Sun drying of *Oxygaster Phulo.*