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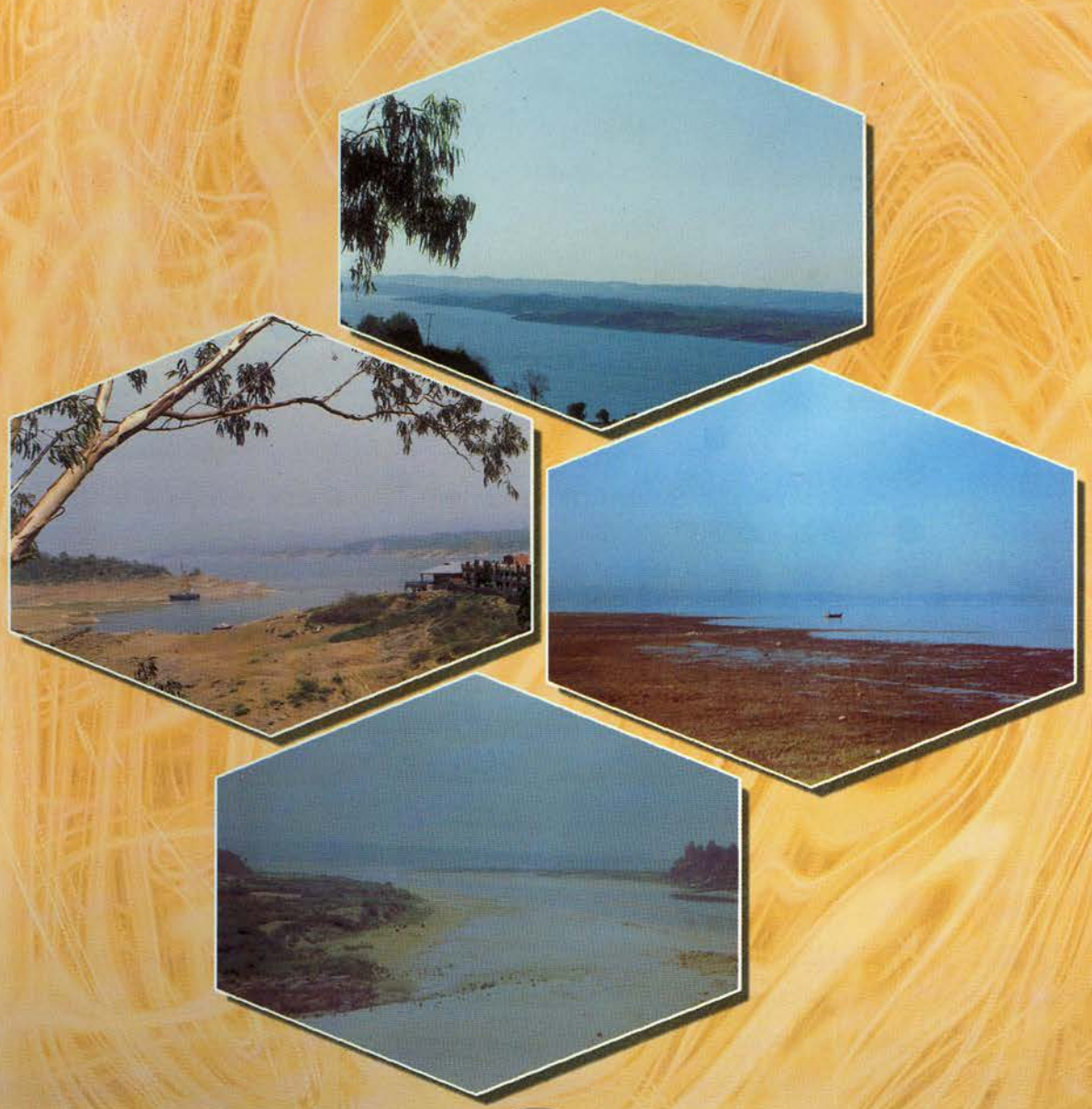
2007

ECOLOGY AND FISHERIES OF PONG RESERVOIR HIMACHAL PRADESH



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ECOLOGY AND FISHERIES OF PONG RESERVOIR HIMACHAL PRADESH

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Bull. No. 148

2007

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FOREWORD

Reservoirs constitute vast resource with immense potential of enhancement fish production of the Country. Unfortunately fisheries development in reservoirs on scientific lines has been given a very casual attention. CIFRI, in order to develop a national data base on reservoirs, has initiated studies in various reservoirs situated in different States of India. Pong reservoir of Himachal Pradesh which is situated on river Beas,in Kangra district, is one of the constituent of Indus River System , was taken up for intensive investigations for a number of years by scientists of CIFRI. The valuable data generated is documented in this publication.

I am hopeful that this document will greatly help in formulating guidelines for scientific management of said reservoir in particular and other similar ecosystem in general.

DIRECTOR

INVESTIGATING TEAM

Name	Designation
Dr. G. K.Bhatnagar	Principal Scientist (July, 90 to 18.01.92)
Dr. D. K. Kaushal	Senior Scientist (July, 90 to 31.03.95)
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CONTENTS

1. INTRODUCTION:

The economic progress of a country and the rise in standard of living of the people entirely depend upon the development and utilization of available resources. India is rich in water resources and their utilization is contributing greatly to the prosperity of the country. Recognition of this important fact is evident from the prominence given to the large number of river valley projects for increasing irrigation facilities, generating power for industrial development and for controlling floods. These reservoirs can also be used for fish culture. According to Sugunan (1995) there are 19000 reservoirs including irrigation tanks in India covering an area of 3 million ha.

At the present level of expertise and scientific management Indian reservoirs are capable of producing at least 50 kg of fish per hectare. However, average fish production form Indian reservoirs is frustratingly low i.e. less than 20 kg/ha (Sugunan, 1995). These underutilized fishery resources offer immense scope and potential for generating additional national income to the tune of Rs.1000 million per year providing employment to fishermen and others through ancillary industries.

In India, comprehensive research has been done under the All India Co-ordinated Research project of Ecology and Fisheries of Freshwater Reservoirs and some basic facts regarding productive potential of some large reservoir have emerged. Formulation of a standard techniques and management plan for manipulating fish productions is however, needed. This bulletin, portraying some significant finding of the investigations conducted on Pong reservoir in the State of Himachal Pradesh, is a step in this direction.

2. OBJECTIVES OF STUDY:

The main objectives for undertaking the studies on Ecology and Reservoir Fisheries Management were as follows:-

(a) To understand the ecology and dynamics of fish stocks in Pong reservoir with a view to obtaining sustained optimum fish production.

(b) To evolve suitable stocking and recruitment policies for the reservoir through studies on the biology of important commercial fishes from the reservoir.

(c) To suggest suitable gears and intensity of exploitation of different species.

3. RESUME OF WORK DONE:

According the Sehgal (1998) no detailed studies on ecology and fisheries of River Beas have done prior to the construction of Pong dam. However, Howel (1916) recorded *Oreinus sinnatus*, *S. richardsonii* and *Glyptosternum striatus* as the major fishes of river Beas. Tandon & Sharma (1976) and Sharma (1979) have reported Ichthyofauna of Kangra district of Himachal Pradesh. Food and feeding habits of fishes from Kangra district have been studied by Sharma and Tandon (1982).

Singh (1985) listed, *T. putitora*, *S. richardsonii*, *L. dero* and *W. attu* from river Beas. Sharma (1993) studied fish fauna of Pong reservoir. Kumar (1990) studied fluctuation of fishery in the reservoir. Kuashal et al., (1955) presented Limno-chemical parameters vis-à-vis production potential of the reservoir.

4. PHYSIOGRAPHIC AND MORPHOMETRIC ATTRIBUTES

4.1 Location of the reservoir:- Pong reservoir is situated at a distance of 7 km north-east of Talwara (32^0-25'N and 76^{0}E) at an elevation of 435.86m above mean sea level. The reservoir came into existence in the year 1975 as a result of construction of a 132.5 high earth core gravel shell dam across the river Beas at Pong village in Himachal Pradesh. In the course of its flow, the river receives a number of rivulets locally known as Khads. The project although originally envisaged for meeting the irrigation requirements of Rajasthan, Punjab and Haryana, is now used for power generation also. The reservoir impounds 8,750 million M^3 of water, of which 7,290 million M^3 constitute the live storage. The reservoir has a total catchment area of 240 km^2. The average water spread area is 15000 ha.

The location map of the reservoir alongwith catchment area is shown in Fig. 1.

4.2 Morphometry of the reservoir:- The salient features of the morphometry of the reservoir are presented in Table 1. Basin of the reservoir is concave towards the surface as indicated by the volume development being above 1. The shoreline development of 2.48 indicates an irregular shoreline. Pong reservoir has a maximum depth of 97.84m and mean depth of 35.7m. The total length of reservoir is 41.8 km with the widest stretch of 19.0 km.

The reservoir has a number of seasonal, rainfed streams, locally known as *'Khads'*, the important ones being *the Baner, Gaj and Dehar*. With the rise in level of the reservoir, the water extends to all these Khads, thereby forming a number of bays, of which Dehar is the biggest. The Khads carry nominal discharge into the reservoir during the dry season of March to June and October to December, but bring in appreciable discharge during monsoon and winter rains.

5. SAMPLING PROCEDURE:

For the purpose of studying the physico-chemical and biological parameters, the reservoir was divided into three zone viz. lotic, intermediate and lentic zones. Samples pertaining to limnological parameters were collected at monthly intervals with the help of standard instruments (Welch, 1948) and analysis were done as described by Jhingran et al., (1969) for biological and APHA for chemical parameters. Monthly survey at Dehra, Nogrota Suriyan and Khatiad landing centres was conducted to determine the fish catch in the reservoir, besides, the landing data made available by the department of Fisheries, Himachal Pradesh.

6. METEOROLOGICAL OBSERVATIONS:

6.1 Air temperature:- Meteorological observations for the five years have been presented in Table 2. The minimum air temperature varied from 5.8 (February 1992) to 27.2^0 C (June, 1993) while the maximum air temperature ranged from 16.7^{0}C (January, 1993) to 39.5^{0}C (June, 1994).

6.2 Rainfall:- Yearly rainfall varied from 84.3 cm (1991-92) to 149.0 cm (1992-93) with 40.2 to 83.3 occurring during July-September indicating the influence of South-West monsoon.

7. HYDROLOGICAL FEATURES OF RESERVOIR:

7.1 Water level:- Minimum reservoir level during the period of investigation was 394.6 m in June 1994 and the highest level was 424.0m in September 1990. The maximum yearly variation was in 1994-95 to the extent of 28.8 m (Table 2)

7.2 Water inflow and out flow: Data on inflow and outflow pertaining to year 1990-91 and 1994-95 are given in Table 2. The main inflow into the reservoir is from the Beas river throughout the year. The inflow commences from March onwards with the influx of snowmelt water and continue till July-August due to run-off from the monsoon. The yearly inflow decreased from 11,672 million M^3 in 1994 to 7,878 million M^3 in November 1990. The maximum inflow fluctuated form 1,259 in September 1993 to 4,479 million M^3 in August, 1992.

Outflow was through the spillways and the power houses. It was maximum (10,919) in 1994-95 and minimum 97,402 million M^3) 1993-94. The outflow ranged between 96 million M^3 in May 1993 and 2,252 million M^3 in August 1992.

8. SOIL PROFILE

The bottom soil of the reservoir was, in general, sandy in texture and poor in quality. It is apparent from the data (Table 3) that the contribution of sand was highest in all the zones varying between 40 and 90% except in lotic zone (38%) in the year 1990-91. The clay was highest in intermediate (30%) in 1992-93 and was lowest in lotic zone (2%) in 1994-95. Similarly, silt was highest in intermediate followed by lotic zone. The soil pH invariably was towards alkaline side ranging between 7.1 and 8.6 in lotic, 6.1 and 8.8 in intermediate and 6.9 and 8.8 in lentic zone. Calcium carbonate was high in lotic zone (2.3%). It fluctuated from 0.75 to 0.94% in intermediate and 0.50 to 1.24% in lentic zone.

The values of organic carbon was highest in lotic zone (0.31-1.2%) and lowest in lentic zone (0.15-1.08%). The soil was poor in available nitrogen though its concentration was higher in intermediate zone (15.12-44.2mg/100gm0. The available phosphorus was also quite low (0.55-40.0 mg/100gm). The basin soil appeared to have very little effect on the quality of water as the later mainly derived its nutrients from the catchment.

9. PHYSICO-CHEMICAL CHARACTERISTICS OF WATER: μ

The range of physico-chemical characterization of water based on surface samples in different zones are presented in Table 4-7/

9.1 Lotic zone:- The water temperature in lotic zone varied from 13.0 to 28.5°C in 1991-92, 16.0 to 26.0°C in 1992-93, 14.0 to 25.0°C in 1993-94 and 16.0 to 27.0°C in 1994-95. The water temperature ranged from 13°C (February) to 28.5°C (September) with an annual fluctuation of 15.5°C. The wide seasonal variation in water temperature thus had a great bearing on the heat cycle of the reservoir. Due to the incoming turbid waters from the rains, the water in lotic zone was generally turbid during monsoon months. However, transparency increased from September onwards reaching maximum in November-December. During the period of January to July a more or less lotic conditions prevailed in this zone (Table 4).

The water always remained alkaline in reaction with pH varying from 7.0 to 8.2. The variation in pH declined from the value of 7.8 to 8.2 in 1991-92 to 7.0-7.8 in 1994-95.

The narrow range of fluctuations in pH indicated a strong buffering capacity of the reservoir which did not allow wide variation in pH.

Alkalinity alongwith carbon dioxide form an equilibrium system which plays an important role in the ecology of the reservoir. Free carbon dioxide varied from nil to 6.0 ppm whereas total alkalinity was always found to be high, ranging between 52.0 and 110.0 ppm. The concentration of total alkalinity was highest in the year 1993-94. It showed higher values during summer and decline thereafter. It has been observed that water bodies having total alkalinity around 50.0 ppm and above are conducive to high fish productivity.

Dissolved oxygen remained high in the reservoir within the range of 6.0 to 10.4 ppm indicating high rate of photosynthetic activity. It fluctuated between 8.0 and 10.4 ppm in 1993-94 to 6.0 and 9.6 ppm in 1994-95. The highest values was recorded in the month of February 1994 and the lowest in September 1994. Organic matter which indicates the oxidisable organic substances in water is a good indicator of productive nature of water. Its value ranged from 2.4 to 5.4 ppm. Value of dissolved organic matter more than 1 ppm are generally considered to be indicative of high production potential.

The phosphate level of the reservoir varied from 0.06 in May to 0.24 in September, was found to be optimum. Calcium content was found to be high (24.0-33.0 ppm). It may be due to the presence of more calcium in catchment area. Silicates were fairly rich in concentration ranging from 1.84 to 2.10 ppm. Specific conductivity fluctuated from 96.4 to 266.8 mmhos/cm. Their values increased with the onset of monsoon which may be due to account bionic enrichment from the incoming floods.

9.2 **Intermediate zone**:- The water temperature in intermediate zone (Table 5) varied between 13.0 and 32.0°C during the period of investigations. It was highest in the months of July-August and the lowest values was recorded in the month of January. Transparency increased steadily from July, reaching maximum in December and thereafter showed a declining trend. pH value (6.8-8.3) varied within a narrow range. Free carbon dioxide varied from nil to 6.0 ppm indicating its absence in certain months. Total alkalinity ranged between 68 and 100 ppm in 1992-93, 48 and 86 ppm in 1992-93, 60 and 90 ppm in 1993-94 and 52 and 80 ppm in 1994-95. The concentration of dissolved oxygen exhibited decreasing trend. Its value of 8.1 to 9.6 ppm in 1992-93 fell to 5.2 to 8.8 ppm in 1994-95. Values of organic matter ranged from 2.2 to 6.0 ppm indicating high productive potential.

The nutrient status in this zone of reservoir with respect to phosphate was also optimum with value ranging between 0.08 to 0.26 ppm. The specific conductivity showed an almost similar trend during all the years, its value varying within the range of 111.4-187.5 umhos/cm.

9.3 **Lentic zone**:- The water temperature in the lentic zone fluctuated between 15 and 33°C with an annual fluctuation of 18.0°C in 1991-92. The highest and lowest values were recorded in the months of June and February respectively (Table 6). Thermal stratification was also observed in this zone. The transparency value increased steadily from August onwards and reached its peak in December-January and thereafter showed a declining trend. pH indicated a strong buffering capacity, varying within a narrow range of 7.2 to 8.2. Maximum variation in the concentration of dissolved oxygen

(6.0 to 9.4 ppm) was recorded in 1993-94. Depth profile of oxygen generally showed a klingo ograde distribution.

Free carbon dioxide was generally absent at the surface and appeared at the bottom varying within the range of nil-4.0 ppm. This indicates high rate of decomposition of organic debris which releases carbon dioxide. The total alkalinity indicated its highest fluctuation and concentration in the year 1993-94 (52.0 to 86.0 ppm). No definite trend was observed. The value of calcium, magnesium and phosphate was high, but the value of silicate was low. Some of these chemical constituents show higher value during monsoon season.

The specific conductivity fluctuated between 114.6 and 195.8 mmhos/cm in 1992-93 to 131.0 and 198.4 mmhos/cm in 1991-92.

Limno-chemical parameters clearly suggest that there were very little spatial variation among different zones of the reservoir.

9.4 **Thermal stratification**;- Thermal stratification was observed during May-September and during the remaining months, near isothermal condition prevailed during 1992-93 with variation in water temperature never exceeding 3°C. In May, the temperature difference from surface (27.5°C) to bottom (18.0°c) was 9.5°C consisting of thermocline between 8 and 9 m, the drop of temperature being 1.0°C from 25 to 24.0°C. During July, three thermoclines were observed, water temperature dropped from 29.0°C at 10 m to 27.0°C at 11 m @ 2.0°c/m, from 24.0°C at 29 m to 23°C at 27 m and from 23°C at 28 m to 22°C at 29 m showing a decline @ 1.0°c/m. During September, thermoclines were observed between 5 and 6 m with drops in temperature from 29.4°C to 28.4°C and between 8 and 9 m wherein temperature declined from 27.4°C to 26.2°C (Table 8).

Thermal stratification during the year 1993-94 was recorded in the months of June to September. In June, the temperature difference from surface (30.5°C) to bottom (18.0°C) was 12.5°C consisting of five thermoclines (Table 8). During July, thermocline was observed between 12 and 13 m, the drop of temperature being @1.0°C from 24 to 23.0°C. In August, the drop of water temperature with depth again showed occurrence of five thermoclines viz between 7 (30°C) and 8 m (29°C), 8 (29°C) and 9 m (28°C) and 10 m (27°C), 11 (27°C) and 12 m (26°C) and between 13 (26°C) and 12 m (27°C), Table 8.

In the year 1994-95, thermocline was observed in the month of June from 11m to 12 m depth when temperature dropped @ 1.0°C from 27°C to 26°C and between 17 m (25°C) and 18 m (24°C), Table 8.

9.5 **Chemical stratification**:- The chemical stratification was observed in Pong reservoir in respect of dissolved oxygen and specific conductivity during all the depth-wise observations made with varying degree. In the month of October 1991 chemocline was observed in respect of following chemical parameters ; pH 8.2 (s), 7.6 (30m), D. O. 992 (s), 3.4 (30m); Specific conductivity 144.67 (s) 173.61 (30m) mmhos/cm (Table 8).

During the year 1992-93, the values of dissolved oxygen was high at 9.6 ppm at the surface and dropped to 7.6 ppm at 30 m depth in the month of December. pH with 7.86 at surface and 6.93 at 30 m depth in the month of May showed narrow range of variation. The value of specific conductivity increased with depth. The maximum variation was observed in the month of September, ranging from 114.6 at surface to

138.2 mmhos/cm at 30 m depth. The stratification of specific conductivity however, indicated reverse trend during the months of April to August with values ranging from 192.3 at the surface to 158.4 mmhos/cm at 30 m depth in the month of May (Table 8). The occurrence of reverse stratification of specific conductivity could be due to non-mixing of reservoir water with the influx of cold snow melt standing from the month of April, forming different layers of water in the reservoir.

In the year 1993-94, the value of dissolved oxygen was high at 9.4 ppm at the surface and dropped to 7.6 ppm at 30 m depth in the month of April. Maximum variation in dissolved oxygen was observed in the month of June varying from 6.0 ppm at surface to 1.6 ppm at 30 m depth. pH with 8.3 at surface in the month February and minimum value of 6.9 at 30 m in the month of July showed narrow range of variation. Values of specific conductivity increased with depth, the maximum variation was observed in the month of September, ranging from 127.3 at surface to 158.3 mmhos/cm at 30 m depth.

The values of dissolved oxygen during 1994-95 was high at 8.0 ppm in surface and dropped to 6.8 ppm at 30 m depth in the month of April, June and October (Tabel 8). The values of specific conductivity increased with depth (Table 8).

Limnological parameters clearly suggest the high productivity potential of Pong reservoir. Despite the poor quality of soil the water remained rich in nutrients. Climatic factors like rainfall seems to determine the productive potential of the reservoir to a great extent. A high rate of run-off into the reservoir may be affecting the nutrient status of the reservoir.

9.6 Diurnal variation;- A critical perusal of data on diel cycle of oxygen (Table 9) indicated erratic trend in the value of dissolved oxygen in Lentic zone. It ranged between 6.4 and 9.6 ppm with maximum values during winter (December) at 12 hrs. Oxygen values of lower magnitude varying from 6.4 to 8.0 were observed during summer (June). Water temperature varied from 26 to 32°C during the months of June and September while it fluctuated between 16 and 21°C in the month of December and March.

10. PRIMARY PRODUCTION:

10.1 Gross/net production;- The rate of primary organic carbon production was studied in the Lentic zone using light and dark bottle technique. The ranges of gross and net carbon production are presented in Table 10.

The gross organic production fluctuated between 124.9 and 666.6 mgC/m²/day in 1991-92, 359.4 and 687.4 mgC/m²/day in 1992-93, 374.9 and 624.9 mgC/m²/day in 1993-94 and 292.6 and 666.6 mgC/m²/day in 1994-95. Net organic production varied from 208-4 to 656.2 mgC/m²/day in 1991-93, 140.6 to 531.1 mgC/m²/day in 1992-93, 124.9 to 500.0 mgC/m²/day in 1993-94 and from 166.6 to 333.2 mgC/m²/day in 1994-95. The highest gross production was observed in December 1992 (687.4). The lowest value of gross production was observed in November 1991 (124.9). Observations on the primary production in general indicated higher values of carbon production during winter months.

Depth-wise analysis indicated decrease in productivity from surface to sub-surface. Gross and net production were more in littoral regions.

10.2 **Ratio of Net and Gross carbon production**;- The annual ratio between net and gross production fluctuated between 0.50 in 1994-95 and 0.79 in 1991-92. This shows that the net gross ratio values is approaching unity and is indicative of a productive water body.

10.3 **Potential fish yield**:- The primary production studies indicated that the average gross production varied from 0.465 mgC/m^2/day in 1991-92 to 0.503 mgC/m^2/day in 1992-93. The total annual production on an average is thus calculated as 167.54 mgC/m^2/day or 77655 t/yr for the entire reservoir.

Carbon values divided by 0.44 (Waldickuk, 1950) indicated total plankton biomass in the reservoir as 176484 t. Considering that 100 kg of dry plankton yield 1 kg of fish the harvest from Pong reservoir is expected to be 1,765 t. Thus potential annual yield calculated on the basis of carbon is 118 kg/ha/yr.

10.4 **Conservation value**:- The energy conversion efficiency, from primary fixed energy to fish (0.24%) observed in Pong reservoir is better than the values recorded from may Indian reservoirs. Srinivasan (1966) found a ratio of 0.1% for Stanley reservoir and Mathew (1975) reported a meager ratio of 0.07% in Govindgarh lake.

11. PLANKTON:

The data on monthly variation in volumetric abundance (ml/m^3) and numerical abundance (u/I) of plankton over the period 1990-91 to 1994-95 are presented in Table 11 and 12 respectively. Plankton population ranged from 1.06 ml/m^3 in 1994-95 to 3.68 ml/m^3 in 1990-91; and 4.466 u./l in 1994-95 to 12,128 u/l in 1991-92. Values of planktonic biomass showed high density of plankton during reduced monsoon inflow and lower plankton population during increased monsoon inflow. The ratio of phyto to zooplankton fluctuated from 54:1 in 1991-92 to 28:1 in 1992-93.

11.1.1 **Lotic Sector**:- Lotic sector exhibited comparatively poor productivity of the plankton biomass (ml/m^3). An average standing crop ranged between 0.24 ml/m^3 in 1993-94 to 3.77 ml/m^3 in 1990-91. The seasonal distribution of plankton biomass depicted two pulses; the primary peak during post monsoon and secondary peak during early winter, coinciding with the abundance of plankton peaks numerically. Post monsoon months (September-October) generally had the highest crop of plankton mainly due to greater proliferation of diatoms, *Synedra* in particular. The predominant diatoms records were *Synedra, Cembella, Navicula, Diatoma* and *Cyclotella.* Zoo-plankton contributed 0.89-7.31% of the plankton population. among zooplankton, *Cyclops, Brachionus* and *Keratella* were the dominant forms.

The lotic sector of the reservoir showed a tendency to produce non-persistent bloom of *Synedra* during the period August to October in the 1990-91 and 1991-92.

11.1.2 **Intermediate Sector**:- Intermediate sector was the most productive sector of Pong reservoir with an average planktonic biomass ranging between 0.90 ml/m^3 in 1994-95 and 4.39 ml/m^3 in 1990-91. The availability of planktonic biomass was higher in this zone than of the other two zones. Monthly abundance of planktonic biomass was erratic. Maximum occurrence of 13.81 ml/m^3 was recorded in September 1990 and minimum occurrence of 0.38 ml/m^3 was observed in August 1994.The average plankton population fluctuated from 5,102 u/l in 1994-95 to 11,655 u/l in 1991-92 (Fig 2).

Seasonal distribution of plankton indicated three distinct peaks in general, the primary in October-November, secondary in January and tertiary in June. The primary and tertiary pulses were mainly represented by *Synedra* while the secondary pulse was represented by *Rhizoclonium*. Bacillariophyceae, thus dominated the plankton population during the period June-November. *Synedra* showed spurt in the density in October 1991 in littoral sector with 60,409 u/l. Myxophyceae, represented by *Microcystis* dominated in the months of April-May whereas Chlorophyceae were dominant during the period December-February. Zooplankton formed 2.34% (1991-92) to 4.66%b (1993-94) of total plankton and were dominated by Rotifera (*Brachionus, Keratella, Hexarthra, Trichocercae, Asplanchana* and *Colurella*).

Intermediate sector of the reservoir was also observed to yield short-lived bloom of *Synedra*.

11.1.3 Lentic Sector:- Average standing crop of planktonic biomass in lentic sector ranged from 0.98 in 1992-93 to 3.47 ml/m^3 in 1990-91. Seasonal abundance of biomass showed a trimodal distribution with the primary peak in September-October, secondary peak in January and tertiary peak in May-June. It was observed that the secondary peak was due to greater proliferation of green algae *Rhizoclonium* while the primary and tertiary peaks were mainly due to abundance of diatoms coupled with *Cyclops*. *Synedra* showed spurt in its density in October 1991 in littoral section of this zone with 3,27,021 u/l.

The average density of plankton indicated decrease from 12,128 u/l in 1991-92 to 4,466 u/l in 1994-95 (Fig 2). On an average the plankton population of the reservoir comprised Bacillariophyceae 66.03%, Chlorophyceas 25.42%, Myxophyceae 4.75%, Dinophyceae 0.97%, Copepods 1.14%, Rotifers 1.40%, Cladocerans 0.24% and Protozoans 0.02%

LIST OF PLANKTON

The following is the list of plankters reported from the reservoir.

Myxophyceae	*Microcystis, Phormidium Comphosphaeria, Nostoc, Stigonema, Oscillatoria, Spirulina, Merismophedia.*
Chlorophyceae	*Spirogyra, Botryoccocus, Pediastrum, Scendesmus, Arthrodesmus, Staurastrum, Closterium, Rhizoclomium, Pachycladon, Cosmarium, Cladophors, Trochiscia, Ulothrix.*
Dinophyceae	*Ceratium, Peridinium, Cystodinium.*
Bacillariophyceae	*Amphora, Diatoma, Synedra, Melosira, meridion, Frustulia, Navicula, Achnanthes, Cyrosigma, Nitzschia, Cyclotella, Tabellaria, Cymbella.*
Protozoa	*Actinophrys, Acrella, Actinesphaerium.*
Rotifera	*Brachionus, Hexarthra, Deratella, Notholca.*
Cladocera	*Daphnia, Ceriodaphnia, Bosmina.*
Copepoda	*Cyclops, Diaptomus*

11.2 **Diurnal variation**:- Diurnal variation in plankton was studied from September, 92 onwards in the months of June, September, December and March. The plankton count in general was more at 06 hrs and 18 hrs in the months of September, December and March (Table 13). Higher concentration of plankton at 12 hrs was observed in the months of June. The minimum plankton population (250 u/l) was at 12 hrs in the month of March 1994 while the maximum plankton population of 5800 u/l was observed at 18 hrs in the months of September 1992. The variation in numerical abundance was mainly controlled by the fluctuations in the availability of *Synedra, Microcystis* and *Rhizoclonium.*

Plankton population indicated the eutrophic tendency of Pong reservoir with the presence of dinoflagellates *comprising Peridinium inconspicuum*, eutrophic diatomas representing by *Synedra ulna* and blue green *Microcystis*. It appears that no marked changes have taken place with regards to dominance of plankton species in the reservoir during the period of study.

12. MACROBENTHOS:

12.1 **Annual and monthly variation**:- The average abundance of benthic macro-fauna during the different years was 296/3.66 g/m^2 (1990-91), 513/3.71 g/m^2 (1991-92), 511/20.49 g/m^2 (1992-930, 541/9.39 g/m^2 (1993-94) and 618/6.97 g/m^2 (1994-95). On an average the benthic community in general consisted mainly of dipterans (59.29%), oligochaetes (35.41%), mollusks (7.11%) and ephemeropterans (0.19%) by number.

Seasonal distribution of benthic standing crop revealed binemic pattern of distribution in all the years except 1990-91. The primary maxima was in winter (December-January) and secondary being in summer (May-June). The greater abundance of organisms was recorded in May 1993 (1378 units/m^2) Table 14. The two minima observed were in monsoon and spring. The macrobenthos were poor in monsoon (July-August) period and ranged between 150 u/m^2 to 496 u/m^2 during the year 1990-91 to 1991-93. The post-monsoon period during which reservoir gets stabilized after the monsoon floods, was found to be more productive and fauna increased in their abundance and attained their peak in December-January. The fauna were found to decrease from the month of February and dropped to form a second minimum in March ranging between 373 to 706 u/m^2.

The succession, association and diversity of different constituents of macrobenthos showed that dipteran larvae (*Chironomus*) occurred throughout the year with binemic distribution the primary pulse being in January and the secondary pulse in May. Oligochaetes also occurred throughout the year with binemic distribution, the primary pulse being in May and the secondary in January. Among oligochaetes, Branchiura sowerbyi has association with *Limnodrilus hoffmeisteri*, Mollesca, especially *Sphaerium* start appearing from October and attained their peak in the month of May. The peak of bottom fauna are controlled mainly by dipterans and oligochaetes.

12.2 **Sectorial Variation**:- The composition and the average quantitative abundance of macrobenthos in the three sectors of the reservoir varied considerably (Table 14 and 15) and presented in Fig. 3 and 4.

Lotic Sector:- Lotic sector has sandy bottom and the maximum depth was upto 20 m during the period July to February. This sector attained riverine conditions from January to July. The bulk of the fauna in lotic sector comprised dipterans larvae (*Chironomus, Chaoborus, Culex, Ceratopogon*) only. Oligochaetes and molluscs were uncommon. The average standing crop of bottom fauna in this zone was 167/0.118 g/m^2 (1990-91), 733/3.21 g/m^2 (1991-92), 428/0.72 g/m^2 (1992-93), 450/0.50 g/m^2 (1993-94) and 575/3.31 g/m^2 (1994-95).

Intermediate zone:- The intermediate zone had an almost equal preponderance of oligochaetes and molluscs. The average standing crop over the years (Table 14 and 15) varied between 353/0.38 g/m^2 (1990-91) and 659/6.79 g/m^2 (1993-94).

Lentic Sector:- The lentic sector was dominated by oligochaetes and dipterans larvae. The average population showed increasing trend from 260 u/m^2 in 1994-95. The standing crop in this zone was next to intermediate zone (Table 14).

The zonal distribution pattern of benthic fauna revealed that invariably their composition and availability within the reservoir varied considerably.

Qualitatively, oligochaetes (*Branchiura, Limnodrilus, Tubifex, Nais*), dipterans (*Chironomus, Chaoborus, Ceratopogon, Culex*), molluscs (*Lymnaea, Cygaulus, Sphaerium, Pisidium, Viviparous, Margaritifera*) and ephemeropterans (*Ephemera*) constituted the fauna of the reservoir.

12.3 Bathymetric distribution:- Bathymetric distribution of bottom macrofauna is presented in Table 16. The average standing crop in lotic sector ranged between 50 u/m^2 at 2 m and 225 u/m^2 at 10 m (1991-92); 436 u/m^2 at 2 m and 1400 u/m^2 at 10 m (1991-92); 212 u/m^2 at 2 m and 550 u/m^2 at 8 m (1992-93) and between 290 u/m^2 at 2 m and 913 u/m^2 at 6 m (1994-95). The congregation of fauna thus showed increasing trend with depth. The maximum abundance was between 8-10 m depth. Low water level during 1993-94 prevented sampling.

Intermediate zone showed abundance of benthic fauna at intermediate depth ranging from 8 to 14 m. The higher concentration of macrofauna were at 8 m in 1990-91 (45 u/m^2); at 20 m in 1991-92 (800 u/m^2); at 6 m in 1992-93 (782 u/m^2); at 10 m in 1993-94 (950 u/m^2) and at 14 m in 1994-95 (1775 u/m^2). Oligochaetes and dipterans were found at all the depths upto 30 m. The substratum contained detritus laden soft mud supported abundance of oligochaetes and dipterans larvae. This favoured by higher fraction of clay and organic matter.

In lentic zone, the benthic fauna exhibited their congregation towards high depths. Bathymetric configuration of fauna were at 26 m in 1990-91 (475 u/m^2); 26 m in 1991-92 (658 u/m^2); 26 m in 1992-93 (725 u/m^2); in 1993-94 (1400 u/m^2) and at 22 m in 1994-95 (1175 u/m^2). Oligochaetes and dipterans larvae were recorded at all the depths.

12.4 Benthos distribution vis-à-vis environmental factors;- The period of maximum rainfall (July-August) adversely affected the production of benthic organisms as reflected by their minimum population during this period. The probable reason could be dislodging of the population as result of turbulent inflow. Further, the higher water temperature favours the development of molluscan fauna resulting in a summer peak. The benthic population in general was abundant and more or less uniformly distributed in all the

three sectors during pre-monsoon period when water levels were low and the inflowing water was laminar in action. Thus inverse relationship between water level and numerical abundance of benthos was recorded. Increased water flow and current adversely affected the benthic organisms.

The soil texture was found to affect the distribution of benthic organisms. The higher fraction of clay in intermediate zone favoured the abundance of oligochaetes and sandy structure of soil in lotic zone favoured the growth of dipterans. The congregation of benthos at higher depths could be due to richness of sediment. Further due to wide fluctuations in reservoir level the benthic fauna were concentrated around the dead storage level.

The benthic organisms found in Pong reservoir are listed below:-

Nemata	*Dorylaimus*
Oligochaets	*Nais, Tubifex, Branchiura, Limnodrilys,*
Ephemeropteran	*Ephemera*
Diptera	*Chironomus, Chaoborus, Culex, Ceratopogon*
Mollusca	*Pisidium, Sphaerium, Gyraulus, Lymnaea, Viviparous, Maragaritifera.*

13. PERIPHYTON;

13.1 Yearly Variation:- The periphytic community of the reservoir was largely dominated by different groups of algal flora. The observations on annual qualitative and quantitative distribution of periphyton are as given below:-

Years	No/m²	Bacillario.	Myxophy.	Chlorophyceae
1990-91	1512	88.03	1.24	10.73
1991-92	1758	89.56	2.27	8.07
1992-93	1524	88.86	2.91	
1993-94	1443	87.23	2.87	9.90
1994-95	1336	87.23	3.25	9.12

The periphytic population decrease from a maximum of 175a No/cm² in 1991-92 to 1336 No/cm² in 1994-95. The population was dominated by bacillariophyceae (87.23-89.56%) in all the years followed by chlorophyceae (8.17-10.73%) and myxophyceae (1.24-3.25%)

13.2 Monthly Variation:- Seasonal distribution of periphyton exhibited binemic distribution in the year 1990-91, 1993-94 and 1994-95 with peak in October and March (Fig. 5) where as it showed trinemic distribution in the years 1991-92 and 1992-93 with peaks in June, October and March (Table 17). Qualitatively, Bacillariophyceae occurred throughout the year ranging between 83.0 and 95.3% in 1990-91, 85.0 and 92.0% in 1991-92, 86-98 and 92.45% in 1992-93, 80.4 and 91.89% in 1993-94 and 83-78 and 91.3% in 1994-95. Similarly, Chlorophyceae were also present all through the years. The Myxophyceae were absent in June and August (Table 18)

14. MACROPHYTES

The observations on macrovegetation revealed that they were confined to shallow areas of lotic zone only and were mainly represented by *Potamogeton crispus* and *Chara* sp. Aquatic vegetation were not encountered in the lentic and intermediate zone of the reservoir. It shows that lotic environment is providing conducive condition for the growth of *Potamogeton* and *Chara* sp. The average standing crop of macrophytes during the 1994-95 was of low magnitude (75 to 400 g/m^2).

15. FISH FAUNA

Thirty five species belonging to six orders and eleven families (Sharma 19930 have been recorded from the Pong reservoir of Himachal Pradesh. Of these only ten fish species were frequently observed in the commercial fish catches from the reservoir. Comparison of fish fauna of the area after the reservoir came into existence in 1974 and that observed before reservoir came into being showed that some fish species have disappeared due to changed ecosystem. Earlier observations showed (Tandon and Sharma 1976) presence of 47 fish species and 3 sub species belonging to 27 genera and 12 families. List of fishes observed from the reservoir and associated water is given below as per the classification Berg (1940).

Super Order : Osteoglossomorpha

Order : Osteoglossiformes

Family : Notopteridae

Sr. No.	Species	Local Name	Distribution
1.	*Notopterus notopetrus* (Pallas) Order : Cypriniformes Family : Cyprinidae Sub-family : Schizothoracinae	Moh, But, Pari	Lentic & Intermediate zone
2.	*Schizothorax plagiostomus* (Ham.) Sub-family : Cultrinae	Heckel Googli, Gurgal	Lotic zone and Khads
3.	*Salmostoma phulo punjabensis* Sub-family : Rasbroinae	Day, Chilwa	Khads
4.	*Danio (Brachydanio) rerio* (Ham.)	Kangi	All over in Khads
5.	*Danio devario* (Ham.)	Kangi	All over in Khads
6.	*Barilius barna* (Ham.)	Patha	All over in Khads
7.	*Barilius bendelisis* (Ham.)	Patha	All over in Khads
8.	*Barilius bola* (Ham.)	Patha	All over in Khads
9.	*Barilius vagra vagra* (Ham.) Sub-family : Cyprininae	Patha, Chilwa	All over in Khads
10.	*Cyprinus carpio communis* Linn.	Common carp	All over the reservoir
11.	*Puntius sarana* (Ham.)	Sarana	All over in Khads
12.	*Puntius ticto* (Ham.)	Puthi	All over in Khads
13.	*Puntius sophore* (Ham.)	Chidu	All over in Khads

14.	*Osteobrama cotio cotio* (Ham.)	Patha	All over in Khads
15. *	*Labeo calbasu* (Ham.)	Kalbans	Reservoir only
16.	*Labeo dero* (Ham.)Gid	All over the area	
17. *	*Labeo rohita* (Ham.)	Rohu	Reservoir only
18.	*Labeo dyocheilus* (Mc Clell)	Gid	All over the area
19. *	*Tor putitota* (Ham.)	Chitrahtii/ Chinyartoo	All over the area
20. *	*Cirrhina mrigala* (Ham.)	Mrigala	Reservoir only
21. *	*Cirrhina reba* (Ham.)	Reba, Sunhi/gulli	All over the area
22. *	*Catla catla* (Ham.)Katla/Thella Sub-family : Garrinae	Reservoir only	
23.	*Crossocheilus latius* (Ham.)	Taler/Dogru	Khads only
24.	*Garra gotyla gotyla* (Gary) Family : Cobitidae Sub-family : Noemacheilinae	Kurka	Khads only
25.	*Nemacheilus botia* (Ham.)	Sudal	Khads only
26.	*Nemacheilus kangrae* menon Order : Siluriformes Family : Bagridae	Sudal	Khads only
27. *	*Mystus (Aorichthys) seenghala* SykesFamily : Siluridae	Singhara/Singhi	Reservoir only
28. *	*Wallago attu* (Schn.) Family : Sisoridae	Malli	Reservoir only
29.	*Glyptothorax pectunopterus* (Ham.) Order : Channiformes Family : Channidae	Kundar	Khads only
30. *	*Channa marulius* (Ham.)	Sol	All over the area
31.	*Channa punctatus* (Bloch) Order : Perciformae Family : Chandidae	Donka	Reservoir only
32.	*Chanda nama* (Ham.) Family : Gobiidae Sub-family : Gobiinae	Chilwa	Khads only
33.	*Glossogobius giuris giuris* (Ham.) Order : Mastacembelidae Family : Mastacembelidae	Anhi	Khads only
34.	*Mastacembelus armatus armatus* Lacepede	Bam, Godal	All over the area

* Commercial fishes.

Due to the impoundment following fish species either have disappeared or receded to the riverine stretch as these have not been observed during the course of studies. The fish species are:-

Cyprinideae :

Esomus danricus (Ham.), *Rasbora daniconius* (Ham.), *Labeo pungusia* (Ham.), *Puntius chola* (Ham.), *Puntius conchonius* (Ham.), *Puntius tetrarupagus* (McClell), *Botia birdi* (Chaudhuri), *Botia geto* (Ham.), *Botia dayi* (Gunther), *Lepidocephalus guntea* (Ham.), *Noemacheilus horai* (Menon), *N. kangarae* (McClell), *N. punjabensis* (Hora).

Amblycepidae :

Amblyceps mangois (Ham.)

Bagridae :

Mystus bleekari (Day), *M. aor* (BI), *M. vittatus* (Block)

Sisoridae :

Glyptothorax garhwali (Tilak), *Pseudechenous sulcatus* (McCell)

16. BREEDING AND RECRUITMENT OF FISH

Spawn collection nets were operated for the first in the River Beas at Dehra during 1991-92 which appeared as the potential breeding grounds of fishes. Developing eggs were collected in spurts with a maximum rate of 2000 ml/hr/net.

During 1992-93, developing eggs at a maximum rate of 4000 ml/hr/net in Gaj Khad were collected. The diameter of fertilized eggs ranged from 2.18 to 3.99mm. The rearing of eggs revealed the breeding of *Labeo calbasu* in Gaj Khad during the month of July.

In 1993-94, developing eggs were collected in spurts with a maximum of 2500 ml/hr/net in the confluence area of Dehra and Dehri khads joining the reservoir. The breeding grounds of major carps were located. The species composition of fry reared showed dominance of *L. rohita* (80%). The more common associates were *Barelius bandelisis, B. vagra, Ambasis nama, T. putitora* and M. seenghala.

Developing eggs were also collectd in spurts with a maximum of 1500 ml/hr/net in Gaj khad joining intermediate zone of the reservoir in 1994-95. The eggs diameter varied from 1.81 to 4.85mm. The associates observed were *Glossogobius giuris giuris, Ambasis nama, Barilius bandelisis, Oxygaster phulo and Puntius ticto.*

17. COMMERCIAL FISHING

17.1 Fish biodiversity : Commercial fishing was initiated in the Pong reservoir soon after its impoundments. The important fishes in order of abundance were *L. rohita, M. seenghala, L. calbasu, Tor putitora, Cirrhina mrigala* and *Wallago attu*. A look at the catch from the reservoir for preceding 14 years (1976-77 to 1989-90) shows that the fish catch increased to all time high of 797 t (yield 53-1 $kgha^{-1}$) in 1987-88 from 98 t (yield 17.6 kg/ha) in 1976-77. The fish landings during these years fluctuated with in a narrow range of 443 t-596 t 1977-78 to 1986-87 (Table 19.1). On an average catch of 484.8 t (range 98-797 t) with average yield of 32.3 $kgha^{-1}$ (range 6.5-53.1 $kgha^{-1}$) was estimated

for the years preceding present studies. Catch of *Labeo rohita* showed progressive increase from 0.4-42.5% (1982-83 to 1987-88) where as *Catla catla* despite stocking remained 0.04%-1.6%. *C. mrigala* increased from 5.3 to 9.7% (82-83 to 87-88). The impact of heavy stocking of *Cyprinus carpio* which fluctuated between 2.6-5.9% could not be felt.

The catch of fish oscillated around 371-485 t (yield 24.87-32.33 $kgha^{-1}$) between 1990-91 and 1994-95 except marginal increase to 485 t (32.33 $kgha^{-1}$) in 1991-92. It decline from 442 t (1990-91) to 371 t (1994-95). On an average 423.8 t(yield 28.25 $kgha^{-1}$) with range of 371-485 t and 24.73-32.33 $kgha^{-1}$ was observed during the period 1990-91 to 1994-95 despite heavy stocking of the reservoir with common carp and Indian major carps, Table 19.2, 19.3; Fig. 5.2.

17.2 **Yearly variation in fish Yield :-**Species-wise catch during 1990-91 to 1994-95 shows that Catla increased from 1.56% in (90-91) to 9.16% of total in (94-95) where as catch of *Labeo rohita* another Indian major carp stocked declined from 31.22% (1990-91) to 15.36% (1994-95), Table 19.3. Similar was the scenario for other two major carps viz. *C. mrigala* (declined from 3.85% to 1.08%) and *L. calbasu* (declined from 9.50% to 2.43%). The impact of heavy stocking of *Cyprinus carpio* could not be felt as it declined from 1.12% in (90-91) to 0.81% (94-95) despite heavy stocking. The fishery of the reservoir was dominated by *M. seenghala* which showed a steady rise from 121.0 t (27.36%) in 1990-91 to 193 t (52.02%) in 1994-95. Other fishery of same consequence is that of *Tor putitora* which fluctuated between 50 t (13.40%) in 1993-94 and 65.0t (14.70%) in 1990-91). Table 19.4 & 20; Fig. 5.4.

The present scenario of Pong reservoir is not with much difference as the fish catch oscillated between 330 t (22 $kgha^{-1}$ in 1995-96) and 453 t (30.2022 $kgha^{-1}$ in 1999-2000). The catch increased marginally from 330 t (95-96) to 415 t (97-98) thereafter it declined to 360 t (98-99). On an average the catch for 10 years (1995-96) to 2004-05) is 389 t with range of 308-453 t and with average yield of 25.9322 $kgha^{-1}$ with range of 20.53-30.2022 $kgha^{-1}$, Table 19.5; Fig. 5.3 and 5.5.

Species-wise catch of *M. seenghala* the dominant catfish increased from 185 t and 56.06% in 1995-96 to 324 t and 75.53% in 2004-05, Table 19.4 and 19.5. The presence of *M. seenghala* has affected the catch of prized mahseer, *Tor putitora* which was caught upto 59.0 t (17.88%) in 1995-96, 64 t (16.12%) in 1996-97 and increased to 90 t (18.87%) in 1999-2000 has declined to all time to of 30 t (6.99%) in 2004-05. The catch of *carpio* though improved from 3 t (0.90%) in 95-96 to 39.0 t (9.09%) in 2004-05 is not commensurable from 1995-96 to 1999-2000 (10.91%-13.25%) has declined to all time low 2.10% (2004-05). However catch of *C. mrigala* showed improvement with 3 t (1995-96) to 21 t (2004-05). The catch of *Catla catla* too was adversely affected by the presence of *M. seenghala*. It declined from 22 t (6.67%) 95-96 to 1t (0.23%) in 2004-05. The other catfish *W. attu* which showed its presence with 24 t (5.42%) in 1990-91 has all together vanished in commercial catch with strap records during 2003 to 2005, Fig. 5.6.

17.3 **Stock characterization as related to fishing effort**:- The fish yield of Pong reservoir has changed considerably. The fish catch increased from 442 t (CPUE 709) in 1990-91 to 486 t (CPUE 793 g) in 1991-92 although the fishing effort decreased marginally from 2225 in 1990-91 to 2190 in 1991-92. The fish yield however decreased from 447 t (CPUE 688 g) in 1992-93 to 372 t (CPUE 602 g) in 1994-95, though the fishing effort increased to 2024 in 1994-95 from 2190 in 1991-92 (Table 20.1)

The fish yield scenario oscillated between 330 t (1995-96) and 543 t (1999-2000). The fish catch decline to 330 t (CPUE 513 g) in 1995-96, thereafter it increased to 453 (CPUE and 526 g) in 1999-2000 with marginal decrease in 1998-99 (360 t and CPUE 524 g). The fishing effort increased from 2142 in 1995-96 to 2934 in 1999-2000 (Table 20.2).

The fish catch declined to 428 (2001-01) with CPUE 461 g, in spite of increase in fishing effort to 3092. The catch further declined to 308 t (CPUE 303 g) 2003-2004 with slight increase to 429 t (CPUE 394 g) in 2004-2005. The fishing effort increased from 3092 (2001-02) to 3634 (2004-05).

C. catla:- The fish yield increased from 7.0 t in 1990-91 to 34 t in 1994-95 thearafter decreased to steady 22 t all through 1995-96 to 1999-2000. Its production further became all time low with 6 t (2000-01) to 1 t (200405). Likewise the CPUE also fluctuated with increase from 11 g to 55 g (1990-91-1994-95), thereafter decreasing to 34g (1995-96) to 25g (1999-2000) and to all time low 0.9g (2004-05) this was despite the increase in effort. The stock strength of catla is at low level. Its is necessary to increase it through stocking.

L. rohita:- Higher fish yield of this species recorded in the year 1991-92 (150 t, CPUE 246g) declined 57 t (CPUE 92g) in 1994-95. Its catch further declines to 36t (CPUE 56g) 1995-96 to 41t (CPUE 50 g) in 1998-99. Thereafter increase in 1999-2000 (65t, CPUE 74g) showed a steady decline to all time low of 9t CPUE 89g (2004-05). The sharp decline indicated need for heavy stocking support.

C. mrigala;- The CPUE of *C. mrigala* was 27 g in 1990-91 which decreased in subsequent years to a minium 6 g 1994-95 with corresponding decrease in yield from 17t to 4t. The yield further declines from 3t, CPUE 5g (1995-96) to 2t, CPUE 2g in 1998-99. It started increasing from 8t CPUE 9g (1999-2000) to 11t CPUE 12g (2000-2001 and increased to 21t, CPUE 19g (2004-05 iwth marginal decreased here and there. The fluctuation shows poor recruitment and need for stocking support.

C. carpio:- The fish landing of *C. carpio* showed decline in catch from 5t (CPUE 7g (1990-91) to 3t CPUE 3 g (1995-96). It increased to 14t CPUE 19g (1996-97) to 21t CPUE 23g (2000-01) with marinal increase or decrease. There after in increased to all time high of 39t, CPUE 36g (20040-05) with decline in 2001-02. Its stocking need be maintained at present level.

M. seenghala:- The cat fish has become dominant fishery of the reservoir with 121t, CPUE 295g in 1990-91 to 193 t, CPUE 315g in 1994-95; 185t, CPUE 288 g (1995-96) to 257t, CPUE 292g (1990-2000) and 264 t, CPUE 285 g (2000-01) to 324 t, CPUE 297 g (2004-05). Its dominance has affected the Indian major carp fishery of the reservoir. Long line fishing may be introduced to exploit the species further.

T. putitora:- The catch of this prized mahaseer fluctuated in the reservoir. Its catch was 65t, CPUE 104g (1990-91) which slight increase to 71t, CPUE 110g (1992-93) declined to 59t, CPUE 92g (1995-96). It increased to 90t, CPUE 102g (1999-2000) but there after declined to low of 30t, CPUE 28g (2004-05). This decline is due to the increase of *M. seenghala* fishery. So strick conservation measures are suggested to conserve the species.

17.4 Mesh selectivity:- It is evident from mesh selectivity study (Table 21) that the small mesh bar gill nets (38-75mm) were more effective for fishing *M. seenghala* (345-950mm). *L. rohita* 9466-800mm). Mesh bar of 88-100 were used for fishing C. catla (920-1000mm). *L. rohita* (655-730mm) and *M. seenghala* (750-870mm0.

17.5 **Maximum sustainable yield (MSY) and optimum fishing effort (fmsy):-** Observations on the fish yield of the last ten years suggests MSY at 538 t and fmsy at 1652 nets as per schaeffer equation.

17.6 **Mode of Commercial fishing**:- The fishing in the reservoir is done with licenses issued by the Himachal Pradesh Fisheries Department. The licensed fishermen in Pong reservoir are mostly fulltime fishermen and all are members of the fishermen co-operative societies which have been organized to do fishing in their respective areas. Presently there are 12 fishermen Co-operative Societies functioning in the reservoir. There are around 1200 fishermen settled near the reservoir. The fishermen normally use gill nets and each one have on an average 3-4 nets of 60x5 m of length and mesh bar of 40-200mm. The fishermen hand over the fish caught to the Co-operative Society to which he belongs, which in turn hands over to the contractor at the landing centres on the rate fixed from time to time by the State Fisheries.

17.7 **Regulatory provisions**;- Hook and line fishing is allowed at selected places for sport purposes on taking a license. Fishermen are generally to use two gill net for commercial fishing. The prescribed length of the net is 60 and depth 3 meters of varying mesh bar. Following are the length and weight prescribed under Himachal Pradesh Fisheries Act., for various species of fish caught

Species	Minimum T.L. (cm)	Minimum total wt. (kg)
C. catla	45	1.5
L. rohita	40	1.0
C. mrigala	30	0.5
T. putitora	30	0.5
L. dero	25	0.5
C. carpio	30	0.9

18. FISH BIOLOGY

18.1 **Length-weight relationship**:- The length-weight relationship of various fish species studied from the Pong reservoir have been derived by analysis of the polled data as under:-

1. *C. catla* : $W = 4.2785 \times 10^{-6} L^{3.2442}$ Log W = 3.2442 Log L = 5.3687 r = 0.9869
2. *L. rohita* : $W = 1.9774 \times 10^{-5} L^{2.9269}$ Log W = 2.9269 Log L = -4.7039 r = 0.9369
3. *C. mrigala* : $W = 4.7315 \times 10^{-4} L^{2.4202}$ Log W = 2.4202 Log L = -3.3250 r = 0.9265
4. *L. calbasu* : $W = 1.9656 \times 10^{-4} L^{2.5581}$ Log W = 2.5581 Log L = -3.7087 r = 0.9267
5. *T. putitora* : $W = 2.0816 \times 10^{-5} L^{2.9269}$ Log W = 2.8746 Log L = 4.6816 r = 0.9506
6. *M. seenghala* : $W = 1.3270 \times 10^{-6} L^{3.2442}$ Log W = 3.2442 Log L = 5.3687 r = 0.9869
7. *W. attu* : $W = 6.7390 \times 10^{-4} L^{2.2727}$ Log W = 2.2727 Log L = 3.1714 r = 0.9251

It is evident from above formulae that the exponent for *Catla catla* is more than 3 Where as for rest of fishes it is less than 3.

18.2 **Age and growth**:- The age and growth of various fish species of Pong reservoir was studied with the help of scales. This was also verified from von-Bertalanffy's growth equation. The growth equation and average length of various fish species at each year group for the pooled data have been calculated. These are:-

Growth data for pooled samples (Year groups mm)

Species	I	II	III	IV	V	VI	VII
C. catla	411	531	652	750	842	910	963
L. rohita	358	476	589	694	767	815	
L. calbasu	286	391	476	-	-	-	-
C. mrigala	390	511	613	732	-	-	-
T. putitora	289	381	486	577	685	751	-
P. sarana	203	251	274	-	-	-	-

It is evident from the observations that the growth in these fish species from this ecosystem, is more in the first year of their lives, as compared to the later period and that the growth rate does not follow the usual parabolic equation. This is in conformity with the work of Tandon and Johall (1995) from Gobindsagar and north West India. The observations on the age and growth of various fish species of commercial importance are presented in following text:-

C. catla:- The von-Bertalanffy's growth equation for this species as:-

$$Lt = 1396\ (1-e^{-0.1651\ (t+0.6525)})$$

$$L\alpha = 1396\text{mm}$$

The average lengths derived for various years for the species from Pong reservoir comes to be:-

Average Age Growth (in mm)

Years	I	II	III	IV	V	VI	VII
1991-92	356	470	640	760	860	-	-
1992-93	420	553	665	760	857	-	-
1994-95	456	569	652	728	808	910	963

The observations shows that this species has been showing a steady growth rate from 1991-92 to 1994-95, which is attributed to availability of more space in the bio-sphere and less competitors. The average length derived for pooled data by different methods are:-

Age in years	Length by scale study mm	Length by growth equation
I	411	333.36
II	531	495.02
III	652	632.25
IV	750	748.40
V	842	847.09
VI	910	930.57
VII	963	1001.49

L. rohita:- The growth equation calculated for this species for pooled data as:-

$L_t = 1218\ (1-e^{-0.1409\ (t+1.0052)})$

$L_\alpha = 1218mm$

Age Group (in mm)

Years	I	II	III	IV	V	VI
1991-92	369	468	567	671	-	-
1992-93	350	453	571	660	766	815
1993-94	335	497	613	753	844	-
1994-95	377	485	605	690	-	-

The observations show that this species did not show steady growth in 1st or 2nd year of life due to its probable competition with other juveniles for food and space. But thereafter a steady growth has been observed. The average lengths derived for this species by different methods are :

Age in years	Lengths by scale methods	Length by growth equa
I	358	299.74
II	476	420.45
III	589	525.25
IV	694	695.48
V	767	764.17
VI	815	823.72

C. mrigala:- The growth equation derived for this species is:-

$L_t = 1386\ (1-e^{-0.1355\ (t+1.6260)})$

$L_\alpha = 1396mm$

The average lengths for various years for the species are:-

Years	Age Group (in mm)			
1991-92	352	475	575	732
1992-93	352	478	577	732
1993-94	402	521	649	-
1994-95	415	533	-	-

This species too showed a steady growth over these years. The lengths derived for this fish by different methods are:-

Age in years	Lengths by scale methods	Length by growth equation
I	390	414.96
II	511	537.98
III	613	645.45
IV	732	739.30

L. calbasu:- The growth equation for this species is:-

$$Lt = 693\ (1-e^{-0.2342\ (t+0.9777)})$$
$$L\alpha = 693mm$$

The lengths derived from various methods for the fish are:-

Age in years	Lengths by scale methods	Length by growth equation
I	286	256.96
II	391	347.95
III	476	420.00

The average length for various years are as under:-

Age Group (in mm)

Years	I	II	III
1992-93	286	391	476
1993-94	298	394	457
1994-95	317	416	510

This fish too showed a steady growth over the years owing to same reasons as are explained for *C. catla, L. rohita* and *C. mrigala*

T. putitora:- The growth equation for *T. putitora* the golden mahaseer of hills is:-

$$Lt = 2447\ (1-e^{-0.0520\ (t+1.0611)})$$
$$L\alpha = 2447mm$$

and length (mm) derived by different methods are:-

Age in years	Lengths by scale methods	Length by growth equation
I	289	248.45
II	381	359.82
III	486	465.62
V	577	565.99
VI	685	661.25
VII	751	751.81

The average length at each years group for various years for this fish are:-

Age Group (in mm)

Years	I	II	III	IV	V	VI
1991-92	317	412	513	593	730	-
1992-93	260	349	448	550	634	765
1993-94	209	382	497	587	691	736

P. sarana:- The growth equation for the fish species is:-

$$Lt = 334\ (1\text{-}e^{-0.5206\ (t+0.2977)})$$

$$L\alpha = 334mm$$

The average lengths derived by different methods are:-

Age in years	Lengths by scale methods	Length by growth equation
I	203	164.02
II	251	233.00
III	274	273.99

The average lengths for various years are:-

Age Group (in mm)

Years	I	II	III
1991-92	210	246	-
1992-93	188	248	274
1993-94	210	258	-

18.3 Food and feeding habits:- Food and feeding habits of fishes studied are given below.

M. seenghala:- The gut contents consisted mainly of fish matter (85.0%) followed by insects (4.7%).

T. putitora:- Food composition indicated that the fish feeds on fish matter (46.5%) and plant matter 26.0%).

W. attu:- The bulk of gut contents comprised of fish matter (87.5%).

C. carpio:- The food of this fish mainly comprised of detritus (68.8%) and plant matter (13.8%).

L. rohita:- The gut contents consisted mainly of chlorophyceae (36.8%), detritus (32.8%) and bacillariophyceae (16.7%).

L. calbasu:- The food of this fish comprised mainly of detritus (65.5%) and mud and sand (12.5%).

C. mrigala:- The gut contents consisted detritus (40.0%) and mud and sand (32.0%) and insects (10.0%).

S. plagiostomus:- The food of this fish comprised of detritus (50.0%), dipterans (10.0%) and mud and sand (10%).

P. sarana:- The bulk of gut contents comprised of detritus (70.3%) and chlorophyceae (8.5%).

C. reba:- The gut contents comprised of detritus (55.7%0 and bacillariophyceae (23.6%).

C. catla:- The of this fish consisted mainly copepods (957.5%) and chlorophyceae (19.0%).

A picture of interspecific composition among the *M. seenghala, W. attu* and *T. putitora*) shows that all three species compete to great extent for fish matter. It may also inferred

that C. catla is not in competition with other commercial species available in the reservoir. However, *C. mrigala* and *C. carpio* competes considerably with *L. calbasu* for detritus.

18.4 **Length-frequency distribution**:- The length frequency distribution of various fish species in commercial catches were pooled and analysed in the size interval of 20mm. The distribution pattern shows that majority of fishes are caught in the size of 200-700mm. *C. catla* had its dominance 53.1% in size range of 700-999mm whereas 57.3% of *L. rohita* occurred in size group of 400-579mm. *C. mrigala* were maximum (48.498%) in size group of 500-699mm. *T. putitora* were abundant between 360 and 679mm length whereas *P. sarana* were dominant in size range of 200-339mm . Among cat fishes *M. seenghala* dominated in size group of 460-679mm while *W. attu* were abundant in size range of 540-819mm.

19. STOCKING

The following are the stocking figures:-

Years	*C. carpio* (Lakh)	Indian major carps (Lakh)
1990-91	5.46	-
1991-92	3.35	5.00
1992-93	5.43	6.40
1993-94	5.00	-
1994-95	-	0.90
1995-96	-	6.00
1996-97	2.00	1.00
1997-98	3.57	12.80
1998-99	3.50	10.10
1999-2k	2.95	12.00
2000-01	1.50	14.13
2001-02	2.30	15.42
1002-03	1.50	11.29
2003-04	1.50	15.00

Owing to feeble natural recruitment in the reservoir maintenance, stocking is virtually the most significant forms of management for this reservoir to supplement natural reproduction and should be ranked as a top priority. On an average, the stocking rate worked out to be 72 fingerlings/ha for the reservoir. Considerable stocking have been done only with *C. carpio* which appear to have been not suitable for the reservoir. The probable reasons for its poor performance are (i) presence of piscivores in large number (ii) establishment of *L. calbasu* as fishery which have similar feeding habits as of *C. carpio* and (iii) being sluggish, it form an early prey for carnivores.

20. RECOMMENDATIONS

Presently, the reservoir harbour a large variety of fish species. It is unique in nature wherein besides indigenous carp like *T. putitora*, the Gangetic major carps as well as the cat fishes are found to thrive.

As a result of stocking of common carp and Indian major carps in earlier years, the per hectare yield of the reservoir increased from meager 6.5 kg/ha (Table 19.1) during 1976-77 to 53.1 kg/ha during 1987-88. The fish yield declined during subsequent years reaching all time low 2 kg/ha (1995-96) (Table 19.2), there after showed recovery to 28.60 kg/ha in 2004-05. Based on the limnological investigations on the reservoir.

1. Stocking of fish seed of common carp and Indian major craps into the reservoir has been undertaken on an arbitary basis without taking into consideration the number and sizes of fingerlings and the ratio of species to be stocked which may be due to dearth of stocking material and sufficient knowledge of the biogenic capacity of the reservoir. On an average, the stocking rate worked out to be 72/fingerlings/ha/yr for the reservoir. Owing to feeble natural recruitment in the reservoir maintenance stocking is virtually the most significant from to management for this reservoir to supplement natural reproduction and should be ranked as a top priority. The potential annual yield of the reservoir depending upon the net energy fixed by producers is 118 kg/ha, whereas the present yield is 28.6 kg/ha/he which could be due to inadequate stocking and limited spawning habitat. This indicated that with prudent stocking an yield of 70-80 kg could be an achievable target. A stocking rate 200 fingerlings (50-70 mm size) per annum may therefore be adopted. It is recommended that fingerlings of rohu, mrigala and catla in ratio of 2:1:1 may be stocked during September-October within inundated bays joining intermediate zone of the reservoir.

   A 1.1 ha Kangra fish Farm near the reservoir site is being used for the State Fisheries Department for production on common crap seed. Since the production capacity of the farm is limited, the stocking demand of the reservoir can be met out by raising fingerlings in floating nurseries in the reservoir.

2. There is an urgent need to review the stocking of common carp into the reservoir which has been going on for past several years. Despite heavy stocking, the common carp catch each year and reached to lowest 3t (0.81%) during 1993-94. It increased to 17t (4.10%) in 1997-98 but there after fluctuated reasing high of 39 t (9.09%) during 2004-05. From the stocking its evident that the stocking of common crap is not any scientific basis but arbitary as the increase or decrease of catch is not linked with increased or decrease in stocking. So a steady of this species be maintained to cope with stress on the fish due to increase presence of *M. seenghala* in the reservoir.

3. The niches occupied by the fishes feeding on diatoms as well as periphyton are not being fully utilized by phytophagus fishes in the reservoir. This indicated the need to strengthen stock of *C. mrigala* and *L. rohita* and also to stock any other suitable indigenous fish to utilize the niche fully so as to give a higher trophic transfer efficiency from primary production to fish. The catch of *Catla catla* which was 7 t, 1.56% (1990-91) reach all time high 34 t (9.16%) by 1994-95 there after declined to 1 t (0.23%) in 2004-05. Similarly *L. rohita* 138 t (31.22%) in 1990-91 has come down to 9 t (2.10%) by 200405 and *C. mrigala* 17 t, 3.85% in 1990 to 21 t, 4.91% and *L. calbasu* 42 t, 9.50% (1990-91) to 1 t, 0.23% (2004-05) shows that there is a great strees on *C. catla* and *L. rohita* so heavy stocking of these fish species in size range of 50 mm be stocked along with heavy fishing of *M. seenghala* which has estalished as natural stocks in the reservoir.

4. Pong reservoir has a flourishing cat fish fishery dominated by *M. seenghala*. It fihsery increased from 121 t (27.36%) in 1990-91 to 193 t (52.02%) in 1994-95, 185 t (56.06%) in 1995-96 to 257 t (56.70%) in 1999-2000 and 264 t (61.68%) in 1000-01 to 324 t (75.53%) in 2004-05. This steady increase despite no stocking support reflects the establishment of this species as natural population. Being pscivorous in nature its control is of immediate concern so efforts should be centered onits fishing of all size groups and stocking of Indian major craps of appropriate size on heavy quanitities. As the catfish dominance is banned to afect overall production of reservoir. This calls for intensive fishing of *M. seenghala* by nets ans hooks and lines so that population coul be kept under check.

5. In view of good fishery of *Tor putitora* 65 t (14.70%) in 1990-91, 59 t (17.88%) in 1995-96 and 64 t (14.84%) in 2000-01 and the reservoir may be developed to attract tourist/ anglers.

6. Capture fishery regulations viz. limits on fishermen number, fishing gear, size limits of fish caught and closed season are essential to ensure sustainable yield from reservoir ecosystem. Such development measures must therefore be taken to control the fishery activity in Pong reservoir.

7. Regular monitoring of total and species-wise catch and catch unit effort is recommended which would help to plan rational fishing. Breeding success and recruitment of economically important fishes should also be monitored in future for framing a judicious stocking policy for the reservoir.

21. PUBLICATIONS

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22. ACKNOWLEDGEMENTS

It is to place on record sincerest thanks to Ch. Gopalakrishnayya & Dr. V.R. Desai, Heads, Reservoir Division, Bangalore, during the period investigation, for their constant guidance

and going through the manuscript critically. Their encouragement and guidance helped in achieving the goal. Grateful thanks are due to Dr. Kuldip Kumar, Former Director and Warden of Fisheries, Himachal Pradesh, for his keen interest and full cooperation during the course of the investigations. The Bhakra Beas Management Board supplied the inflow, outflow, reservoir level and meterological data for which the authors are thankful. Sincere thanks are due to Sh. M. S. Akhtar, Assistant Director of Fisheries, Pong reservoir, Jassur, and his field staff, for day to day help in carrying out the work. Thanks are also due to Sh. Paras Ram Bhatia to assisted in the preparation this bulletin, especially the graphics.

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Table 1 : Salient features of the morphometry of Pong Reservoir.

Elevation at top of dam	-	433.36 m (1430 ft)
Maximum reservoir level	-	433.12 m (1421 ft)
Maximum reservoir area	-	24,000 ha
Dead storage level	-	384.05 m (1260 ft)
Dead storage area	-	6,000 ha
Average area	-	15,000 ha
Catchment area	-	12,561 sq. km.
Gross storage capacity	-	8570 million M^3 (6.95 million ac. ft.)
Live storage capacity	-	7290 million M^3 (5.91 million ac. ft)
Maximum reservoir depth	-	97.84 m (321 ft)
Moan depth	-	35.7 m
Shore development at 1260 ft.	-	2.48
Volumes development	-	1.08
BENEFITS FROM THE RESERVOIR/PROJECT	-	
Annual irrigation	-	1.6 million ha (4 million acres)
Electrical energy delivered per annum	-	1400 million units approx.

Table 2 : Hydrological and meterological data of Pong reservoir.

Year	Reservoir (m)	Total inflow (million M^3)	Total outflow (million M^3)	Air temp.°C		Rainfall (cm)
				Max.	Min.	
1990-91	410.6-424.0	11359	10601	19.0-38.2	7.6-23.4	132.2
1991-92	407.6-422.2	8128	7751	18.3-37.6	5.8-23.2	84.5
1992-93	407.0-426.3	10271	10555	16.7-38.0	5.9-24.0	149.0
1993-94	398.5-414.0	7878	7402	20.2-38.4	8.6-27.2	122.5
1994-95	394.5-423.4	11672	10919	17.6-39.4	7.3-26.0	109.0

Table 3 : Physico-chemical characteristics of soil in Pong reservoir.

Year/Zone	1991-92			1992-93			1993-94			1994-95		
	Lotic	Int.	Lentic	Lotic	Int.	Lentic	Lotic	Int.	Lentic	Lotic	Int.	lentic
Physical												
Clay	5.0	30.0	12.5	3.5	4.5	16.1	2	11	3			
Silt	5.0	30.0	27.5	8.5	9.0	16.2	10	12	15			
Sand	38.0	49.4	62.0	90.0	40.0	60.0	88.0	86.5	67.7	88	77	82
pH	8.6	8.8	8.8	7.1	6.1	6.9	7.2	7.1	7.0	7.8	7.4	7.4
Chemical												
Organic carbon (%)	1.2	1.2	1.08	0.85	0.15	0.13	0.31	0.43	0.58	0.48	0.42	0.18
Av. Phosphates (mg/100g)	16.0	6.4	7.2	8.0	40.0	28.0	0.55	1.37	2.33	5.05	22.5	3.7
Av. Nitrogen (mg/100g)	11.48	15.12	14.56	12.32	19.04	14.0	12.7	20.1	16.9	16.2	44.2	14.2
Cal. Carbonate (%)	-	-	-	-	-	-	-	-	-	-	-	-
El. conductance (umhos/cm)	0.135	0.120	0.130	-	-	-	-	-	-	0.56	0.47	0.19

Table 4 : Ranges of physico-chemical characteristics of water of Pong reservoir in lotic zone.

Parameters	1990-91	1992-93	1993-94	1994-95
Water temperature (°C)	13-28.5	16-26	14-25	16-27
Transparency (cm)	45-278	26-225	21-80	18-63
pH	7.8-8.2	7.1-7.7	7.0-7.9	7.0-7.8
Dissolved oxygen (ppm)	8.4-9.6	8.2-10.0	8.0-10.4	6.0-9.6
Free CO_2 (ppm)	2.0	Nil-6.0	Nil-2.0	Nil-3.0
Total alkalinity (ppm)	62-104	64-84	52-110	54-80
Calcium (ppm)	-	-	24.0-33.0	29.4-30.4
Magnesium (ppm)	-	-	3.8-5.6	5.4-5.6
Phosphate (ppm)	0.06-0.22	0.10-0.18	0.12-0.20	0.22-0.24
Silicate (ppm)	-	-	1.64-2.10	2.02-2.04
Organic matter (ppm)	2.4-4.6	3.2-4.2	3.2-5.4	3.4-3.8
Hardness (ppm)	50-84	66-80	56-172	80-132
Total dissolved shilds (ppm)	-	48.3-77.1	58.8-145.7	62.3-103.2
Specific conductivity (uhmos/cm)	138.8-198.4	96.4-154.2	117.6-266.8	125.0-198.6

Table 5 : Ranges of physico-chemical characteristics of water of Pong reservoir in Intermediate zone.

Parameters	1990-91	1992-93	1993-94	1994-95
Water temperature (°C)	13-32	13-31	16-32	18-32
Transparency (cm)	63-211	45-196	27-192.5	53-231
pH	7.8-8.3	7.3-8.1	6.8-8.2	7.1-7.8
Dissolved oxygen (ppm)	8.0-9.6	8.1-9.6	7.2-9.2	5.2-8.8
Free CO_2 (ppm)	Nil-2.0	Nil-4.0	2.0-6.0	Nil-4.0
Total alkalinity (ppm)	68-100	48-86	60-90	52-80
Calcium (ppm)	-	-	20.6-26.2	24.6-25.8
Magnesium (ppm)	-	-	2.18-4.6	4.6-5.0
Phosphate (ppm)	0.08-0.24	0.10-0.18	0.12-0.20	0.22-0.26
Silicate (ppm)	-	-	1.16-1.86	1.92-2.00
Organic matter (ppm)	2.2-5.6	3.4-4.2	3.2-6.0	3.4-4.0
Hardness (ppm)	52-72	64-72	54-150	70-128
Total dissolved shilds (ppm)	-	64.9-86.2	56.9-89.6	55.7-90.1
Specific conductivity (uhmos/cm)	138.8-187.5	130.0-172.9	113.8-178.9	111.4-180.2

Table 6 : Ranges of physico-chemical characteristics of water of Pong reservoir in Lentic zone.

Parameters	1990-91	1992-93	1993-94	1994-95
Water temperature (°C)	15-33	16-30.8	16-31	18-30.5
Transparency (cm)	121-423	126-376	35-309	58-475
pH	7.8-8.2	7.5-8.1	7.3-8.3	7.2-7.9
Dissolved oxygen (ppm)	8.0-9.2	8.0-9.6	6.0-9.4	6.4-9.2
Free CO_2 (ppm)	Nil-2.0	Nil-4.0	2.0-3.0	Nil-2.0
Total alkalinity (ppm)	64-88	62-94	52-86	52-68
Calcium (ppm)	-	-	21.6-24.0	20.8-24.2
Magnesium (ppm)	-	-	4.4-7.1	4.0-5.2
Phosphate (ppm)	0.08-0.24	0.16-0.22	0.20-0.30	0.24-0.28
Silicate (ppm)	-	-	1.76-2.22	2.10-2.16
Organic matter (ppm)	3.6-5.2	4.0-4.4	3.6-4.6	3.8-4.2
Hardness (ppm)	50-72	64-78	68-154	92-130
Total dissolved shilds (ppm)	-	59.8-106.3	56.2-91.2	54.6-84.6
Specific conductivity (uhmos/cm)	131.0-198.4	114.6-195.8	118.5-183.2	109.3-169.3

Table 7 : Ranges of physico-chemical characteristics of water of Pong reservoir.

Parameters	1990-91	1992-93	1993-94	1994-95
Water temperature (°C)	13-33	13-31	14-31	16-32
Transparency (cm)	45-423	26-376	27-309	-
pH	7.8-8.3	7.1-8.1	6.8-8.3	7.0-7.9
Dissolved oxygen (ppm)	8.0-9.6	8.0-10.1	6.0-10.4	5.2-9.6
Free CO_2 (ppm)	Nil-2.0	Nil-6.0	Nil-6.0	Nil-4.0
Total alkalinity (ppm)	62-100	48-94	52-110	52-80
Calcium (ppm)	-	-	20.6-33.0	20.8-30.4
Magnesium (ppm)	-	-	2.18-7.1	4.6-5.6
Phosphate (ppm)	0.06-0.24	0.10-0.22	0.12-0.30	0.22-0.28
Silicate (ppm)	-	-	1.16-2.22	1.92-2.16
Organic matter (ppm)	2.2-5.6	3.2-4.4	3.2-6.0	3.4-4.2
Hardness (ppm)	50-84	64-80	54-172	70-132
Total dissolved shilds (ppm)	-	48.3-106.5	56.2-145.7	54.6-103.2
Specific conductivity (uhmos/cm)	131.0-198.4	96.4-195.8	113.8-266.8	109.3-198.6

Table 8 : Depth-wise physico-chemical characteristics of water in Pong reservoir.

May, 1992						July, 1992					
Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)	Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)
Sur.	27.5	7.9	9.4	94	193.2	Sur.	29.5	7.9	8.4	66	156.3
2	27	7.8	9.4	94	192.3	2	29.5	7.8	8.4	66	156.1
4	27	7.8	9.2	88	191.6	4	29.5	7.8	8.4	66	155.9
6	26	7.8	9.2	88	190.3	6	29	7.8	8.4	66	155.2
8	25	7.7	9.0	88	189.2	8	29	7.8	8.4	66	154.7
9	24	7.7	8.8	84	187.1	10	29	7.8	8.4	66	154.1
10	24	7.6	8.8	84	187.1	11	27	7.5	8.2	68	150.8
11	23.5	7.6	8.8	84	185.3	12	27	7.4	8.0	68	148.2
12	23.5	7.6	8.8	84	185.3	14	26	7.4	8.0	68	147.9
14	23	7.6	8.6	82	185.6	16	25	7.4	8.0	68	147.3
16	22	7.5	8.6	78	179.8	18	25	7.4	8.0	70	146.9
18	22	7.5	8.4	78	177.9	20	24	7.3	7.8	70	146.8
20	21	7.4	8.2	78	173.7	22	24	7.3	7.8	70	146.1
22	20.5	7.4	8.2	72	170.5	24	24	7.3	7.8	70	145.7
24	20	7.4	8.0	72	168.3	26	24	7.3	7.8	72	145.3
26	19	7.4	7.8	66	164.4	27	23	7.2	7.6	72	144.9
28	19	7.4	7.8	66	162.2	28	23	7.3	7.6	72	144.2
30	18	7.4	7.6	66	158.4	29	22	7.0	7.4	72	144.0
						30	22	6.9	7.2	72	143.8

August, 1992						September, 1992					
Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)	Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)
Sur.	29	7.5	8.0	64	149.0	Sur.	30.8	7.7	9.2	66	114.6
2	29	7.5	8.0	64	148.8	2	30.6	7.6	9.0	66	115.9
4	29	7.5	8.0	64	148.2	4	29.6	7.6	9.0	68	117.2
6	28.5	7.5	8.0	64	147.8	5	29.4	7.6	8.8	68	118.6
8	28.5	7.4	8.0	66	147.4	6	28.4	7.6	8.8	68	118.8
10	28	7.4	7.8	66	145.6	8	27.4	7.6	8.4	68	119.0
12	28	7.4	7.8	66	144.9	9	26.2	7.6	8.0	68	119.2
13	27	7.4	7.8	66	144.7	10	26.0	7.6	7.6	68	119.5
14	27	7.4	7.8	66	144.4	12	25.5	7.6	7.6	68	119.8
16	27	7.4	7.8	68	141.9	14	25.5	7.6	7.6	68	119.9
18	26.5	7.4	7.8	68	140.8	16	25.3	7.6	7.2	70	120.0
20	26	7.4	7.6	68	140.3	18	25.2	7.6	7.2	70	120.1
22	26	7.4	7.6	70	139.7	20	25	7.5	7.2	70	120.5
24	26	7.4	7.6	72	137.4	22	24.9	7.5	7.0	70	120.7
26	26	7.3	7.6	72	136.5	24	24.8	7.5	7.0	70	133.1
27	25	7.3	7.6	72	135.6	26	24.5	7.5	6.8	72	135.4
28	25	7.3	7.6	74	133.9	28	24.4	7.5	6.8	72	137.3
30	24.5	7.3	7.6	74	133.3	30	24.4	7.5	6.8	72	138.2

June, 1993						July, 1993					
Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)	Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)
sur	30.5	7.9	6.0	70	183.2	Sur.	25	7.3	7.6	64	134.2
2	30.5	7.9	6.0	70	185.6	2	25	7.3	7.6	64	134.8
4	30	7.9	6.0	70	186.3	4	25	7.3	7.6	64	135.3
6	29.5	7.9	5.6	72	187.1	6	25	7.3	7.6	64	135.6
8	29	7.9	5.6	72	187.5	8	24.5	7.3	7.2	64	137.4
10	29	7.8	5.6	74	188.0	10	24	7.2	7.2	66	138.5
12	28.5	7.7	4.0	74	192.7	12	24	7.2	7.2	66	139.6
14	28	7.7	4.0	76	195.4	13	23	7.2	7.2	66	140.1
15	27	7.6	2.4	78	196.3	14	23	7.2	7.2	66	140.7
16	25.5	7.5	2.4	80	197.0	16	22.5	7.1	7.2	68	142.2
17	25.5	7.5	2.4	80	197.6	18	22	7.1	7.2	68	142.9
18	24	7.4	2.0	80	198.2	20	22	7.0	6.8	68	143.4

19	23.5	7.3	2.0	80	198.3	22	21.5	7.0	6.8	70	144.3
20	22	7.2	1.6	80	198.5	24	21.5	7.0	6.8	70	145.2
21	20.5	7.1	1.6	82	198.5	26	21	6.9	6.8	70	146.6
22	20.5	7.1	1.6	82	198.7	28	21	6.9	6.8	70	147.1
24	19.5	7.0	1.6	82	198.8	30	21	6.9	6.8	70	147.7
26	19.0	7.0	1.6	82	199.0						
28	18.5	7.0	1.6	82	199.2						
30	18.0	7.0	1.6	82	199.4						

August, 1993						September, 1995					
Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)	Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)
Sur.	30.0	8.0	8.0	52	120.2	Sur.	31	7.8	8.0	56	127.3
2	30	8	8	52	120.6	1	30	7.8	8.0	56	129.5
4	30	8	8	54	122.8	2	30	7.8	8.0	56	132.2
6	30	8	7.6	54	123.4	4	30	7.7	8.0	58	134.7
7	30	8	7.6	54	124.0	6	30	7.7	8.0	58	139.9
8	29	7.9	7.6	56	124.3	8	29.4	7.7	7.6	60	143.3
9	28	7.9	7.6	58	126.7	10	28.5	7.7	7.6	60	149.6
10	27	7.9	7.2	60	127.9	11	28	7.7	7.2	62	154.1
11	27	7.9	6.8	62	129.8	12	27	7.6	6.8	64	154.7
12	26	7.9	6.8	64	130.1	14	26.5	7.6	6.8	64	155.3
13	26	7.9	6.4	64	132.7	16	26	7.5	6.8	66	155.5
15	25	7.8	6.4	66	134.0	18	26	7.5	6.8	66	155.9
16	25	7.8	6.0	66	134.3	20	26	7.5	6.8	66	156.2
18	25	7.7	6.0	68	134.7	22	25.5	7.5	6.4	66	156.7
20	25	7.6	6.0	70	135.1	24	25	7.5	6.4	68	157.4
22	25	7.6	6.0	70	137.3	26	24.5	7.4	6.0	68	157.6
24	25	7.5	5.6	70	138.2	28	24	7.4	5.6	68	158.0
26	24	7.5	5.6	70	140.6	30	24	7.4	5.2	68	158.3
28	24	7.4	5.6	72	143.5						
30	24	7.4	5.6	72	146.4						

June, 1994					
Depth (m)	Water temp. (°C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Sp. Conductivity (uhmos/cm)
Sur.	28.0	7.8	8.0	68	169.3
2	28.0	7.8	8.0	68	169.5
4	28.0	7.8	8.0	70	169.8
6	28.0	7.8	8.0	70	170.2
8	27.5	7.7	7.6	70	170.6
10	27.5	7.7	7.6	70	171.4
11	27	7.7	7.6	70	171.8
12	26	7.7	7.6	72	172.2
14	25.5	7.6	7.6	72	172.5
16	25.5	7.5	7.6	72	173.1
17	25	7.5	7.6	72	173.6
18	24	7.5	7.2	74	174.2
19	24	7.5	7.2	74	174.2
20	23.5	7.4	7.2	74	174.4
22	23.5	7.4	7.2	74	174.6
24	23	7.4	7.2	76	175.3
26	23	7.4	7.2	76	175.5
28	22	7.4	6.8	78	175.7
30	22	7.4	6.8	80	175.9

Table 9 : Diurnal variation observed at Lentic zone w.e.f. September 1992 of Pong reservoir.

Date	Time	Air tem. (°C)	Water temp. (°C)	D. O. (ppm)
09.09.92	6 AM	26	29	8.4
	12 AM	33	32	8.0
	6 PM	29	30.5	8.2
	12 PM	26	28	8.2
23.12.92	6 AM	15	16	8.2
	12 AM	25	18	9.6
	6 PM	17	18	8.4
	12 PM	15	16	7.8
10.03.93	6 AM	18	17	8.4
	12 AM	23	19	8.8
	6 PM	26	21	92
	12 PM	19	16	8.4
16.06.93	6 AM	27	29	6.8
	12 AM	33	31	7.2
	6 PM	32	28	7.6
	12 PM	29	29	7.2
08.09.93	6 AM	25	29	8.0
	12 AM	35	32	8.8
	6 PM	29	30.5	8.8
	12 PM	26	29.5	8.4
02.12.93	6 AM	16	20	6.4
	12 AM	23.5	21	7.6
	6 PM	21	20	8.0
	12 PM	19	18	7.2
09.03.94	6 AM	12	18	8.8
	12 AM	25	20	9.2
	6 PM	22	19	9.2
	12 PM	15	16	8.4
24.06.94	6 AM	28	26	6.8
	12 AM	32	30	7.6
	6 PM	36	31	7.2
	12 PM	32	26	6.8
17.09.94	6 AM	28	29	7.2
	12 AM	33	32	7.2
	6 PM	32	31	7.6
	12 PM	29	30	7.2
12.12.94	6 AM	17	18	8.0
	12 AM	22	21	9.2
	6 PM	20	20	8.8
	12 PM	18	19	8.4

Table 10 : Ranges of organic carbon production

Year of observation	Organic carbon production (mgC/M²/day)		Respiration (mgC/M²/day)
	Gross production	Net production	
1991-92	124.9-666.6	208.4-656.2	187.4-112.5
1992-93	359.4-687.4	140.6-531.1	149.9-412.4
1993-94	374.9-624.9	124.9-500.0	150.0-999.0
1994-95	291.6-666.6	166.6-333.2	150.0-399.6

Table 11 : Sector-wise monthly variation of plankton biomass (ml/m³).

Months	1990-91				1991-92				1992-93			
	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.
April	-	-	-	-	-R-	1.41	0.39	0.90	-R-	2.48	0.97	1.76
May	-	-	-	-	-R-	0.71	0.46	0.58	-R-	1.53	1.15	1.34
June	-	-	-	-	-R-	1.59	0.42	1.00	-R-	4.12	1.63	2.88
July	-	-	-	-	-R-	-	0.46	0.46	-R-	1.53	0.91	1.22
August	3.67	7.64	4.29	5.20	-R-	6.00	1.33	3.66	-R-	1.04	0.33	0.68
September	4.80	13.81	9.52	9.38	0.34	2.24	1.88	1.49	0.38	2.30	0.99	1.22
October	3.56	4.17	4.77	4.17	6.80	6.93	6.47	6.73	1.88	1.55	0.27	1.23
November	6.42	4.36	3.30	4.69	2.39	2.36	0.46	1.74	0.41	2.59	0.46	1.15
December	3.69	3.39	0.69	2.59	0.05	0.84	0.97	0.62	0.06	1.53	0.88	0.82
January	0.47	0.42	0.83	0.57	0.18	1.81	0.73	0.91	-R-	0.59	1.89	1.24
February	-R-	0.71	3.02	1.87	0.12	0.79	0.49	0.47	-R-	0.47	1.58	1.02
March	-R-	0.59	1.32	0.95	0.18	1.08	1.43	0.90	-R-	0.63	0.69	0.66
Average	**3.77**	**4.39**	**3.47**	**3.68**	**1.44**	**2.34**	**1.29**	**1.62**	**0.68**	**1.70**	**0.98**	**1.27**

Months	1993-94				1994-95			
Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.	
April	R	1.49	0.60	1.05	R	0.71	0.63	0.67
May	R	0.65	1.15	0.90	R	0.74	0.85	0.80
June	R	0.70	0.61	0.65	R	1.23	0.63	0.93
July	R	0.76	0.66	0.71	R	-	-	-
August	R	2.00	2.20	2.10	0.27	0.38	1.06	0.53
September	R	1.37	1.48	1.42	0.34	0.75	0.43	0.51
October	0.24	3.85	3.80	2.63	0.52	0.47	0.85	0.61
November	R	1.49	2.28	1.89	0.52	0.94	1.52	0.99
December	R	2.21	1.75	1.98	0.38	1.49	1.41	1.09
January	R	0.83	1.73	1.28	-	1.41	5.92	3.67
February	R	0.79	1.24	1.01	-	1.25	1.20	1.22
March	R	1.25	0.64	0.94	-	0.49	0.70	0.60
Average	**0.24**	**1.45**	**1.51**	**1.38**	**0.41**	**0.90**	**1.38**	**1.06**

Table 12 : Sector-wise monthly variation of plankton (u/l).

Months	1990-91				1991-92				1992-93			
	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.
April	-	-	-	-	-R-	7421	883	4152	R	1532	749	1141
May	-	-	-	-	-R-	1273	975	1124	R	1260	980	1120
June	-	-	-	-	-R-	3922	927	2424	R	1916	1038	1977
July	-	-	-	-	-R-	-	10462	10462	R	2107	867	1487
August	66635	1700	10705	26347	-R-	5536	1649	3592	R	2025	867	1446
September	871	2643	1811	1775	426	9224	2601	4084	248	35553	20181	18661
October	2774	2082	1626	2161	68218	60409	124493	84373	17109	33500	2560	17723
November	2755	5346	8192	5431	53797	20151	1683	25210	2814	38954	2931	14900
December	3250	6673	689	3537	236	1696	1337	1090	212	7342	6216	4590
January	421	1286	2263	1323	428	12366	5128	6040	R	9151	13960	11556
February	R	5958	3751	4855	212	4570	1022	1933	R	696	2703	1700
March	R	2216	2440	2328	496	1632	1030	1053	R	582	1033	808
Average	**12785 (165)**	**3488 (182)**	**3935 (93)**	**5970 (144)**	**17688 (158)**	**11655 (273)**	**12683 (238)**	**12128 (220)**	**5096 (80)**	**11302 (310)**	**4507 (165)**	**6426 (224)**

Months	1993-94				1994-95			
	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.
April	R	587	751	669	R	1107	713	910
May	R	711	938	824	R	908	690	799
June	R	1399	8181	4790	R	1797	4237	3017
July	R	1272	1199	1234	R	-	-	-
August	R	9638	1969	5803	1048	1728	2907	1895
September	R	21417	2368	11684	1080	3572	1316	1989
October	1865	7874	11578	7106	1058	7197	23073	10443
November	R	5900	19671	12786	2096	5406	24350	10617
December	R	3393	4416	3905	529	2611	4916	2685
January	R	2600	18399	10500	R	2721	11677	7199
February	R	4909	6283	5596	R	5652	6178	5915
March	R	4465	1194	2829	R	1420	5893	3656
Average	**1865 (53)**	**5343 (249)**	**6412 (126)**	**5644 (184)**	**1162 (85)**	**3102 (140)**	**7814 (116)**	**4466 (124)**

Table : 13: Diurnal variation in plankton in Lentic zone.

Date	Time (hrs)	D. O. (ppm)	Water temp. (°C)	Phytop-lankton (u/l)	Zooplan-kton	Total Plankton (u/l)
Sept, 92	6	8.4	29	5150	50	5200
	12	8.0	32	21358	37	2175
	18	8.2	30.5	5763	37	5800
	24	8.2	28	1625	50	1675
Dec, 92	6	8.2	16	3850	25	3875
	12	9.6	18	1938	12	1950
	18	8.4	18	4000	-	4000
	24	7.8	16	2425	-	2425
March, 93	6	8.4	17	550	75	625
	12	8.8	19	650	25	675
	18	9.2	21	1000	25	1025
	24	8.4	16	225	75	300
June, 93	6	6.8	28	250	100	350
	12	7.2	31	1200	25	1225
	18	7.6	28	250	150	400
	24	7.2	29	775	75	850
Sept, 93	6	8.0	29	1750	100	1850
	12	8.8	32	2000	-	2000
	18	8.8	30.5	850	-	850
	24	8.4	29.5	2925	100	3025
Dec, 93	6	6.4	20	925	50	975
	12	7.6	21	425	25	450
	18	8.0	20	650	-	650
	24	7.2	18	1025	25	1050
March, 94	6	8.8	18	350	125	475
	12	9.2	20	250	-	250
	18	9.2	19	475	50	525
	24	8.4	16	325	50	375
June, 94	6	6.8	26	550	150	700
	12	7.6	30	1175	75	1250
	18	7.2	31	450	100	550
	24	6.8	26	850	50	900
Sept, 94	6	7.2	29	1800	100	1900
	12	7.2	32	1150	-	1150
	18	7.6	31	3100	-	3100
	24	7.2	30	850	100	950
Dec, 93	6	8.0	19	1425	50	1475
	12	9.2	21	1125	50	1175
	18	8.8	20	2075	50	2125
	24	8.4	19	850	50	900

Table 14 : Sector-wise monthly variation in numerical abundance of macrobenthos (No/m²).

Months	1990-91				1991-92				1992-93			
	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.
April	-	-	-	-	-R-	586	408	497	R	475	275	375
May	-	-	-	-	-R-	500	405	453	R	300	286	293
June	-	-	-	-	-R-	600	367	483	R	465	500	482
July	-	-	-	-	-R-	-	294	294	R	550	250	400
August	20	340	90	150	538	454	496	R	300	419	360	
September	180	133	100	138	125	100	-	112	250	263	538	350
October	100	367	293	254	686	275	367	443	188	279	363	277
November	350	308	178	279	1257	675	370	767	325	540	513	459
December	170	190	388	249	1500	636	450	862	950	350	572	624
January	183	283	321	262	1075	550	400	675	R	1350	600	975
February	R	550	413	482	138	1080	394	537	R	1200	450	825
March	R	650	295	472	350	688	572	537	R	1017	395	706
Average	**167**	**353**	**260**	**286**	**733**	**566**	**407**	**513**	**428**	**591**	**430**	**511**

Months	1993-94				1994-95			
	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.
April	R	800	900	850	R	388	450	419
May	R	1838	920	1379	R	500	483	492
June	R	1100	500	800	R	353	610	472
July	R	Nil	150	75	R	-	-	-
August	R	267	510	389	138	600	-	369
September	R	338	567	453	438	1636	-	1037
October	450	688	363	500	625	600	607	611
November	R	717	588	653	875	667	675	739
December	R	600	50	325	1000	860	806	889
January	R	700	267	484	R	890	039	915
February	R	483	310	397	R	433	438	436
March	R	375	Nil	188	R	383	450	417
Average	**450**	**659**	**427**	**541**	**575**	**665**	**606**	**618**

Table 15 : Sector-wise monthly variation in gravimetric abundance of macrobenthos (g/m²).

Months	1990-91				1991-92				1992-93			
	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.
April	-	-	-	-	R	0.63	0.95	0.78	R	7.38	0.75	4.07
May	-	-	-	-	R	0.94	2.47	1.70	R	77.06	2.39	39.73
June	-	-	-	-	R	3.64	3.07	3.35	R	7.35	4.85	6.40
July	-	-	-	-	R	-	11.19	11.19	R	9.06	2.53	5.30
August	neg.	0.43	0.10	0.18	R	1.43	4.80	3.11	R	1.10	0.69	0.90
September	0.11	0.25	0.73	0.36	0.13	0.10	-	0.11	0.32	3.39	1.83	1.85
October	0.03	0.26	23.53	7.94	0.73	2.78	0.51	1.34	038	2.02	0.72	1.04
November	0.10	0.27	4.26	1.59	1.02	19.98	8.94	9.98	0.29	1.25	3.69	1.74
December	0.01	0.10	3.05	1.07	4.54	3.26	1.75	3.18	1.88	1.14	10.35	4.46
January	0.17	0.28	23.43	7.96	1.13	0.70	0.76	0.86	R	9.29	29.05	19.17
February	R	0.69	18.65	9.67	0.19	1.03	7.13	2.78	R	5.00	195.59	100.30
March	R	0.75	0.33	0.54	14.75	2.63	1.17	6.18	R	98.08	24.41	61.25
Average	**0.11**	**0.38**	**9.26**	**3.66**	**3.21**	**3.57**	**3.88**	**3.71**	**0.72**	**18.51**	**23.07**	**20.49**

Months	1993-94				1994-95			
	Lotic	Inter.	Lentic	Res.	Lotic	Inter.	Lentic	Res.
April	R	21.62	52.22	36.92	R	19.38	1.40	10.39
May	R	12.09	36.11	24.10	R	23.75	3.96	13.86
June	R	37.15	36.65	36.90	R	3.78	8.35	5.72
July	R	Nil	0.67	0.33	R	-	-	-
August	R	0.81	1.43	1.12	0.38	1.56	-	0.97
September	R	0.94	3.54	2.24	1.00	10.86	-	5.93
October	0.50	0.94	80.4	3.16	2.31	4.69	5.53	4.18
November	R	2.25	3.81	3.03	7.31	7.42	5.32	6.68
December	R	1.13	neg	0.57	5.56	5.60	5.44	5.53
January	R	2.28	0.75	1.52	R	4.50	5.28	4.89
February	R	1.55	3.33	2.44	R	3.00	3.38	3.19
March	R	0.74	Nil	0.38	R	12.58	18.13	15.35
Average	**0.50**	**6.79**	**12.21**	**9.39**	**3.31**	**8.83**	**6.31**	**6.97**

Table 16 : Bathymetric distribution of macrobenthos (No/m²).

Depth (m)	1990-91			1991-92			1992-93			1993-94			1994-95		
	Lotic	Int.	lentic	Lotic	Int.	lentic	Lotic	Int.	lentic	Lotic	Int.	lentic	Lotic	Int.	lentic
2	50	300	300	436	481	225	212	345	258		607	121	290	320	142
4	117	550	200	700	525	300	412	495	263		566	200	640	538	233
6	133	430	280	808	561	306	537	782	280		680	281	913	644	530
8	75	450	238	792	695	281	550	595	364		944	512	775	1217	470
10	225	100	220	1400	520	330		375	283		950	507	713	1470	825
12	-	-	-	1150	540	350		350	267			-		-	713
14	-	-	-	735	600	408		517	367			980		1773	415
16	225	400	350		450	336			242			550		650	1040
18	-	-	-		-	700			700			1400		-	850
20	100	350	350		800	490			473			600		650	800
22	-	-	-			421			520			625			1175
24	-	-	-			525			670			633			788
26			475			658			725			988			1067
28			-			417			400			325			800
30			400			472			386			880			700

Table 17 : Periphyton density (Nos/cm²) in Pong reservoir from 1990-91 to 1994-95.

Month	1990-91	1991-92	1992-93	1993-94	1994-95
April	-	1615	1357	1389	1389
May	-	1292	1389	1195	1229
June	-	1712	1389	1195	1260
July	-	1452	1292	1066	-
August	1114	1195	1663	1195	1098
September	1583	1938	1518	1485	1260
October	1519	2778	2261	1938	1744
November	1486	1970	1615	1841	1486
December	1421	1841	1712	1583	1357
January	1647	1647	1357	1518	4121
February	1615	1615	1389	1324	1195
March	1712	2035	1841	1583	1260
Average	**1512**	**1758**	**1524**	**1443**	**1336**

Table 18 : Periphyton abundance (%) in Pong reservoir during 1990-91 to 1994-95

Months	Bacillariophyceae					Chlorophyceae					Myxophceae				
	1990-91	1991-92	1992-93	1993-94	1994-95	1990-91	1991-92	1992-93	1993-94	1994-95	1990-91	1991-92	1992-93	1993-94	1994-95
April	95.9	86.0	90.47	90.69	86.05	-	12.00	4.76	9.30	13.95	-	2.00	4.76	-	-
May	-	85.0	90.70	83.78	86.84	-	12.5	4.65	15.53	10.53	-	2.5	4.65	2.70	2.63
June	-	90.56	90.69	89.19	89.73	-	9.43	9.30	10.94	10.26	-	-	-	-	-
July	-	91.11	90.0	87.88	-	-	6.66	7.5	9.09	-	-	2.22	2.5	1.03	-
August	95.3	91.89	91.65	91.89	88.24	4.7	8.10	8.33	8.11	11.76	-	-	-	-	-
September	83.02	88.33	86.96	80.43	84.61	16.98	8.33	10.87	10.87	10.26	-	3.33	2.17	8.70	5.13
October	89.76	89.53	87.14	86.67	87.04	10.64	5.81	7.14	8.33	7.41	-	4.65	5.72	5.00	5.55
November	89.13	91.80	87.99	89.47	91.30	10.87	6.55	10.00	8.77	6.53	-	1.64	2.00	1.76	2.17
December	88.60	87.72	92.45	89.80	90.48	11.40	10.53	5.66	8.16	7.14	-	1.75	1.89	2.04	2.38
January	90.08	90.19	85.71	85.10	88.63	9.92	7.84	11.90	10.63	6.82	-	1.96	2.38	4.26	4.54
February	83.83	92.0	88.37	90.24	83.78	10.04	7.0	4.65	4.88	5.41	6.13	4.0	6.97	4.88	10.81
March	84.90	90.62	84.21	81.63	87.18	11.32	6.25	14.03	16.33	10.26	3.77	3.12	1.75	2.04	2.56
Average	**88.03**	**89.56**	**88.86**	**87.23**	**87.63**	**10.73**	**8.17**	**8.23**	**9.90**	**9.12**	**1.24**	**2.27**	**2.91**	**2.87**	**3.25**

Table 19.1 : Fish production and yield scenario for Pong reservoir from 1976-77 to 1989-90.

Year	Catch (t)	Yield (Kg ha^{-1})
1976-77	98.0	6.5
1977-78	265.0	17.6
1978-79	537.0	35.8
1979-80	596.0	45.7
1980-81	569.0	37.9
1981-82	443.0	29.5
1982-83	498.0	33.2
1983-84	470.0	31.3
1984-85	479.0	31.9
1985-86	552.0	36.8
1986-87	519.0	34.6
1987-88	797.0	53.1
1988-89	475.0	31.6
1989-90	489.0	29.6
Average	**484.8**	**32.3**
Range	**98.0-797.0**	**6.5-53.1**

(Source; H.P. State Fisheries Deptt.)

Table 19.2 : Fish production and yield scenario for Pong reservoir from 1976-77 to 1989-90.

Year	Catch (t)	Yield (Kg ha^{-1})
1990-91	442.0	29.47
1991-92	485.0	32.33
1992-93	448.0	29.87
1993-94	373.0	24.87
1994-95	371.0	24.73
Average	**423.8**	**28.25**
Range	**371.0-485.0**	**24.73-32.33**
1995-96	330.0	22.0
1996-97	397.0	26.47
1997-98	415.0	27.66
1998-99	360.0	24.0
1999-2000	453.0	30.20
2000-01	428.0	28.53
2001-02	391.0	26.06
2002-03	379.0	25.27
2003-04	308.0	20.53
2004-05	429.0	28.60
Average	**389.0**	**25.93**
Range	**308.0-453.0**	**20.53-30.20**

(Source; H.P. State Fisheries Deptt.)

Table 19.3 : Fish landing (t) of Pong reservoir, Himachal Pradesh during 1990-91 to1994-95.

Species	1990-91		1991-92		1992-93		1993-94		1994-95	
	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
C.catla	7.0	1.56	12.0	2.48	15.0	3.35	19.0	5.09	34.0	9.16
L.rohita	138.0	31.22	150.0	30.93	95.0	21.21	84.0	22.52	57.0	15.36
C.mrigala	17.0	3.85	14.0	2.89	7.0	1.56	5.0	1.34	4.0	1.08
L.calbasu	42.0	9.50	49.0	10.10	39.0	8.70	18.0	4.83	9.0	2.43
C.carpio	5.0	1.12	4.0	0.82	2.0	0.45	3.0	0.81	3.0	0.81
T.putitora	65.0	14.70	60.0	12.37	71.0	15.85	50.0	13.40	62.0	16.71
L.dero	3.0	0.66	3.0	0.62	1.0	0.22	1.0	0.27	-	-
M.seen-ghala	121.0	27.36	164.0	33.81	199.0	44.42	180.0	48.26	193.0	52.02
W.attu	24.0	5.42	20.0	4.12	14.0	3.12	9.0	2.41	6.0	1.62
C.idella	-	-	-	-	-	-	-	-	-	-
Others	20.0	4.52	9.0	1.86	5.0	1.12	4.0	1.07	3.0	0.81
Total	**442.0**		**485.0**		**448.0**		**373.0**		**371.0**	

Table 19.4 : Fish landing (t) of Pong reservoir, Himachal Pradesh during 1995-96 to1999-2000.

Species	1995-96		1996-97		1997-98		1998-99		1999-2000	
	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
C.catla	22.0	6.67	22.0	5.54	22.0	5.30	22.0	6.11	22.0	4.76
L.rohita	36.0	10.91	41.0	10.33	49.0	11.81	41.0	10.39	65.0	13.25
C.mrigala	3.0	0.90	3.0	0.76	3..0	0.70	2.0	0.56	8.0	1.67
L.calbasu	12.0	3.64	9.0	2.27	5.0	1.20	6.0	1.67	3.0	0.66
C.carpio	3.0	0.90	14.0	3.53	17.0	4.10	11.0	3.06	13.0	2.77
T.putitora	59.0	17.88	64.0	16.12	81.0	18.52	74.0	19.56	90.0	18.87
L.dero	-	-	-	-	-	-	-	-	-	-
M.seen-ghala	185.0	56.06	236.0	59.45	241.0	57.07	208.0	56.78	257.0	56.70
W.attu	5.0	1.52	4.0	1.0	3.0	0.70	2.0	0.56	1.0	0.22
C.idella	-	-	-	-	-	-	3.0	0.80	3.0	0.66
Others	5.0	1.52	4.0	1.0	4.0	0.96	4.0	1.11	2.0	0.44
Total	**330.0**		**397.0**		**415.0**		**360.0**		**453.0**	

Table 19.5 : Fish landing (t) of Pong reservoir, Himachal Pradesh during 2000-01 to 2004-05.

Species	2000-01		2001-02		2002-03		2003-04		2004-05	
	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
C.catla	6.0	1.40	4.0	1.02	10.0	2.64	5.0	1.62	1.0	0.23
L.rohita	55.0	12.85	22.0	6.63	26.0	6.86	19.0	6.17	9.0	2.10
C.mrigala	11.0	2.57	7.0	1.79	9.0	2.37	5.0	1.62	21.0	4.91
L.calbasu	2.0	0.47	1.0	0.26	3.0	0.79	1.0	0.33	1.0	0.23
C.carpio	21.0	4.91	8.0	2.15	22.0	5.80	25.0	8.12	39.0	9.09
T.putitora	64.0	14.95	63.0	17.11	52.0	13.73	30.0	9.74	30.0	6.99
L.dero	-	-	-	-	-	-	-	-	-	-
M.seen-ghala	264.0	61.68	272.0	69.87	253.0	66.77	220.0	71.43	324.0	75.53
W.attu	1.0	0.23	1.0	0.26	1.0	0.26	-	-	-	-
C.idella	2.0	0.47	2.0	0.52	2.0	0.52	2.0	0.64	2.0	0.46
Others	2.0	0.47	1.0	0.26	1.0	0.26	1.0	0.33	2.0	0.46
Total	**428.0**		**391.0**		**379.0**		**308.0**		**429.0**	

Table 20.1 : Species-wise catch g/unit effort (50 m gill net) of important commercial fishes of Pong reservoir from 1990-91 to 1994-95.

Species	1990-91	1991-92	1992-93	1993-94	1994-95
T. putitora	104	98	110	80	99
C. carpio	7	6	3	4	5
W. attu	39	33	21	15	10
M. seengbala	195	267	303	286	315
L. calbasu	67	80	60	28	14
C. mrigala	27	23	11	8	6
Channa sp.	0.4	0.4	0.5	0.8	0.6
C. catla	11	20	22	31	55
L. rohita	221	246	147	134	92
Misc	37	20	10	6	5

Table 20.2 : Species-wise catch g/unit effort (50 m gill net) of important commercial fishes of Pong reservoir from 1995-96 to 1999-2000.

Species	1995-96	1996-97	1997-98	1998-99	1999-2000
T. putitora	92	88	100	90	102
C. carpio	3	19	21	13	15
W. attu	8	6	4	2	1
M. seengbala	288	325	297	252	292
L. calbasu	19	12	6	7	3
C. mrigala	5	4	4	2	9
C.idella	-	-	-	4	3
C. catla	34	30	27	27	25
L. rohita	56	56	60	50	74
Misc	8	6	5	5	2

Table 20.3 : Species-wise catch g/unit effort (50 m gill net) of important commercial fishes of Pong reservoir from 2000-01 to 2005-05.

Species	2000-01	2001-02	2002-03	2003-04	2004-05
T. putitora	28	64	51	29	28
C. carpio	23	8	22	25	36
W. attu	1	1	1	-	-
M. seengbala	285	275	248	216	297
L. calbasu	2	1	3	1	0.9
C. mrigala	12	7	9	5	19
C.idella	2	2	2	2	2
C. catla	6	4	9	5	0.9
L. rohita	59	22	26	19	8
Misc	2	1	1	1	2

Table 21 : Size range (mm) of various species of fish with reference to different mesh bar gill nets during the period April, 1993 to March, 1995.

Mesh bar	*C. catla*	*L. rohita*	*C. mrigala*	*L. calbasu*	*C. carpio*	*T. putitora*	*W. attu*	*M. seenghala*	*P. sarana*	*C. reba*
53	-	-	-	-	-	-	-	345-500	-	230-280
44	-	-	-	-	-	450-460	-	370-610	-	-
50	-	-	570	380-585	-	340-570	-	380-990	250-320	280-330
57	-	685-740	-	370-580	-	395-650	-	430-830	390	-
63	850-910	460-800	-	370-570	-	480-740	-	465-930	-	-
69	900	565-700	-	-	-	-	790	590-905	-	-
75	-	545-740	680	590-735	-	620-740	790	610-950	-	-
88	920-1000	655-730	-	-	830	830	960	750-870	-	-
100	-	-	-	-	-	-	-	-	-	-
200	820-995	-	-	-	-	-	-	-	-	-

Fig.1a Pong Reservoir of Himachal Pradesh

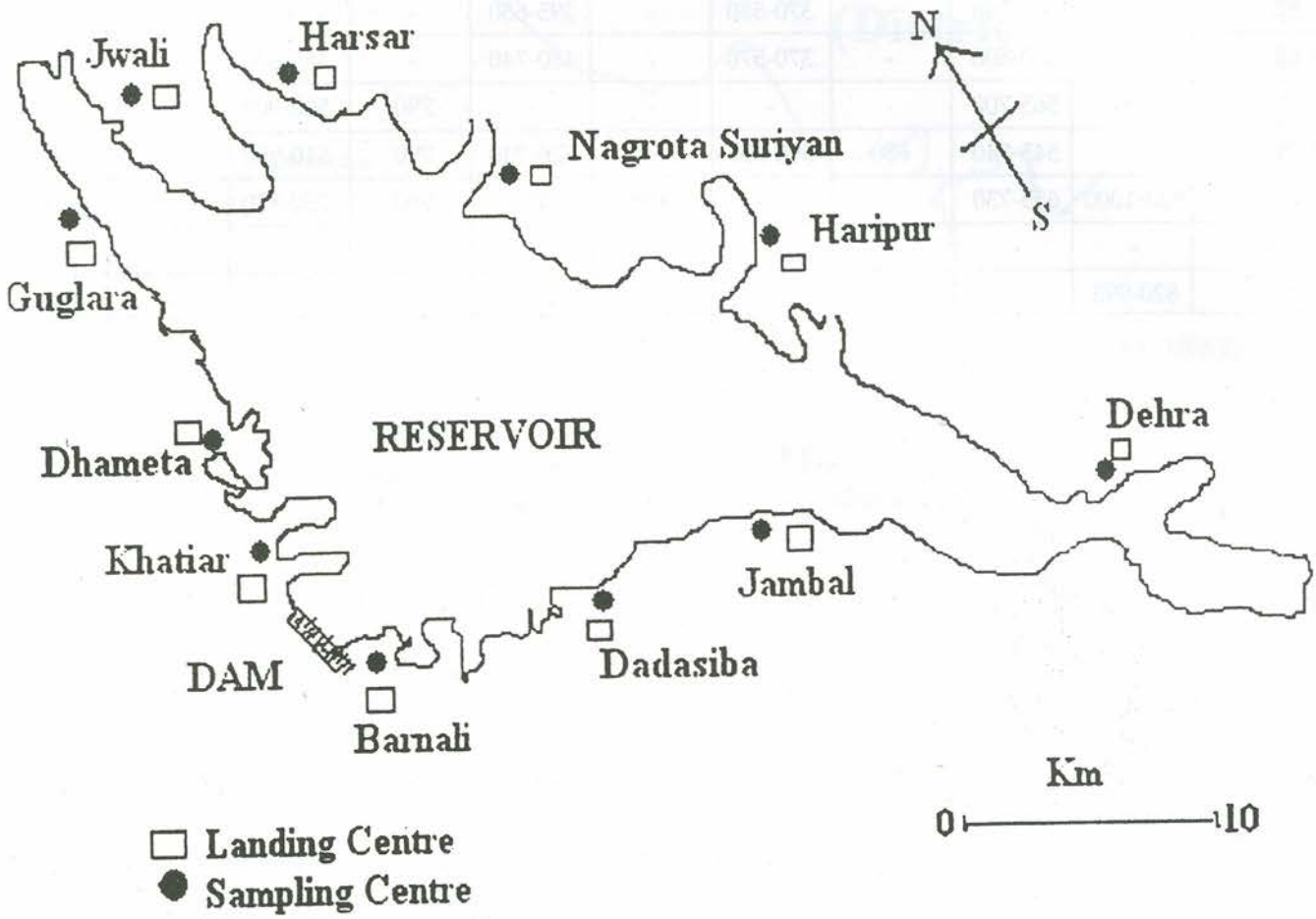
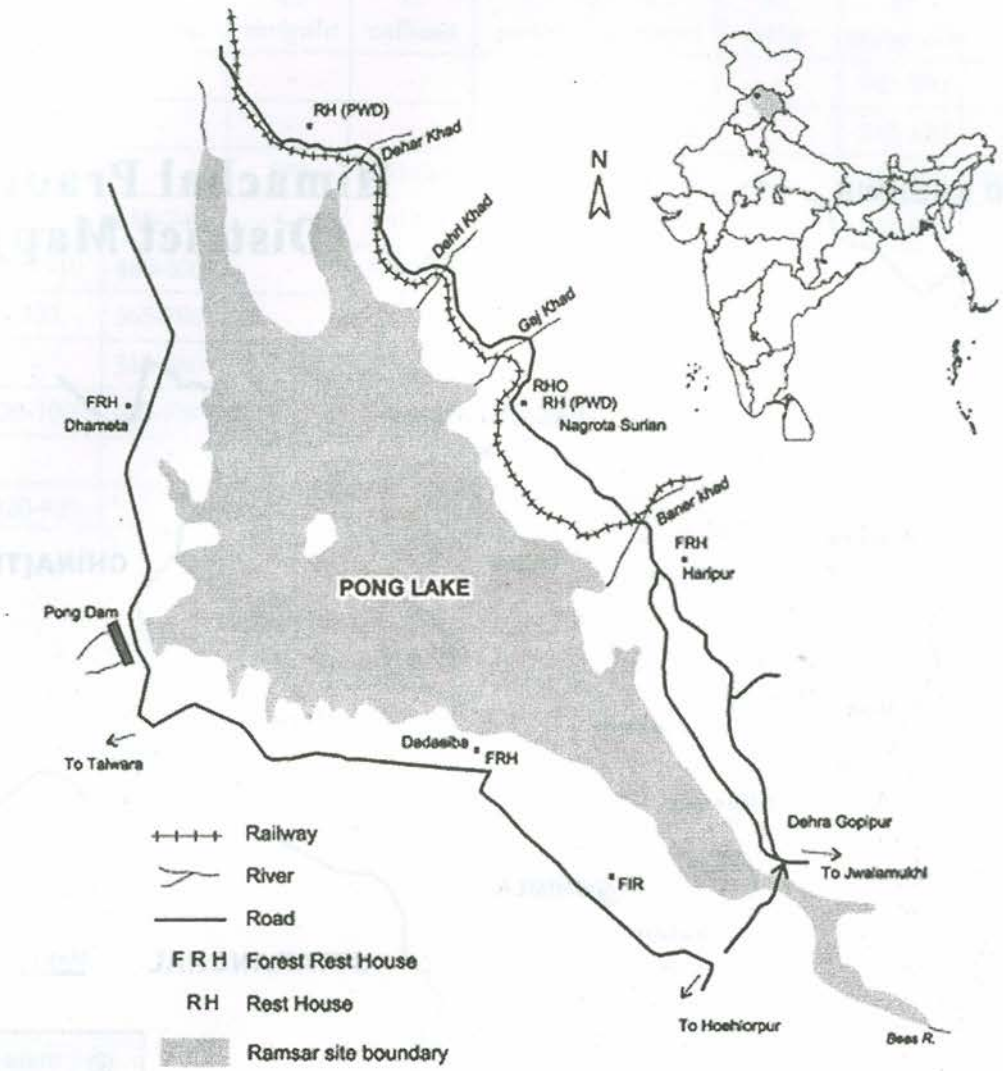


Fig.1 Pong Dam Lake - Himachal Pradesh



Coordinates - 31°52' - 32°10' N latitude and 75°57 - 76°14' E longitude
Area - 15622 ha
Elevation - 450 m above MSL


Himachal Pradesh
(District Map)
N
JAMMU AND KASHMIR
Chamba
Lahul and Spiti
Kangra
Kullu
CHINA(TIBET)
Una
Hamirpur
Mandi
Kinnaur
Bilaspur
PUNJAB
SHIMLA
Solan
UTTARANCHAL
Map not to Scale
Sirmaur
HARYANA
State Capital
District Boundary
State Boundary
International Boundary

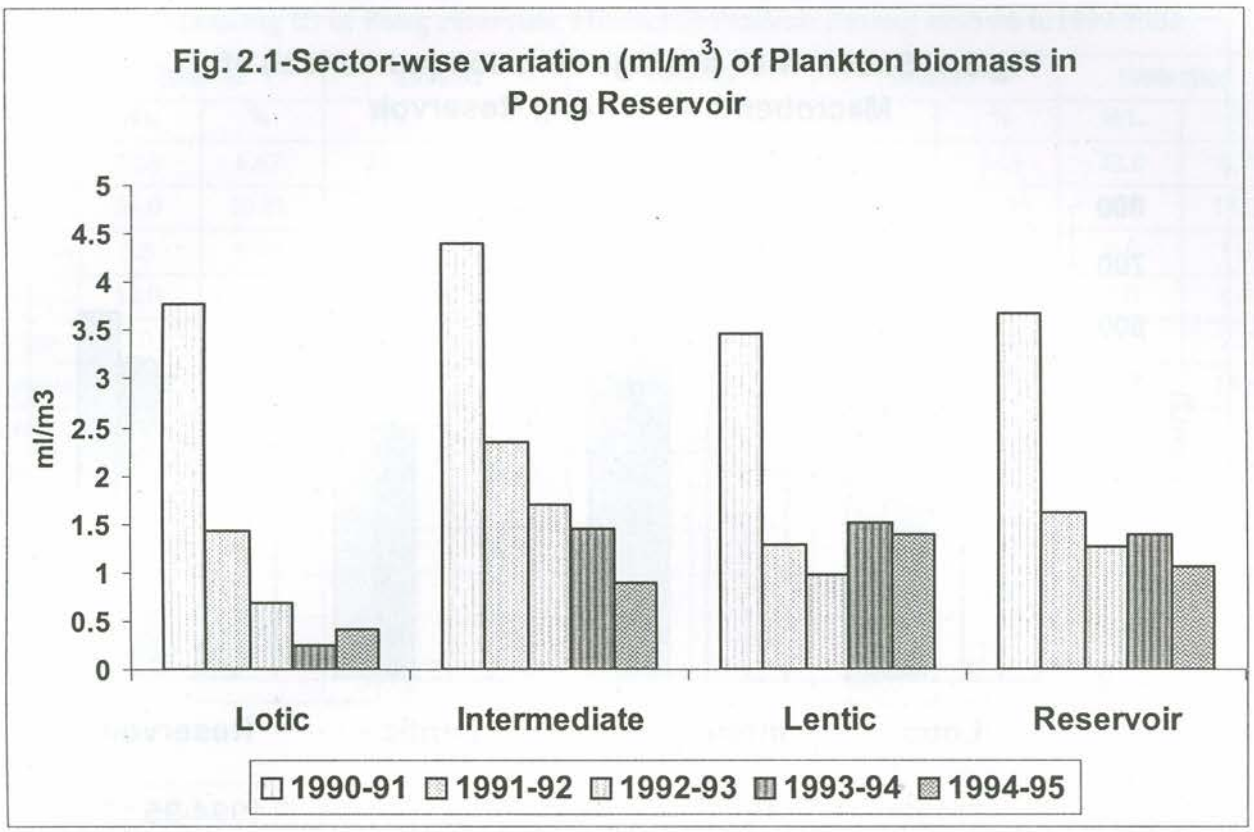


Fig. 2.1-Sector-wise variation (ml/m3) of Plankton biomass in Pong Reservoir
ml/m3
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Lotic
Intermediate
Lentic
Reservoir
1990-91
1991-92
1992-93
1993-94
1994-95

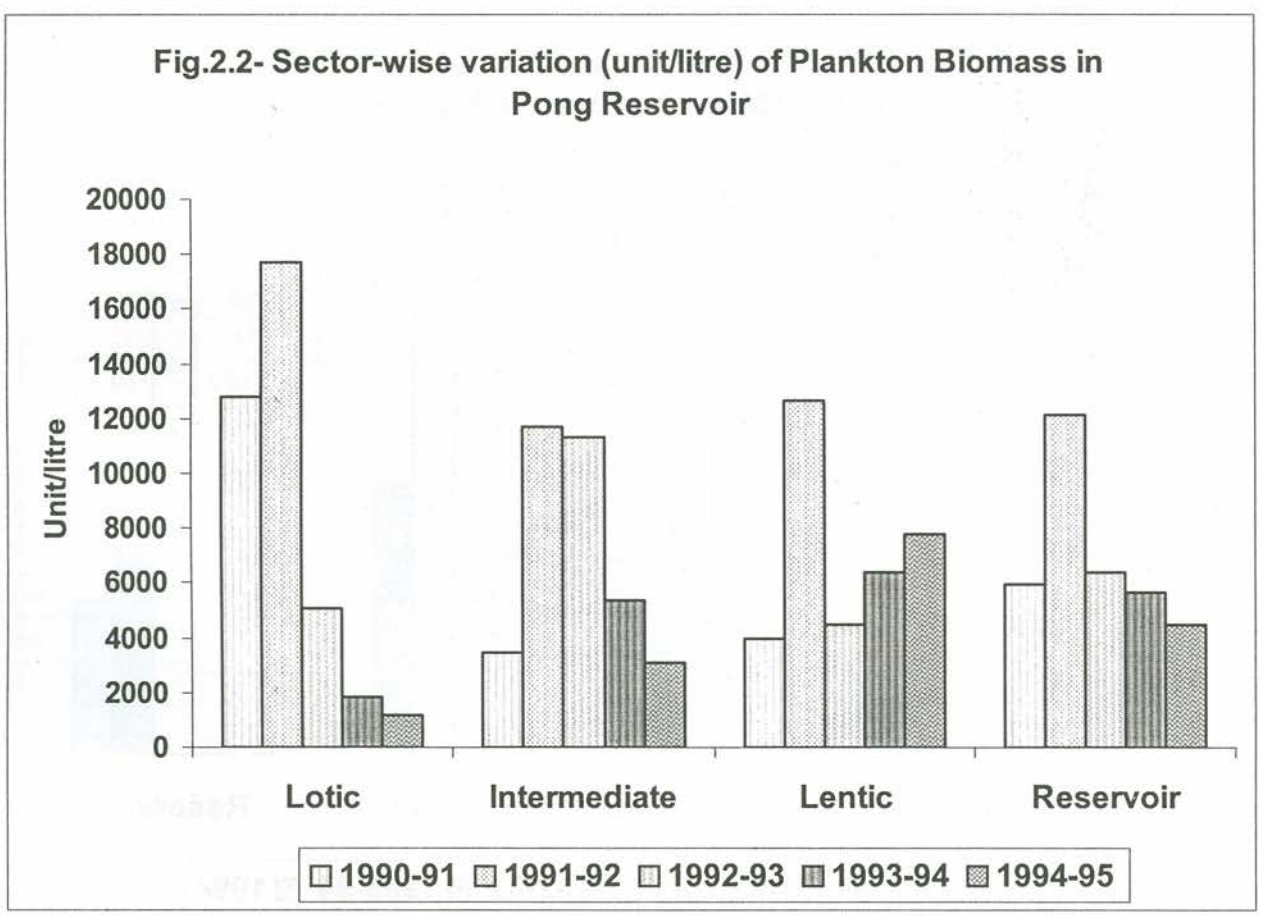


Fig.2.2- Sector-wise variation (unit/litre) of Plankton Biomass in Pong Reservoir
Unit/litre
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Lotic
Intermediate
Lentic
Reservoir
1990-91
1991-92
1992-93
1993-94
1994-95

Fig.3.1- Sector-wise average variation (numerical) of Macrobenthos in Pong Reservoir

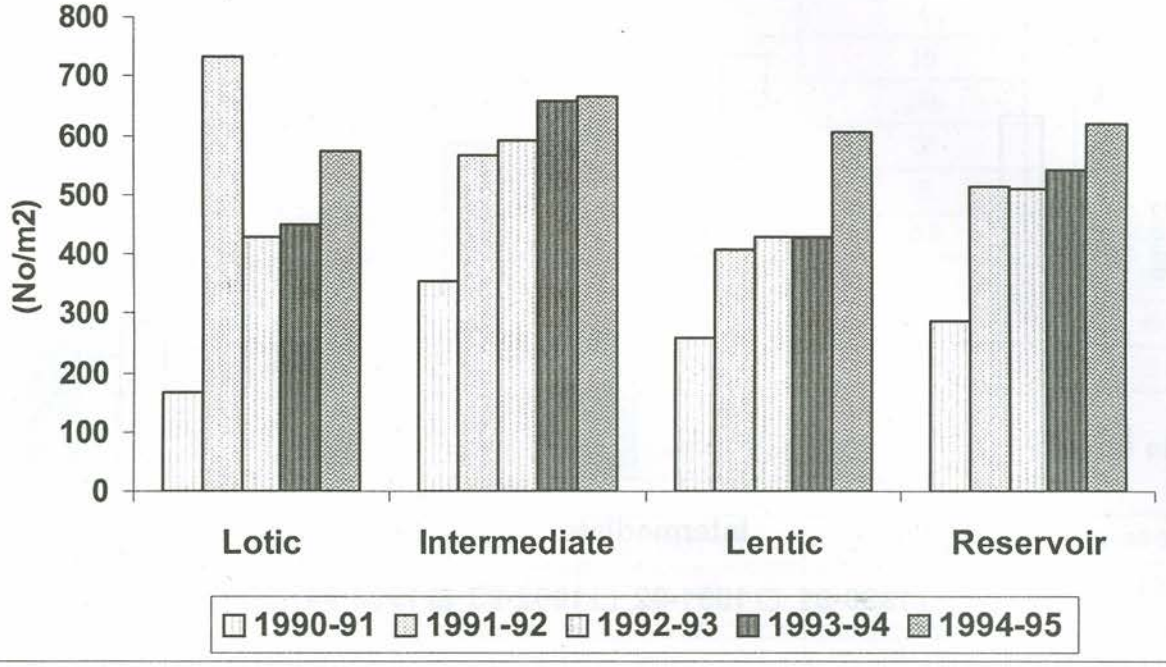
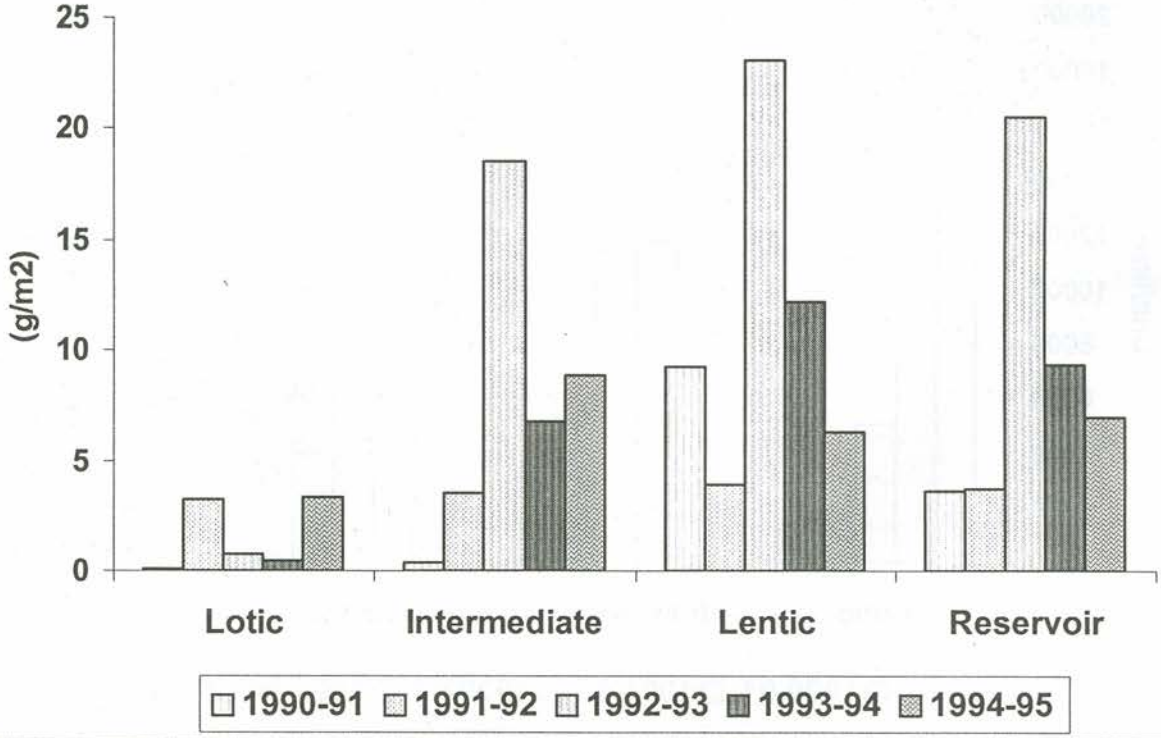


Fig.3.2- Sector-wise average variation (gravimetric abundance) of Macrobenthos in Pong Reservoir



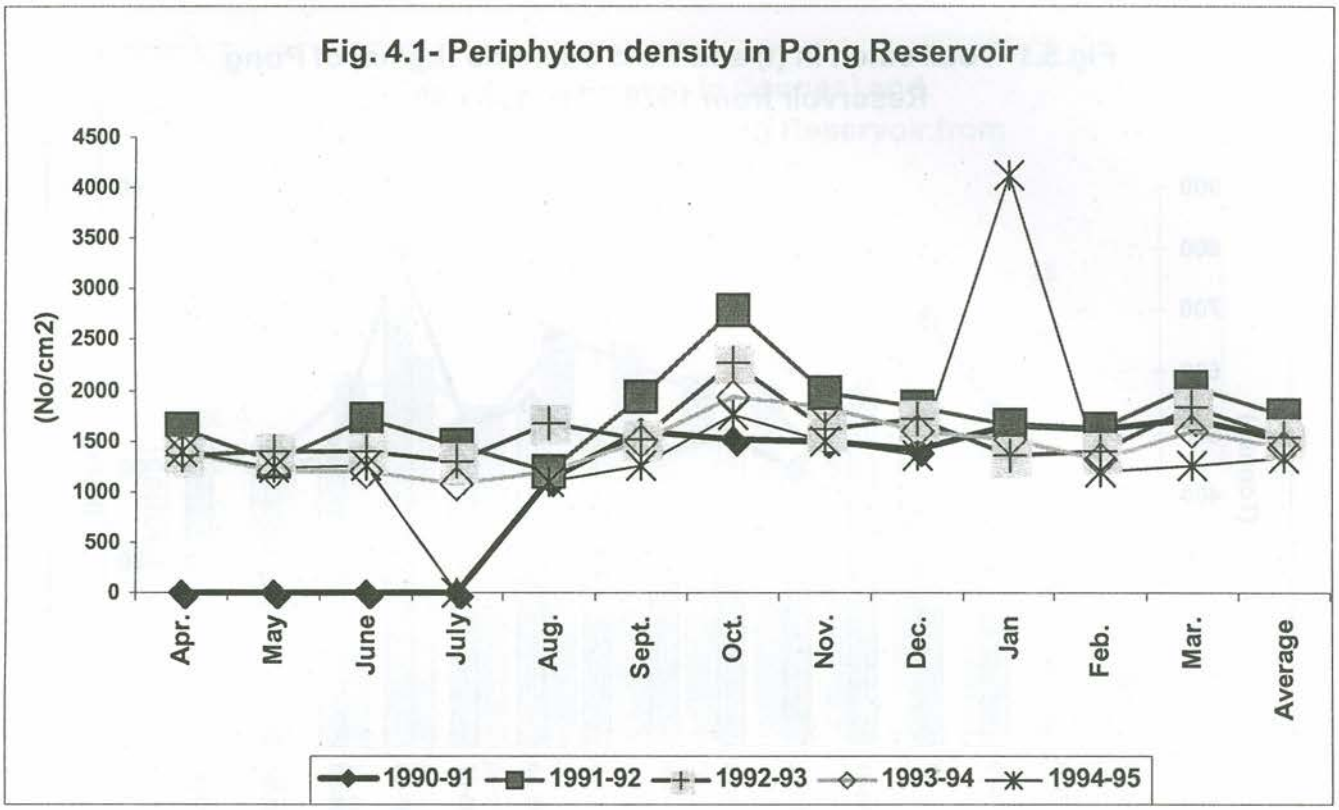


Fig. 4.1- Periphyton density in Pong Reservoir
4500
4000
3500
3000
2500
2000
1500
1000
500
0
(No/cm2)
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan
Feb.
Mar.
Average
1990-91
1991-92
1992-93
1993-94
1994-95

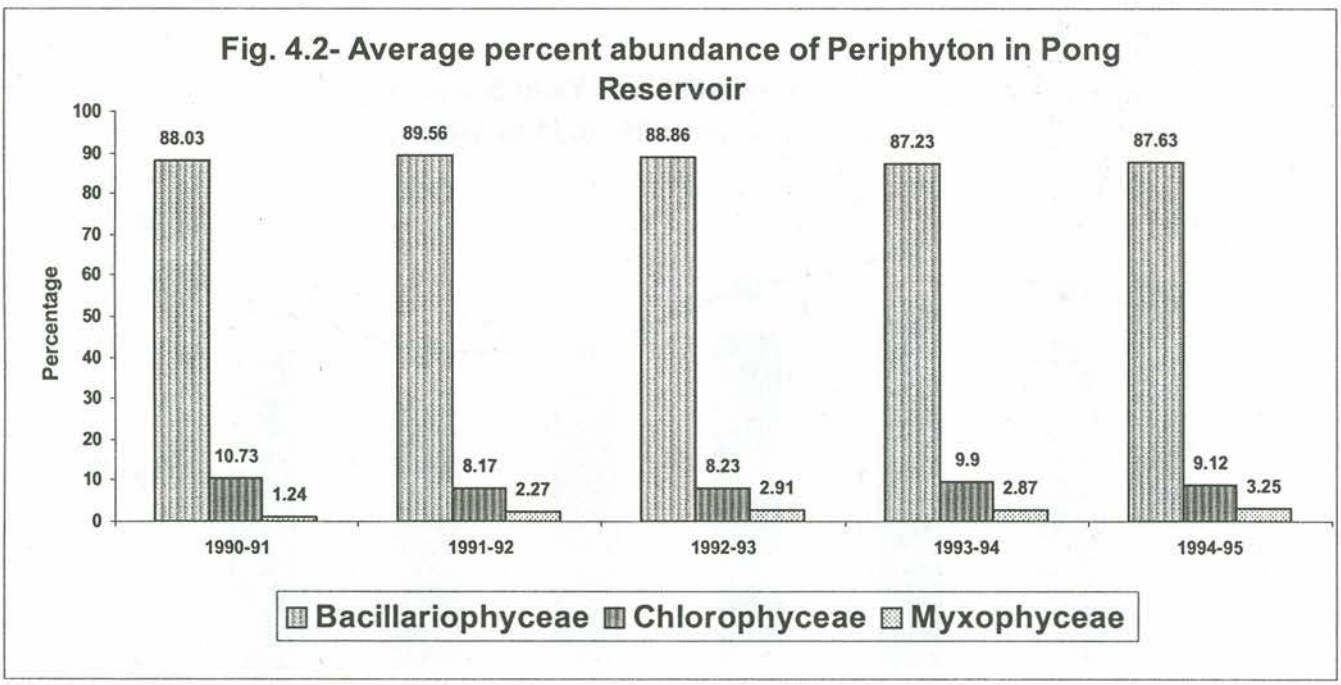


Fig. 4.2- Average percent abundance of Periphyton in Pong Reservoir
Percentage
100
90
80
70
60
50
40
30
20
10
0
88.03
10.73
1.24
89.56
8.17
2.27
88.86
8.23
2.91
87.23
9.9
2.87
87.63
9.12
3.25
1990-91
1991-92
1992-93
1993-94
1994-95
Bacillariophyceae
Chlorophyceae
Myxophyceae

Fig.5.1- Total catch in (t) and Yield Scenario (kg/ha) of Pong Reservoir from 1976-77 to 1989-90

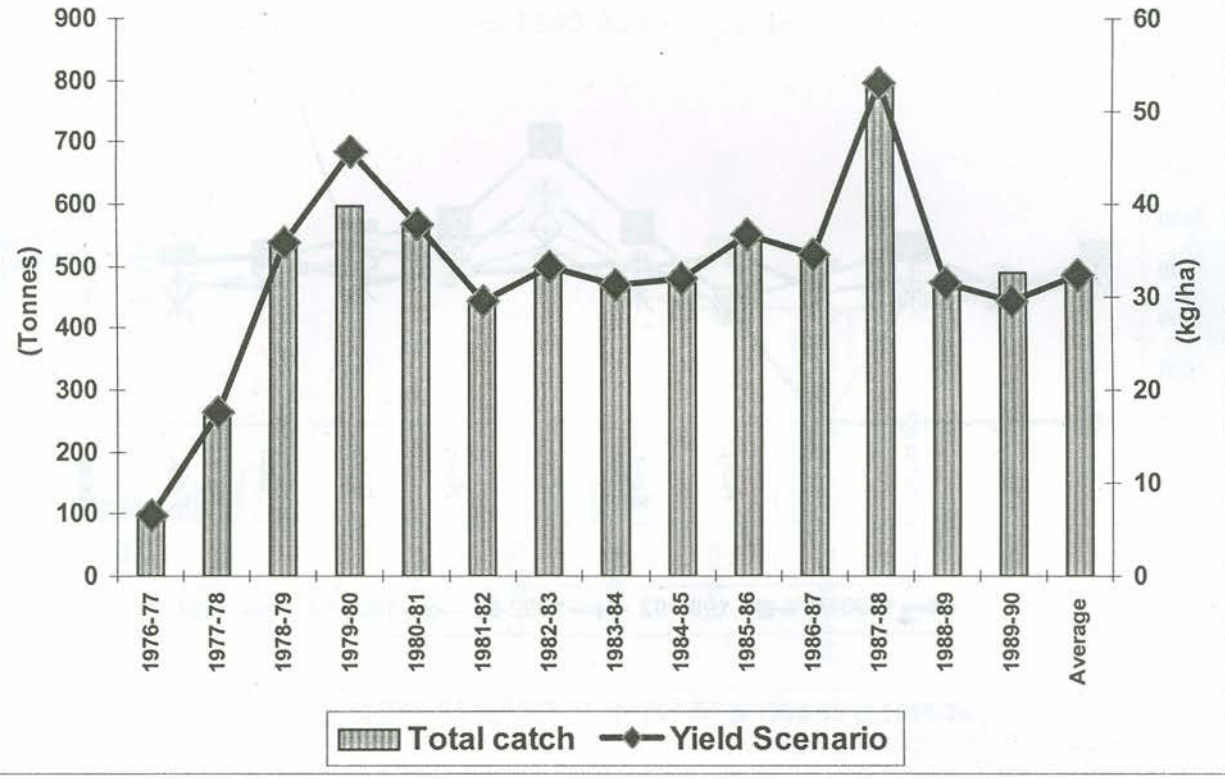
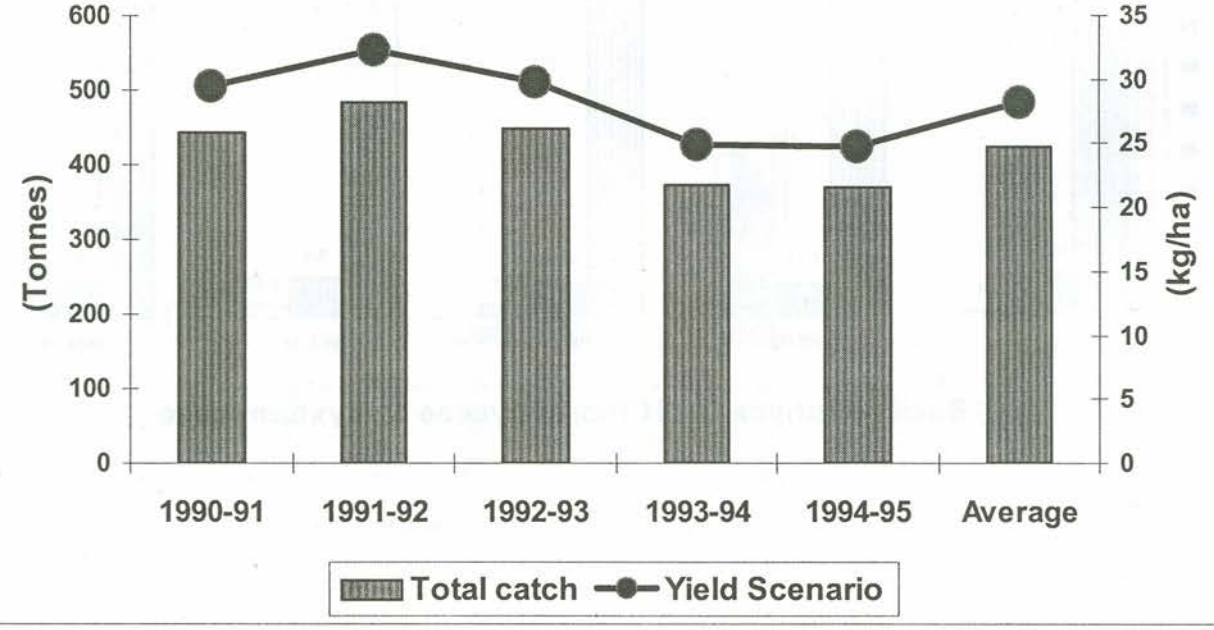


Fig.5.2- Total catch in (Tonnes) and Yield Scenario (kg/ha) of Pong Reservoir from 1990-91 to 1994-95



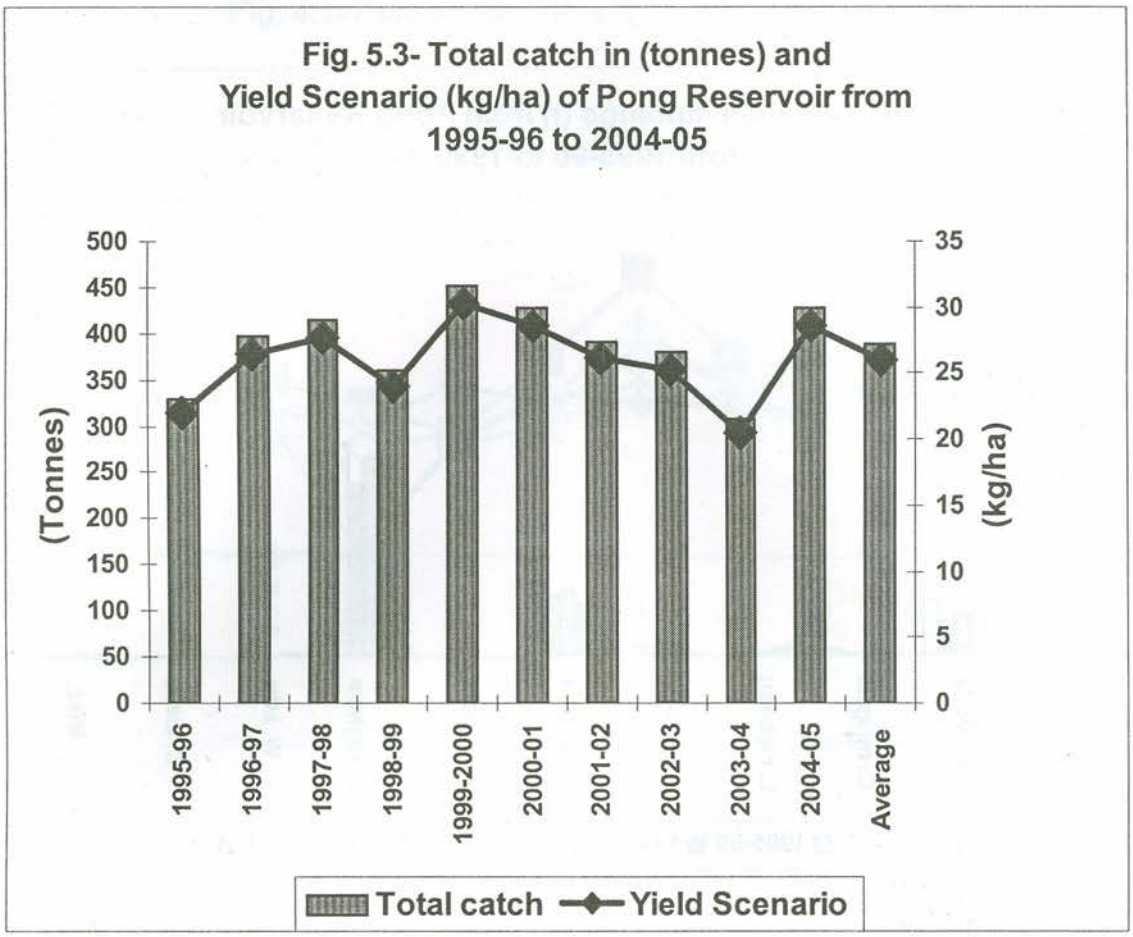


Fig. 5.3- Total catch in (tonnes) and Yield Scenario (kg/ha) of Pong Reservoir from 1995-96 to 2004-05
(Tonnes)
(kg/ha)
500
450
400
350
300
250
200
150
100
50
0
35
30
25
20
15
10
5
0
1995-96
1996-97
1997-98
1998-99
1999-2000
2000-01
2001-02
2002-03
2003-04
2004-05
Average
Total catch
Yield Scenario

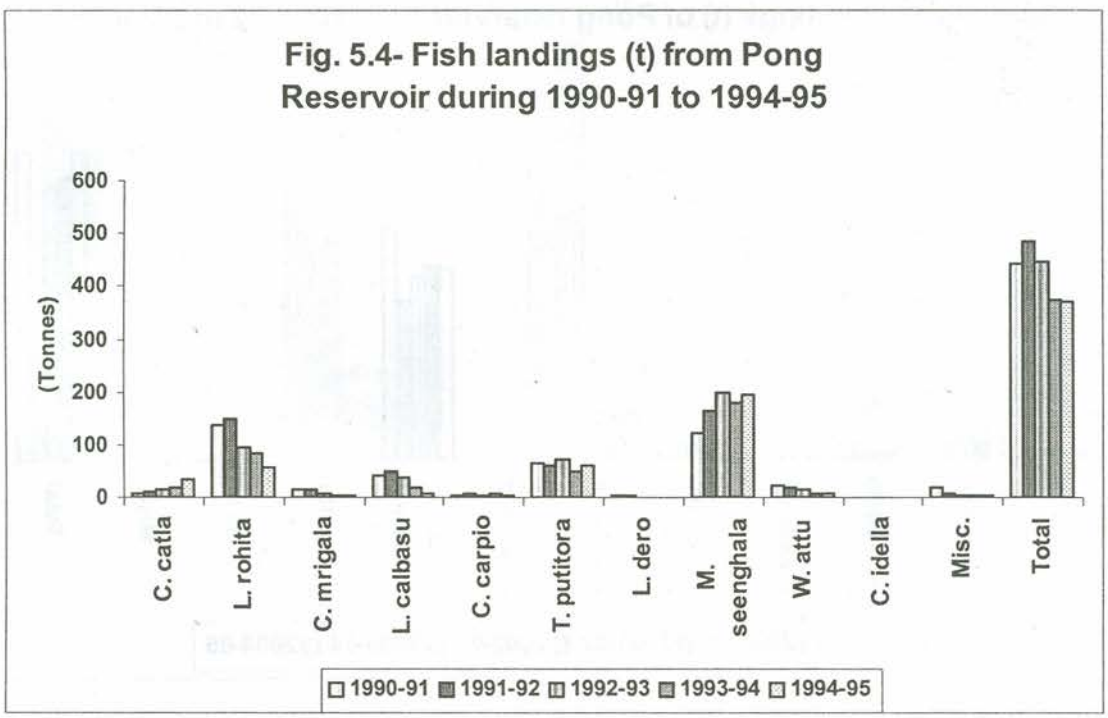


Fig. 5.4- Fish landings (t) from Pong Reservoir during 1990-91 to 1994-95
(Tonnes)
600
500
400
300
200
100
0
C. catla
L. rohita
C. mrigala
L. calbasu
C. carpio
T. putitora
L. dero
M. seenghala
W. attu
C. idella
Misc.
Total
1990-91
1991-92
1992-93
1993-94
1994-95

Fig. 5.5- Fish landings (t) from Pong Reservoir from 1995-96 to 1999-2k.

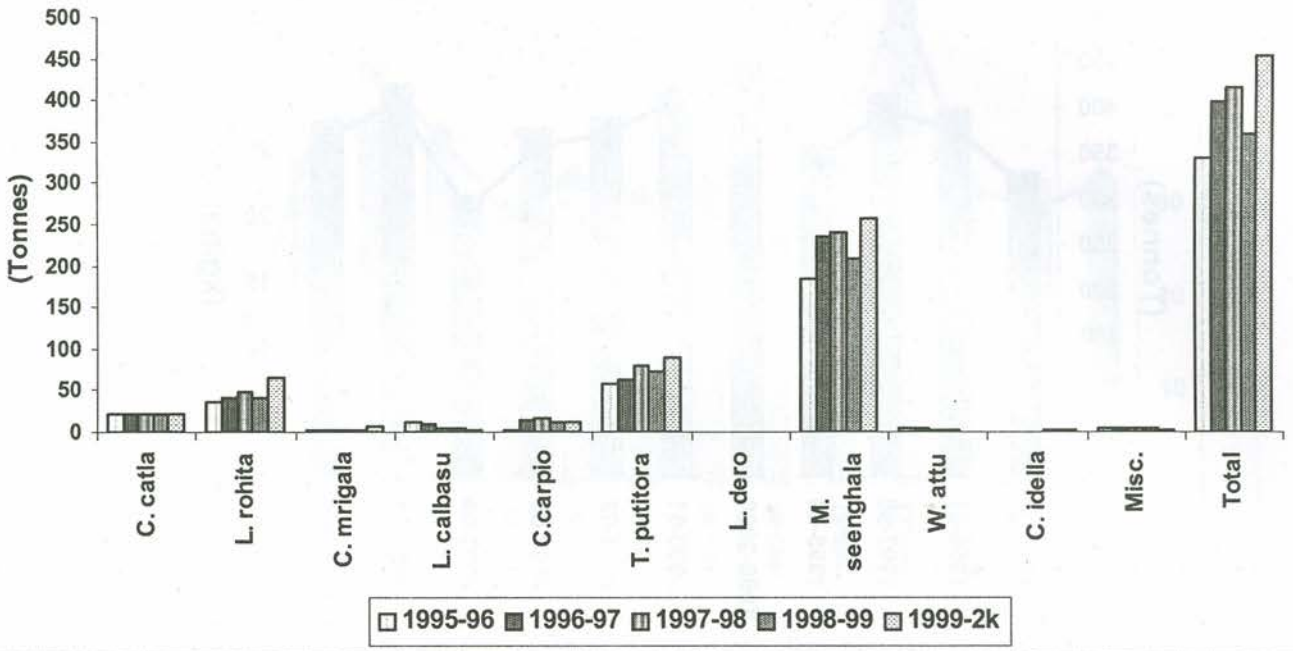
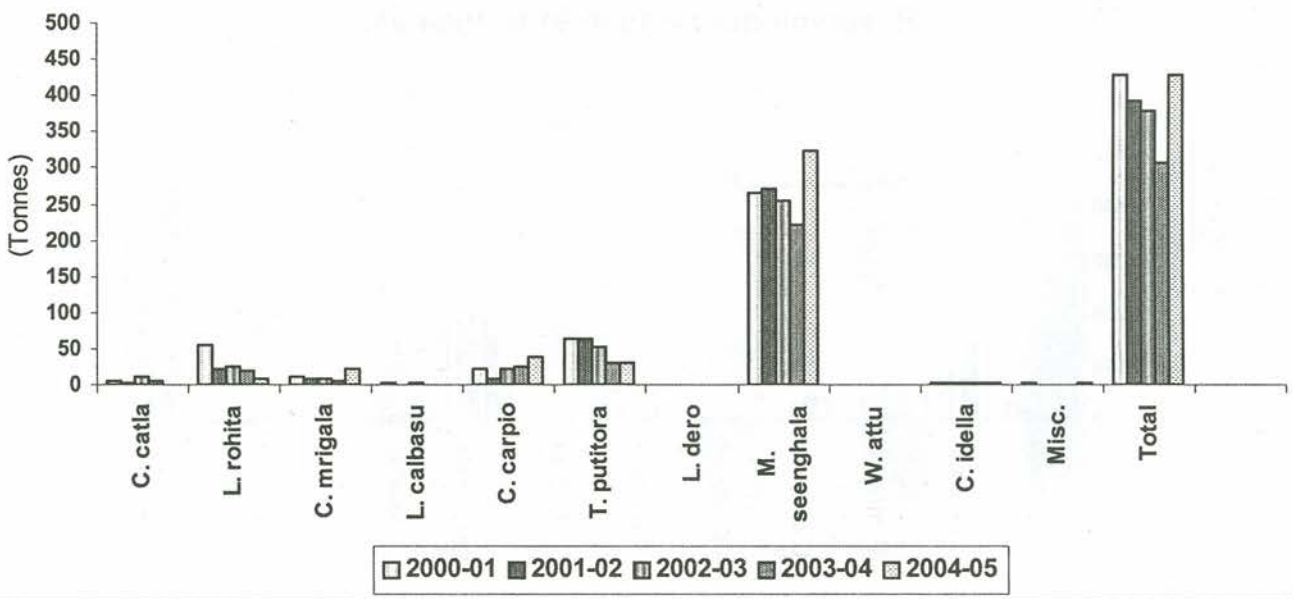
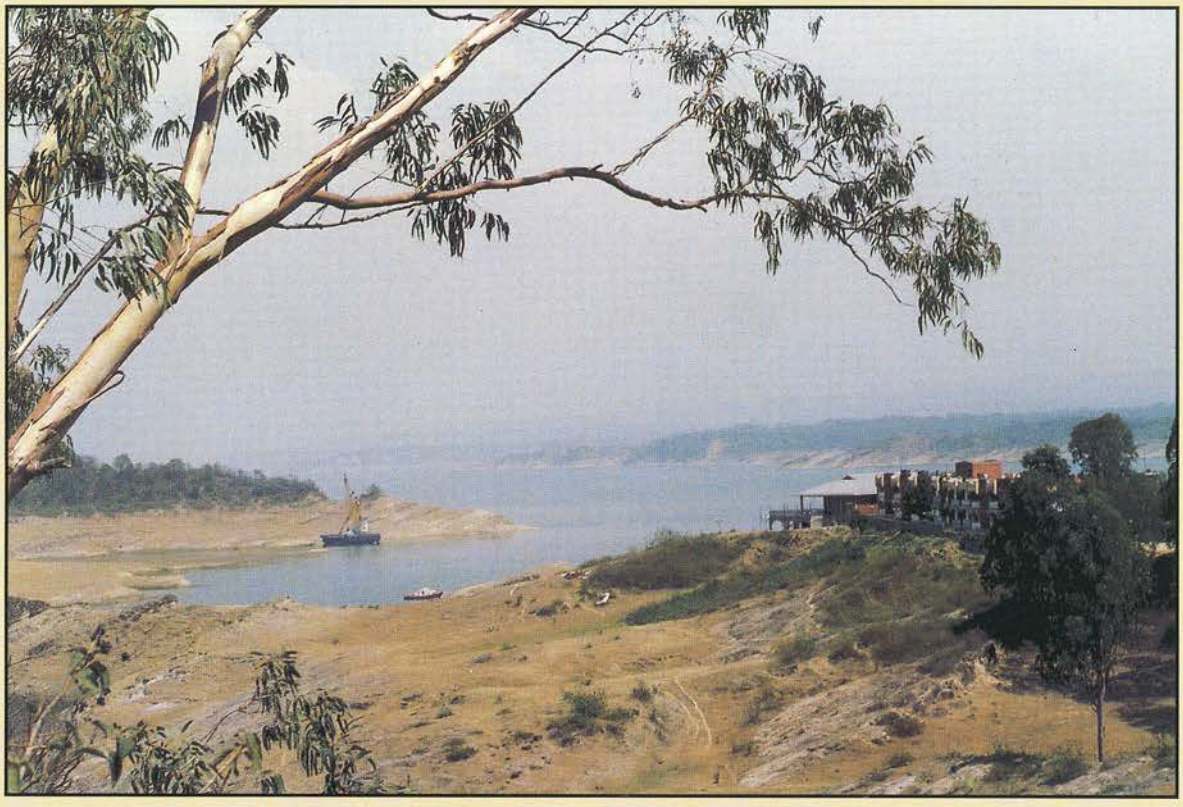


Fig. 5.6- Fish landings (t) of Pong reservoir from 2001-02 to 2004-05.





View of Pong Reservoir (Dam Site)

View of Pong Reservoir (Intermediate Zone)

View of Pong Reservoir (Lotic Zone)