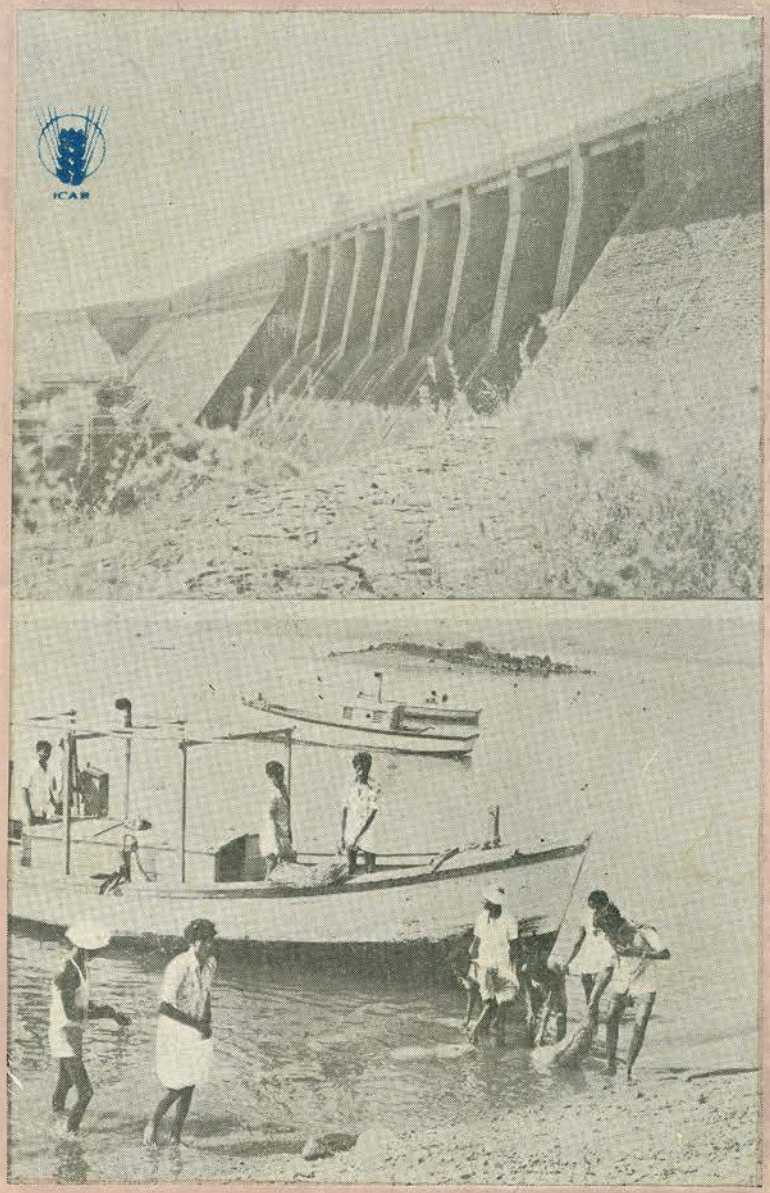

1971 - 81

FINAL REPORT

ALL INDIA CO-ORDINATED RESEARCH PROJECT ON ECOLOGY AND FISHERIES OF FRESHWATER RESERVOIRS

BHAVANISAGAR
Inland Fisheries Research
Information Series 1
May, 1981

ALL INDIA COORDINATED RESEARCH PROJECT ON ECOLOGY AND FISHERIES OF FRESHWATER RESERVOIRS

FINAL REPORT

1971-1981

BHAVANISAGAR SUBCENTRE

Project Coordinator	:	Dr. A.V. Natarajan (8.4.1971-30.6.1979)
		Shri S.D. Tripathi (1.1.1980 - continuing)
Associates	:	Shri Ch. Gopalakrishnayya Officer-in-Charge (11.5.1971-29.3.1976)
		Dr. Mathew Abraham Officer-in-Charge (27.7.1972- till date)
		Smt. S. Sivakami (26.9.1977 - till date)
		Dr. B.P. Gupta (21.4.1972-10.7.1977)
		Dr. K. Algaraja (5.5.1971-26.9.1974)
Other participants	:	Shri C. Selvaraj (22.5.1971-6.7.1972)

FOREWORD

Detailed investigations on ecology and fisheries of Bhavanisagar reservoir was taken up in the year 1971 as part of the programme under the All India Coordinated Research Project on Ecology and Fisheries of Freshwater Reservoirs. The studies covering a period of nearly a decade have resulted in a wealth of information on the physico-chemical parameters of reservoir, nutrient status of basin soil, biotic communities including plankton, benthos and periphyton, fish dispersal in time and space, stock responses to changes in fishing effort, vulnerability of fish species to specific mesh sizes and a host of other data vital for management of reservoir fisheries on scientific basis. The reservoir which provided a production of 19 kg/ha/year in 1970 surged ahead in yield to the level of 80 kg/ha/year in a space of 6 years following adoption of scientific management measures. The studies also revealed the inbuilt recruitment variations in stocks and the need for stocking to even out fluctuations in fish yield. It is sincerely hoped that suitable development measures will be taken by the State in terms of recommendations contained in this report to ensure sustained optimum production of fishes from this reservoir.

I like to place on record my deep appreciation of the excellent supervision and imaginative leadership provided by the Officers-in-Charge, Shri Ch.Gopalakrishnayya, Dr. Mathew Abraham and Mrs. S. Sivakami and vigorous pursuit of research programmes by associates.

It gives me equal pleasure to place on record the excellent cooperation extended by Directors of Fisheries, Government of Tamil Nadu and the staff of Fisheries Directorate at Bhavanisagar.

Barrackpore,
4 May, 1981

A.V. Natarajan
Director 4.5.1981

FOREWORD

Detailed investigations on ecology and fisheries of Bhavanisagar reservoir was taken up in the year 1971 as part of the programme under the All India Coordinated Research Project on Ecology and Fisheries of Freshwater Reservoirs. The studies covering a period of nearly a decade have resulted in a wealth of information on the physico-chemical parameters of reservoir, nutrient status of basin soil, biotic communities including plankton, benthos and periphyton, fish dispersal in time and space, stock responses to changes in fishing effort, vulnerability of fish species to specific mesh sizes and a host of other data vital for management of reservoir fisheries on scientific basis. The reservoir which provided a production of 19 kg/ha/year in 1970 surged ahead in yield to the level of 80 kg/ha/year in a space of 6 years following adoption of scientific management measures. The studies also revealed the inbuilt recruitment variations in stocks and the need for stocking to even out fluctuations in fish yield. It is sincerely hoped that suitable development measures will be taken by the State in terms of recommendations contained in this report to ensure sustained optimum production of fishes from this reservoir.

I like to place on record my deep appreciation of the excellent supervision and imaginative leadership provided by the Officers-in-Charge, Shri Ch.Gopalakrishnayya, Dr. Mathew Abraham and Mrs. S. Sivakami and vigorous pursuit of research programmes by associates.

It gives me equal pleasure to place on record the excellent cooperation extended by Directors of Fisheries, Government of Tamil Nadu and the staff of Fisheries Directorate at Bhavanisagar.

Barrackpore,
4 May, 1981

A.V. Natarajan
Director 4.5.1981

CONTENTS

1 INTRODUCTION

According to the National Commission on Agriculture there are about 50 large and 475 medium and small reservoirs in India covering approximately a surface water area of 3 million hectares (Government of India 1976). These water bodies are important sources of fish production, but the present yield from these reservoirs averaging 6-7 kg/ha (Jhingran and Tripathi 1969), with the existing management practices, are only a fraction of their potential. The reasons for such low yields among others are inadequate understanding of eco-system, scanty stocking, wrong selection of the species and irrational exploitation arising from lack of expertise in basic principles of stock dynamics vis-a-vis fishing effort, mesh size parameters and principles of stock manipulation. With a view to finding solutions to the problems of reservoir fisheries and developing principles for their scientific management, an All India Coordinated Research Project on Ecology and Fisheries of Freshwater Reservoirs was launched in 1971 with centres in different eco-climatic zones. One such centre was located at Bhavanisagar (District Periyar) in Tamil Nadu.

Earlier studies on Bhavanisagar were confined to preimpoundment survey (Chacko and Dinamani, 1949); limnology and primary productivity (Dorai Raj and Pankajam, 1956; Menon and Chari, 1959; Sreenivasan, 1962, 1964, 1970; Franklin, 1969; Sreenivasan *et al.*, 1969); biology of commercial fishes like *P. dubius* (Ranganathan *et al.*, 1962), *M. aor* (Ranganathan and Radha, 1966), *L. calbasu* (Natarajan, 1971) and *O. marulius* (Devaraj, 1973); and, experimental fishing (Ranganathan and Venkataswamy, 1967). The investigations under the All India Coordinated Research Project were aimed at more detailed studies on soil character, water quality, productivity indices which form the guidelines for determining the productive potential of the reservoir, fish food resources and their extent of utilization, stocking and its impact on yield, stock dynamics *vis-a-vis* fishing effort, catch per unit effort and yield and mesh selectivity for different species.

2 PHYSICAL AND MORPHOMETRIC FEATURES OF BHAVANISAGAR

The reservoir was constructed near Pungar village (Periyar district) below the confluence of the rivers Bhavani and Moyar in 1953 and is located at latitude 11°.28' N with the twin objectives of meeting the irrigation demands and controlling the floods. The morphometric data on the reservoir is given below :

River bed level (msl)	:	242.9 m
FRL (msl)	:	278.9 m
MRL (msl)	:	280.4 m
Area at FRL	:	7,265 ha
Area at MRL	:	7,877 ha
Average area $\left(\frac{FRL + DSL}{2}\right)$	:	3,695 ha
Capacity at FRL	:	81,411 ha-m
Average annual water level fluctuations	:	14.24 m
Mean depth	:	11.18 m
Shore line length at FRL	:	125.5 km

The following parameters were derived from the basic data :

Shore development at FRL	:	4.01
Volume development at FRL	:	0.94

3 SAMPLING METHODOLOGY

The reservoir was divided into four sectors for purpose of sampling - Lentic (deep water area having lacustrine conditions), Lotic (the riverine portion of the reservoir having fluviatile conditions) and the Intermediate (the area in between the Lotic and the Lentic sectors) and Moyar intermediate (Fig.1).

Soil samples were collected by using an Ekman's dredge from every 5 sq km area in the initial years of investigations but later from every 13 sq km area.

Water sampling was done during 1973-74 from areas corresponding to littoral, sub-littoral and profundal zones in all the four sectors. From 1974-75 onwards depth profile samples were taken at every 3 m depth in the profundal regions of all the sectors. But each sector was covered once in three months. Thus Lentic sector was sampled in April, July, October and January; Intermediate sector in May, August, November and February; Lotic and Moyar sectors in June, September, December and March. From 1974, studies on diurnal variations were also initiated in the Lentic sector in every quarter.

Primary productivity studies using Dark and Light Bottle technique were conducted from 1972. In the initial years the studies were confined to surface but from 1974-75 the entire euphotic zone was covered.

Plankton samples were taken in the initial years from the littoral zone of the Lentic sector only. From 1974 onwards, all the sectors were covered. Samples were taken from the littoral, sub-littoral and profundal zones of each sector. Vertical hauls were taken from each zone using a plankton net of nylobolt (№.25) having a length of 1 m and 30 cm diameter at mouth.

Bottom biota samples were taken at every 2 m depth up to 10 m and then at a depth of every 5 m. Each sector was covered once in three months during 1974-76. Three samples were taken from each depth with a 23 sq cm Ekman's dredge and the samples were sieved through a 40 mesh sieve (256 meshes/ sq cm).

Data on biological parameters was collected at the fish assembly centre while the catch statistics were noted from the records of the State Fisheries Department.

To study the recruitment, standard shooting nets were operated to collect the spawn in the upper reaches of the river Bhavani during the south-west monsoon. Samples of eggs were reared in earthen hundies and cement cisterns to identifiable size. Drag nets of 1.6 mm mesh were also plied in the littoral areas to collect the fry.

Experimental fishing was conducted during 1978-79 and 1979-80. Multi-meshed surface gill nets from 40 to 300 mm mesh sizes were used. Nets were plied for four days in each sector during a month with the smaller meshes towards the shore. The fishing stations are shown in Fig.1. The nets were hauled after 24 hours. A total of 32 pieces of nets each having 35 m of hung length were used. Thus, the total hung length of the nets was 1,120 m with a hanging co-efficient of 0.5. The nets had a hung depth of 5.1 m with a hanging co-efficient of 0.85. During the second year 40 and 50 mm mesh size nets were not operated.

4 METEOROLOGICAL OBSERVATIONS

The air temperature and wind speed at Bhavanisagar are presented in Table I, Maximum air temperature was recorded in April/May but the minimum air temperature did not follow a set pattern. Maximum wind speed generally occurred during June-August touching 40 km/hr in June 1979. November-January generally showed minimum wind speed. The data on rainfall is presented in Fig.2. The catchment of the reservoir is subjected to both south-west and north-east monsoons, the effect of the latter being usually more than that of the former.

5 WATER LEVEL AND INFLOW AND OUTFLOW

Data on the inflow-outflow, water levels, corresponding areas and capacities during the period of study are shown in Figs. 2-5 respectively. The area capacity curve of the reservoir is shown in Fig. 6.

The water levels during the period fluctuated from 256.64 m (1974-75) to 280.42 m (1978-79). The average water level was maximum in 1978-79 (279.71 m) and minimum in 1976-77 (265.14 m). The water level fluctuations were maximum in 1977-78 (22.06 m) and minimum in 1979-80 (5.46 m). Maximum water levels were generally during December/January and minimum during April/May.

The area and capacity fluctuated in the range of 745 to 7,877 ha and from 2,501 to 92,889 ha-m. The inflow was maximum in 1979-80 (42,007 m^3/sec) and minimum in 1976-77 (14,731 m^3/sec). The outflow also showed maximum and minimum values (42,413 and 16,378 m^3/sec) during the same years as inflow. The reservoir generally received maximum inflow during north-east monsoon (November/December). It is mainly regulated by the discharge from the Pillur Dam - a hydel dam situated in the upper reaches of the Bhavani river.

TABLE I

DATA ON METEOROLOGICAL OBSERVATIONS IN BHAVANISAGAR DURING 1971-72 TO 1980-81

Year	Air temperature (°C)		Wind speed (km/hr)		Average wind speed (km/hr)	
	Max	Min	Max	Min	Max	Min
1971-72	38.34 (May)	18.49 (Nov)	18.98 (June)	0.08 (Dec)	-	-
1972-73	40.00 (May)	16.67 (Dec)	37.21 (July)	0.03 (Jan)	15.54 (July)	1.24 (Nov)
1973-74	40.00 (Apr-May)	16.7 (Jan)	30.34 (July)	0.29 (Nov)	6.27 (July)	0.96 (Jan)
1974-75	45.43 (May)	21.3 (Jan)	30.32 (Aug)	0.10 (Nov)	9.32 (June)	0.75 (Dec)
1975-76	45.43 (May)	21.3 (Feb)	23.94 (June)	0.23 (Oct)	8.45 (June)	1.17 (Dec)
1976-77	41.11 (May)	23.33 (Apr)	23.39 (July)	0.06 (Jan)	11.48 (July)	0.58 (Jan)
1977-78	38.6 (Apr)	12.2 (July)	24.00 (Aug)	0.68 (Apr)	10.60 (July)	2.01 (Apr)
1978-79	39.5 (Apr)	18.0 (Dec)	22.0 (May-Sep)	2.0 (Jan)	10.4 (Aug)	4.0 (Dec-Feb)
1979-80	39.0 (Apr-May)	17.0 (Jan)	40.0 (June)	2.0 (Nov-Jan)	11.08 (Aug)	2.0 (Nov-Jan)
1980-81	39.0 (Apr-May)	18.0 (Feb.)	16.0 (June)	2.0 (Apr.-Oct., Dec. & Jan.)	-	-

6 CHEMICAL CHARACTERISTICS OF SOIL

The reservoir productivity is very much influenced by the quality of the soil of the reservoir basin as well as that of the catchment. Studies made during 1973-76 in different sectors of the reservoir revealed that the basin soil contains fairly high values of organic carbon (1.83 to 2.68%) and available nitrogen (31.6 to 50.8 mg/100 g) but the available phosphorus (1.0 to 3.58 mg/100 g) was poor. Soil was always acidic in nature with pH ranging from 5.2 to 6.4. Lower values of soil pH were due to the presence of free carbondioxide in the bottom water layers of the reservoir. Studies during the premonsoon and post-monsoon seasons indicated that the values of all the parameters were higher in the premonsoon season than post-monsoon. Moyar and Lotic sectors of the reservoir were richer in organic carbon, total nitrogen and available nitrogen than the other sectors. C:N ratio (10 : 1 to 18 : 1) for this reservoir basin was ideal. By going through the data given in Table II, Bhavanisagar can be placed under the group of average productive reservoirs.

7 PHYSICO-CHEMICAL FEATURES OF SURFACE WATER OF THE RESERVOIR

7.1 Physical features of different sectors

Sectorwise water temperature fluctuated between 23°.1C (January) to 29°.0 C (April) in the Lentic sector, 24°.9 C (November) to 28°.2 C (May) in Intermediate sector, 24°.6 C (December) to 28°.8 C (March) in Lotic sector and 25°.0 C (December) to 28°.2 C (March) in the Moyar sector. Sector-wise water transparency (Fig. 7) varied from 23-135 cm, 21-133 cm, 18.5-117 cm and 37.0-78.8 cm in the Lentic, Intermediate, Lotic and Moyar sectors respectively.

7.2 Chemical features of different sectors

Chemical feature of surface water in different sectors and seasons have been presented in Table III.

7.2.1 Lentic sector

This sector showed a high value of pH (7.9) and fairly high values of alkalinity (40.9 ppm) but organic matter (2.8 ppm), calcium (15.1 ppm) and specific conductivity (257.4 /umhos) were lower than the other sectors.

TABLE II

SECTOR-WISE SOIL CHARACTERISTICS OF BHAVANISAGAR DURING 1973-76

Soil characteristics	PRE-MONSOON SEASON				POST-MONSOON SEASON			
	Bhavani Lotic	Inter-mediate	Lentic	Moyar	Bhavani Lotic	Inter-mediate	Lentic	Moyar
pH	6.4	6.0	6.1	5.9	5.7	5.2	5.3	5.6
Organic carbon(%)	2.42	2.07	1.83	2.68	2.51	1.98	2.05	2.57
Total nitrogen(%)	0.22	0.20	0.18	0.26	0.14	0.18	0.18	0.21
C:N ratio	11:1	10:1	10:1	10:1	18:1	11:1	11:1	12:1
Available nitrogen (mg/100 g)	50.8	45.3	40.4	45.4	35.6	31.6	33.0	36.9
Available phosphorus (mg/100 g)	1.60	2.41	3.03	3.58	1.25	1.24	1.00	1.03

TABLE III

CHEMICAL FEATURES OF SURFACE WATER IN DIFFERENT SECTORS OF BHAVANISAGAR

Sector	Months	Dissolved oxygen (ppm)	Organic matter (ppm)	pH	Free carbon dioxide (ppm)	Total alkalinity (ppm)	Calcium (ppm)	Magnesium (ppm)	Specific conductivity (Micro-mhos)
Lentic	April	9.0	2.2	8.1	0.3	46.4	15.0	3.7	249.7
	July	9.1	2.4	7.7	2.9	35.4	16.6	2.9	244.5
	October	9.1	3.9	7.8	1.1	36.7	13.6	2.1	216.3
	January	8.0	2.9	7.9	1.5	45.3	15.2	3.9	273.4
	Average	8.8	2.8	7.9	1.4	40.9	15.1	3.2	254.4
Inter-mediate	May	8.5	4.1	8.0	0.5	44.7	17.6	3.2	290.0
	August	10.7	4.8	7.5	3.9	30.0	12.5	2.6	162.2
	November	9.1	3.7	7.8	1.6	38.3	12.7	2.3	266.5
	February	8.7	3.5	8.0	0.5	53.3	19.3	3.9	335.0
	Average	9.2	4.0	7.8	1.6	41.6	15.5	3.0	263.4
Lentic	June	7.3	3.2	7.2	5.7	34.0	13.6	3.6	255.3
	September	8.8	4.2	7.3	3.0	32.0	12.1	2.4	183.5
	December	8.3	3.9	7.3	4.6	38.3	12.3	2.8	257.8
	March	7.9	3.5	7.9	2.0	48.1	15.9	3.3	340.2
	Average	8.1	3.7	7.4	3.8	38.1	13.5	3.0	259.2
Moyar	June	8.8	2.7	7.6	1.1	42.7	15.0	4.2	300.8
	September	8.3	4.3	7.4	1.7	30.7	11.2	2.8	180.2
	December	9.3	2.8	8.1	1.3	42.6	17.6	2.5	248.1
	March	8.7	3.2	7.9	1.3	40.0	18.3	3.3	306.5
	Average	8.8	3.2	7.8	1.4	39.0	15.5	3.2	258.9

Dissolved oxygen, organic matter and pH did not show any regular seasonal pattern. Free carbondioxide was maximum (2.9 ppm) whereas alkalinity and specific conductivity were minimum during the monsoons.

7.2.2 Intermediate sector

This sector showed high values of organic matter (4.0 ppm), alkalinity (41.6 ppm), calcium (15.5 ppm) and specific conductivity (263.4 µmhos). pH, alkalinity, calcium and specific conductivity showed the lowest values during monsoons. The values of all these parameters showed an increasing trend from November onwards.

7.2.3 Lotic sector

This sector showed comparatively low values of pH (7.4), alkalinity (38.1 ppm), calcium (13.5 ppm) and specific conductivity (259.2 µmhos). The values of these constituents were minimum during monsoons.

7.2.4 Moyar sector

This sector was fairly rich in pH (7.8), alkalinity (39.0 ppm) and calcium (15.5 ppm) while specific conductivity showed a slightly lower value (258.9 µmhos).

7.3 Nutrient features of different sectors

7.3.1 Lentic sector

Phosphate was very low and it varied from traces to 0.016 ppm. Nitrate nitrogen varied between traces to 0.34 ppm. Silica concentration varied between 2.0 to 15.2 ppm. Iron (ferric) was in the range of nil to 0.26 ppm.

7.3.2 Intermediate sector

Phosphate contents of water varied between traces to 0.015 ppm. Nitrate nitrogen ranged from traces to 0.24 ppm and its value was high in August. The values of silica were higher than the Lentic sector, ranging between 2.2 to 18.0 ppm. The concentration of iron (ferric) in this sector was about the same as in the Lentic sector.

7.3.3 Lotic sector

Phosphate concentration in this sector was very poor and varied between traces to 0.018 ppm. Nitrate nitrogen ranged between traces to 0.04 ppm and was lower than the Lentic and Intermediate sectors. Silica ranged between 1.6 to 13.6 ppm and its value was lower than in the Lentic and Intermediate sectors. Iron (ferric) ranged between nil to 1.5 ppm.

7.3.4 Moyar sector

The values of phosphate ranged between traces to 0.06 ppm. Nitrate-nitrogen varied between traces to 0.04 ppm. Silica ranged between 2.0 to 14.0 ppm. Iron (ferric) varied between nil to 0.46 ppm. No marked seasonal differences were noticed in the nutrient features of the reservoir.

7.4 Impact of viscose industry on water quality of different sectors

The effluents of the South India Viscose Factory at Sirumughai are discharged at a point which is about 3 km downstream of the Moolathurai spawn collection centre. Comparative studies on water quality in different sectors of the reservoir are presented in Table IV. It is apparent from the table that the water quality in respect of different chemical parameters like pH, D.O., CO_2, HCO_3, Ca^{++}, Mg^{++} etc. shows a sudden change in Sirumughai stretch. However, the impact of effluents on water quality remains confined to a certain stretch below Sirumughai only. Further the adverse effect is noticed mainly when the inflow is very low. During the course of investigation only once on 30th March 1974, when water inflow was extremely low, pH of water was recorded below 4.0, dissolved oxygen 1.0 ppm with saturation percentage 14.0 at Sirumughai. Dead plankton and fishes were observed on the surface of water. The discharge of acidic effluents and subsequent depletion of pH and oxygen were the cause of mortality of plankton and fishes. Similar oxygen depletion (1.5 ppm), decrease in pH (5.0 ppm) and accumulation of carbondioxide (126.0 ppm) were noted in June 1976 also when the inflow in the reservoir was of a low order.

8 VERTICAL DISTRIBUTION OF PHYSICO-CHEMICAL CHARACTERISTICS

Bhavanisagar did not show any thermal stratification. The maximum difference between surface and bottom water temperature was 2 to 3°C. This is clear from the narrow range of seasonal variation in water temperature. On the other hand a strong oxycline and klinograde distribution of oxygen (decline of 3 to 6 ppm from surface to bottom) has been noted in this reservoir (Fig. 8). In tropical impoundments, high temperatures prevailing in the bottom zone accelerate the rate of chemical reactions and hence their oxygen demand is higher than temperate waters. It has been

TABLE IV

EFFECT OF THE EFFLUENTS OF VISCOSE INDUSTRY ON THE WATER QUALITY (AVERAGE VALUES) OF BHAVANISAGAR DURING 1973-77

Characteristics of surface water	S E C T O R S					
	Moolathurai	Sirumughai	Lotic	Intermediate	Lentic	Moyar
Water temperature (°C)	28.1	28.0	26.8	26.2	26.2	26.2
pH	7.5	6.4	7.3	7.7	7.9	7.8
Dissolved oxygen (ppm)	8.6	6.1	7.5	9.1	8.8	8.8
Free CO_2 (ppm)	1.5	27.6	3.8	2.0	2.2	1.9
Bicarbonate (ppm)	35.0	44.6	38.1	39.0	36.6	35.0
Calcium (ppm)	19.5	9.5	13.3	15.1	15.1	15.5
Magnesium (ppm)	5.8	3.9	3.5	3.0	3.1	3.2
Organic matter (ppm)	2.5	5.9	3.4	4.1	2.8	3.2

found that reservoirs with rich biota reflect sharper oxygen decline causing its klinograde distribution and hence oxygen curve is an important parameter for evaluating the productivity of reservoirs. The klinograde oxygen curve obtained in Bhavanisagar clearly indicates its productive nature (Fig.8). Many productive reservoirs like Amaravati, Stanley, Nagarjunasagar and Govindsagar also show similar oxygen decline but the low productive reservoirs like Tilaiya, Konar and Rihand in spite of the presence of strong thermal stratification have near uniform distribution of oxygen from surface to bottom.

In Bhavanisagar, the oxygen decline from surface to bottom was always associated with accumulation of carbondioxide and decrease of pH in the bottom layers (Fig. 8 and Table V). The release and accumulation of carbondioxide by the decomposition of bottom organic sediments and subsequent increase in hydrogen-ion-concentration causes a fall in the pH. Bottom accumulation of carbondioxide which reflects the amount of oxidisable organic matter and decline of pH are also suggestive of Bhavanisagar being a productive reservoir.

The reservoir also showed stratification of bicarbonate alkalinity that is low value on the surface and high values at the bottom (Fig. 8). Carbondioxide accumulated in the bottom dissolves carbonate deposits thereby increasing the bicarbonate concentration and specific conductivity.

The strong chemical stratification is broken either by wind or by influx of flood water. Table V shows that during 1974, the stratification continued upto October but during 1975 it was broken in July by heavy inflow. It again got stabilised in October. During 1976, a very strong stratification was noted in April (Fig. 8), but due to heavy wind it was broken in May itself and then the entire water column was homogeneous upto October. All these observations point that Bhavanisagar gets stratified chemically, whenever there is less disturbance either by wind or by influx of water. This indicates that both photosynthetic and tropholytic activities are very high in this reservoir.

9 DIURNAL VARIATION IN CHEMICAL PARAMETERS

Diurnal changes in chemical parameters during the different years of study have been represented in Table VI. It is apparent that all the parameters like dissolved oxygen, pH, free carbondioxide, carbonate and bicarbonate show considerable change from morning 6 hrs to evening 6 hrs. Dissolved

TABLE V

PHYSICO-CHEMICAL FEATURES OF SURFACE AND BOTTOM WATERS OF BHAVANISAGAR FROM JUNE 1974 TO FEBRUARY 1977

Year/ Month		Temp. (°C)	Dissolved oxygen (ppm)	pH	Free carbon dioxide (ppm)	Bicarbonate (ppm)	Specific conductivity (micromhos)
1		2	3	4	5	6	7
LENTIC PROFUNDAL							
1974							
June	Surface	26.5	8.8	8.1	0.4	48.0	337.0
	Bottom	25.9	8.0	7.7	2.1	56.0	353.0
July	Surface	25.6	8.0	8.4	Nil	34.0	257.6
	Bottom	23.6	3.6	6.8	8.0	44.0	294.1
October	Surface	26.8	8.8	8.2	Nil	30.0	178.0
	Bottom	25.5	4.0	7.0	9.0	40.0	194.0
1975							
January	Surface	24.5	8.8	8.0	1.2	42.0	267.0
	Bottom	23.5	5.2	7.1	14.0	46.0	281.0
April	Surface	29.0	10.4	7.5	1.0	37.0	262.9
	Bottom	28.5	5.6	6.9	6.2	42.0	286.7
May	Surface	28.0	9.2	8.4	Nil	32.0	276.0
	Bottom	26.9	5.2	7.3	6.0	52.0	286.0
June	Surface	24.9	7.6	7.3	2.4	40.0	220.3
	Bottom	23.5	5.2	7.1	4.6	44.0	223.3
July	Surface	25.0	8.0	7.5	1.6	28.0	183.1
	Bottom	24.0	7.2	7.3	3.0	30.0	185.4
October	Surface	26.9	10.0	7.6	1.4	30.0	167.0
	Bottom	24.7	4.8	6.7	4.6	40.0	170.7
1976							
January	Surface	23.3	7.8	7.5	3.2	38.0	205.4
	Bottom	22.8	6.1	7.2	10.0	48.0	220.3
April	Surface	28.9	7.8	8.4	Nil	34.0	266.6
	Bottom	26.6	1.2	6.8	9.0	56.0	316.6
May	Surface	27.2	8.4	7.5	1.6	40.0	286.7
	Bottom	27.0	7.8	7.4	1.8	42.0	298.0

TABLE V (Contd.)

1		2	3	4	5	6	7
June	Surface	26.6	6.4	7.4	2.0	34.0	271.4
	Bottom	26.2	6.0	7.3	2.4	36.0	276.3
July	Surface	25.5	11.2	7.3	7.0	34.0	292.8
	Bottom	25.5	9.6	7.3	8.0	34.0	304.0
Octo-	Surface	26.8	8.4	7.7	1.8	44.0	304.0
ber	Bottom	25.8	7.6	7.2	2.8	49.0	337.7
1977							
January	Surface	23.1	7.5	8.3	Nil	44.0	347.8
	Bottom	22.6	4.4	7.1	6.0	62.0	389.7
INTERMEDIATE PROFUNDAL							
1974							
August	Surface	25.6	8.4	8.0	1.2	30.0	304.0
	Bottom	23.1	5.4	7.1	4.0	34.0	316.0
Novem-	Surface	26.3	10.0	8.4	Nil	30.0	304.0
ber	Bottom	24.7	4.0	7.2	9.5	46.0	316.0
1975							
May	Surface	27.2	8.0	7.2	3.0	50.0	302.0
	Bottom	27.2	6.4	7.1	5.2	56.0	361.0
August	Surface	25.9	10.8	7.2	2.0	30.0	152.0
	Bottom	23.0	8.0	6.8	2.6	32.0	152.0
Novem-	Surface	25.5	7.6	7.4	4.0	30.0	178.8
ber	Bottom	24.9	6.8	7.3	4.4	34.0	200.0
1976							
Febr-	Surface	25.4	10.8	8.2	Nil	34.0	257.6
uary	Bottom	24.4	6.8	6.9	14.0	50.0	292.3
May	Surface	27.3	7.6	7.3	2.2	40.0	292.3
	Bottom	27.1	7.3	7.2	2.4	40.0	292.3
August	Surface	26.1	13.0	7.3	8.4	30.0	168.8
	Bottom	25.2	10.0	6.8	13.0	31.0	178.8
Novem-	Surface	24.9	9.6	7.5	0.8	45.0	316.6
ber	Bottom	24.5	8.4	7.3	2.0	48.0	344.6
1977							
Febr-	Surface	25.5	7.6	8.2	Nil	56.0	380.0
uary	Bottom	25.0	4.0	7.2	3.4	72.0	389.7

oxygen, pH and carbonate increased from morning to noon (12 hrs) and, in general, showed a decreasing trend whereas free carbondioxide (if present) and bicarbonate decreased from morning to noon and then showed an increasing trend. Diurnal variations in water quality were very well marked during September 1975 when dissolved oxygen increased from 12 to 14 ppm; pH from 7.6 to 8.4, Carbonate from nil to 18.0 ppm and bicarbonate decreased from 30.0 to 12.0 ppm with the progress of the day from morning to evening. In March 1976, the values of DO increased from 8.2 to 9.4, pH from 8.4 to 8.8, carbonate from 16 to 26 ppm while that of bicarbonate decreased from 28.0 to 20.0 ppm. During other seasons also the diurnal trend was similar but the magnitude of variation was of a low order. Studies made from surface to bottom at 6 hrs, 12 hrs and 18 hrs indicated considerable changes in the entire water column (Table VI).

Sharp changes in the chemical parameters with the progress of the day, noted in Bhavanisagar, clearly indicate that the photosynthetic activities are quite high in the reservoir.

10 PRIMARY PRODUCTIVITY

The measurement of the rate of conversion of incident solar energy to chemical energy and its fixation by primary producers gives an important measure for evaluating the productivity of a reservoir.

Both gross and net production were the highest in the Moyar sector followed by the Intermediate sector the minimum being in the Lotic sector/ The production /(Fig.9). rate was minimum during monsoon months. The average gross and net production for 1973-77 were 830.79 $mgC/m^2/day$ and 458.35 $mgC/m^2/day$ respectively. The rate of respiration to gross production was 44.83%. As 3.68 calories of energy is required to liberate one mg of oxygen through algal photosynthesis, the energy fixed by the primary producers in this reservoir amounts to 8158.35 $cal/m^2/day$ showing the photosynthetic efficiency to be 0.412%.

11 FISH FOOD RESOURCES OF THE RESERVOIR

11.1 Plankton

The plankton abundance through months is given in Fig.10. In 1974, it exhibited bimodal production with two pulses, the primary occurring in April-May (summer) and the secondary peak during October-November (post-monsoon)(Fig.10).

TABLE VI

DIURNAL VARIATION IN CHEMICAL CONSTITUENTS IN LENTIC SECTOR-BHAVANISAGAR (JUNE 1974 TO DECEMBER1976)

Months and years		06 hours				
		Dissolved oxygen (ppm)	pH	Free CO_2 (ppm)	Carbonate (ppm)	Bicarbonate (ppm)
June 1974	S	8.8	8.1	0.4	Nil	48.0
	B	8.0	7.7	2.1	Nil	56.0
September	S	8.4	8.2	Nil	8.0	22.0
	B	5.6	7.1	6.0	Nil	32.0
December	S	8.0	7.4	5.0	Nil	42.0
	B	3.6	6.9	10.0	Nil	48.0
June 1975	S	8.8	7.1	3.0	Nil	31.0
	B	7.2	6.9	3.2	Nil	32.0
September	S	12.0	7.6	1.4	Nil	30.0
	B	6.0	6.7	9.0	Nil	36.0
December	S	8.4	7.3	6.0	Nil	38.0
	B	5.2	6.7	16.0	Nil	46.0
March 1976	S	8.2	8.4	Nil	16.0	28.0
	B	3.2	6.8	9.0	Nil	50.0
June	S	8.4	7.4	2.0	Nil	34.0
	B	7.6	7.2	2.8	Nil	36.0
September	S	11.2	7.3	2.2	Nil	26.0
	B	8.8	7.3	2.4	Nil	26.0
December	S	7.6	7.9	0.8	Nil	56.0
	B	4.0	7.0	5.0	Nil	60.0

TABLE VI (CONTD.)

DIURNAL VARIATION IN CHEMICAL CONSTITUENTS IN LENTIC SECTOR-BHAVANISAGAR (JUNE 1974 TO DECEMBER 1976)

Months and years		12 hours Dissolved oxygen (ppm)	pH	Free CO_2 (ppm)	Carbonate (ppm)	Bicarbonate (ppm)
June 1974	S	9.2	8.4	Nil	14.0	42.0
	B	7.0	8.1	1.0	Nil	50.0
September	S	9.2	8.5	Nil	16.0	16.0
	B	5.6	7.3	2.0	Nil	36.0
December	S	10.8	7.6	3.0	Nil	44.0
	B	6.0	7.0	17.0	Nil	48.0
June 1975	S	9.2	7.3	1.6	Nil	30.0
	B	8.0	7.2	2.0	Nil	32.0
September	S	14.0	8.4	Nil	12.0	18.0
	B	10.0	6.8	8.4	Nil	32.0
December	S	9.6	7.9	0.4	Nil	36.0
	B	5.6	6.7	13.4	Nil	46.0
March 1976	S	9.4	8.8	Nil	26.0	20.0
	B	2.4	7.0	6.6	Nil	48.0
June	S	14.8	8.4	Nil	12.0	30.0
	B	10.4	7.4	2.4	Nil	40.0
September	S	12.4	7.6	2.0	Nil	24.0
	B	10.4	7.4	2.0	Nil	26.0
December	S	9.6	8.4	Nil	10.0	50.0
	B	3.6	7.0	6.4	Nil	62.0

TABLE VI (CONTD.)

DIURNAL VARIATION IN CHEMICAL CONSTITUENTS IN LENTIC SECTOR-BHAVANISAGAR (JUNE 1974 TO DECEMBER 1976)

		18 hours				
Months and years		Dissolved oxygen (ppm)	pH	Free CO_2 (ppm)	Carbonate (ppm)	Bicarbonate (ppm)
June 1974	S	9.4	8.4	Nil	16.0	50.0
	B	-	-	-	-	-
September	S	8.8	8.4	Nil	12.0	18.0
	B	5.2	7.2	4.0	Nil	32.0
December	S	9.6	7.6	3.4	Nil	40.0
	B	4.4	6.7	15.0	Nil	44.0
June 1975	S	7.6	7.3	2.0	Nil	31.0
	B	6.6	7.0	2.8	Nil	33.0
September	S	11.2	8.4	Nil	18.0	12.0
	B	5.2	6.8	7.4	Nil	32.0
December	S	9.8	8.2	Nil	8.0	30.0
	B	5.0	6.6	10.0	Nil	42.0
March 1976	S	9.2	8.5	Nil	24.0	24.0
	B	2.0	7.0	6.4	Nil	50.0
June	S	8.8	7.3	2.4	Nil	36.0
	B	8.0	7.2	3.0	Nil	38.0
September	S	10.4	7.5	2.2	Nil	32.0
	B	9.2	7.3	2.0	Nil	32.0
December	S	9.2	8.6	Nil	24.0	36.0
	B	4.0	7.0	5.8	Nil	58.0

In 1975, only a single peak of greater magnitude was noted in summer. In 1976, the summer peak was noted in March and the post-monsoon peak in December, the latter being of greater magnitude than the former. Lowest plankton density was during the flood season.

The average standing crop of plankton (ml/m^3) showed an increase over the years from 0.86 ml/m^3 in 1974 to 1.54 ml/m^3 in 1976(Table VII). Among the sectors, the Lentic sector showed the maximum concentration of plankton followed by Moyar and Intermediate (Table VIII). In 1976, however, Moyar was the most productive sector followed by the Lentic. As chemical parameters in the Lentic sector did not show a proportionate increase in values as plankton density the highest concentration of plankton in this deep sector may be attributed to winds and other physical phenomena. Though numerically Moyar was most productive the smaller size of Mougeotia, which formed the blooms in this sector did not contribute much to the volume (Table VIII).

11.1.1 Phytoplankton

The phytoplankton was dominant all through the year. The relative abundance of phyto- and zooplankters is presented in Table VIII. In all the sectors phytoplankters were overwhelmingly dominant contributing nearly 90% to the total except in the Intermediate profundal. The phytoplankton was represented by Cyanophyceae, Chlorophyceae, Bacillariophyceae and Dinophyceae. Among the four groups Cyanophyceae constituted the bulk in all the sectors except in Moyar. The main constituents of the group were Anacystis (= Microcystis), Oscillatoria and Anabaena. Anacystis was the most dominant form and the other two occurred sparingly. This species occurred throughout the year with maximum abundance during summer and post-monsoon months. Its abundance was more in the Lentic sector and least in the Lotic sector. Winds and water current probably aid in the accumulation of Anacystis in the relatively calm littoral regions of the Lentic sector especially on the right bank. Next in the order of abundance was Chlorophyceae. This group was represented by Mougeotia, Pediastrum simplex and P. boryanum in the stated order of abundance. Mougeotia formed blooms in the Moyar sector in summer and post-monsoon months when it outnumbered Anacystis. Other group of phytoplankters were not significant. Bacillariophyceae was represented by Synedra and Dinophyceae by Ceratium.

TABLE VII

SECTOR-WISE SEASONAL VARIATIONS IN PLANKTONIC ABUNDANCE (ml/m^3) DURING 1974 - 1976

Months	1974				1975				1976			
	Lentic	Intermediate	Lotic	Moyar	Lentic	Intermediate	Lotic	Moyar	Lentic	Intermediate	Lotic	Moyar
January	0.14	-	-	-	0.52	0.30	0.18	1.00	0.74	0.37	0.22	0.71
February	-	0.35	-	-	0.41	1.71	1.07	1.00	1.05	0.90	0.35	1.60
March	-	-	0.04	0.76	0.79	1.32	0.13	2.00	1.18	1.28	0.29	1.06
April	2.87	-	-	-	5.66	4.92	1.25	1.07	0.48	0.46	0.34	0.71
May	3.02	1.38	0.10	2.00	2.42	1.58	0.35	0.35	1.05	0.40	0.10	0.21
June	0.91	0.42	0.07	1.00	2.83	0.54	0.50	0.95	0.83	0.20	0.05	0.50
July	0.75	0.43	0.14	0.35	1.57	2.11	0.71	1.57	1.13	0.17	0.10	3.75
August	1.05	0.67	Traces	Traces	1.43	0.08	Traces	0.18	0.60	0.40	0.09	1.24
September	1.09	1.02	Traces	1.41	0.73	0.58	0.65	0.11	0.22	0.09	0.04	0.35
October	1.93	-	-	-	0.23	0.23	0.03	0.08	1.14	1.10	0.71	1.07
November	-	1.78	-	-	0.10	0.08	0.08	0.08	2.01	2.99	1.00	5.00
December	-	-	0.74	1.10	0.35	0.14	0.08	0.53	3.99	2.22	1.00	18.57
Average	1.47	0.86	0.16	0.95	1.43	1.13	0.42	0.74	1.20	0.88	0.36	3.73
Overall average	0.86				0.93				1.54			

TABLE VIII

SECTORAL ABUNDANCE OF PHYTO-AND ZOOPLANKTON (UNITS/M^3)
DURING 1974-76 (FIGURES IN PARENTHESES SHOW PERCENTAGES)

Sectors	LENTIC			INTERMEDIATE			LOTIC	MOYAR
	Littoral	Sub-littoral	Pro-fundal	Litt-oral	Sub-lit-toral	Profu-ndal	Littoral	Littoral
Phytoplankton	1090912 (94.18)	343261 (89.13)	322608 (90.56)	695635 (93.21)	403138 (90.72)	297097 (74.72)	291167 (89.38)	1471332 (97.56)
Zooplankton	67433 (5.82)	41858 (10.57)	33674 (9.44)	50656 (6.79)	41255 (9.28)	100514 (25.28)	34594 (10.62)	36749 (2.44)
Total plankton	1158345	385119	356282	746291	444393	397611	324761	1508081
Volume (ml/m^3)	1.872	1.042	1.192	1.245	0.869	0.767	0.311	1.806

11.1.2 Zooplankton

Zooplankton did not contribute significantly to the plankton (Table VIII). Its abundance was more in the Intermediate sector. The main groups represented were Copepoda, Protozoa, Rotifera and Cladocera. None of the groups showed significant seasonal abundance. Protozoa was represented by Arcella and Actinosphaerium; Copepoda by Cyclops, Diaptomus and nauplii; Rotifera by Keratella, Filinia, Polyarthra, Brachionus and Cladocera by Daphnia.

The plankton of the reservoir was characterised by the dominance of a single species of Anacystis. in the main reservoir and Mougeotia in the Moyar sector. In the early years of impoundment successive dominance of Melosira, Microcystis, Synedra, Navicula and Ceratium was observed in the course of a year (Menon and Chari, 1959) whereas Anacystis (= Microcystis) dominated throughout the year during the present period of study.

11.2 Bottom biota

The qualitative and quantitative abundance of bottom macro-fauna in different sectors is presented in Table IX.

11.2.1 Lentic sector

The average standing crop (units/m^2) of bottom macro-fauna in this sector was estimated to be 1.848 g (119 units). The abundance of biota steadily increased with depth with maximum at 15 m (324 units and 7.605 g/m^2). Thereafter it decreased in the profundal. Oligochaetes, Chironomus and Chaoborus larvae and mayfly nymphs were represented in the biota.

There is no clear variation in the qualitative abundance with depth. Oligochaetes and Chironomus larvae were present at all depths. Chaoborus larvae were also present throughout the bottom except at $\leq$2 m and 15 m depths. Mayfly nymphs, however, were present only at 8 m depth.

TABLE IX

BATHYMETRIC DISTRIBUTION OF BOTTOM MACRO-FAUNA (UNIT AND WEIGHT/ M^2) OF BHAVANISAGAR DURING 1974-1976

Depth (m)	LENTIC			INTERMEDIATE			LOTIC			MOYAR		
	Species	Unit	Weight (g)	Species	Unit	Weight (g)	Species	Unit	Weight (g)	Species	Unit	Weight (g)
< 2	Oligochaetes	1	-	Chironomus	1	0.010	Oligochaetes	264	1.670	Oligochaetes	6	0.040
	Chironomus	1	-				Chironomus	14	0.154	Chironomus	10	0.040
2	Oligochaetes	3	0.007	Oligochaetes	3	0.013	Oligochaetes	692	5.957	Oligochaetes	6	0.070
	Chironomus	3	0.050	Chironomus	5	0.090	Chironomus	48	0.302	Chironomus	14	0.200
	Chaoborus	2	-	Chaoborus	1	-	Chaoborus	3	-	Chaoborus	3	-
										Mayfly nymph	2	0.030
4	Oligochaetes	6	0.054	Oligochaetes	4	0.020	Oligochaetes	681	5.532	Oligochaetes	11	0.050
	Chironomus	2	-	Chironomus	4	0.080	Chironomus	87	0.820	Chironomus	27	0.090
	Chaoborus	6	0.010	Chaoborus	9	0.007				Chaoborus	20	0.020
										Mayfly nymph	11	1.430
										Damselfly nymph	1	0.120
6	Oligochaetes	15	0.050	Oligochaetes	1	0.010	Oligochaetes	130	0.835	Chironomus	14	0.060
	Chironomus	21	0.275	Chironomus	8	0.030	Chironomus	12	0.046	Chaoborus	3	-
	Chaoborus	36	0.046	Chaoborus	28	0.030				Mayfly nymph	3	0.420
8	Oligochaetes	7	0.134	Oligochaetes	22	0.170				Chironomus	7	0.020
	Chironomus	88	2.064	Chironomus	11	0.120				Chaobrous	2	-
	Chaoborus	72	0.056	Chaoborus	58	0.071				Mayfly nymph	6	0.810
	Mayfly nymph	1	0.011									
10	Oligochaetes	3	0.034	Oligochaetes	67	0.830						
	Chironomus	188	2.889	Chironomus	289	5.080						
	Chaoborus	82	0.217	Chaoborus	77	0.094						
15	Oligochaetes	10	0.075	Oligochaetes	1	-						
	Chironomus	314	7.530	Chironomus	29	1.030						
				Chaoborus	20	0.017						
20	Oligochaetes	25	0.800	Chironomus	2	-						
	Chironomus	17	0.462	Chaoborus	1	-						
	Chaoborus	53	0.023									
Average		119	1.848		80	0.963		483	3.829		29	0.680

11.2.2 Intermediate sector

The standing crop of bottom biota in this sector was estimated to be 0.963 g (80 units). The bathymetric distribution was similar to the Lentic sector with an increase in biota with depth, the maximum being at 10 m. The composition of biota was also similar to that of the Lentic sector except for the absence of mayfly nymphs.

11.2.3 Lotic sector

This sector was by far the richest with a standing crop of 3.829 g (483 units). The bulk of the fauna was constituted by oligochaetes. The biota was maximum at 2 and 4 m depths and least at 6 m.

11.2.4 Moyar sector

The standing crop was least in this sector with 0.68 g (29 units). The constituents were similar to that of the Lentic. In addition, damsel-fly nymphs were also encountered. The maximum abundance was noted at 4 m. Chironomids were present at all depths while oligochaetes were present upto 4 m, Chaoborus and mayfly nymphs from 2m onwards and damsel-fly nymphs at 4 m.

The basin in the littoral zones of the Lentic and Intermediate sectors is composed of red soil with stones and pebbles while the rest of the reservoir basin has a soft muddy bottom. The fluctuations in water level frequently expose the littoral zones of the reservoir inhibiting development of bottom fauna. However, the high concentration of oligochaetes in the Lotic sector can be attributed to the muddy soil with a high organic content. The burrowing habits of oligochaetes help them to survive exposed condition in some seasons.

Gastropod shells observed in the Lentic sector were not taken into account as no live ones were observed in the sample though the empty shells were observed in the samples and in the shore areas.

11.3 Aquatic plants

No large aquatic plants were available in the reservoir.

12 FISH FAUNA

In all, 50 species of fish belonging to 11 families were encountered in the reservoir and are listed below :

Class : Teleostomi
Sub-class: Actinopterygii
Order : Clupeiformes
Sub-order: Notopteroidae
Family : Notopteridae
Notopterus notopterus (Pallas)

Order : Cypriniformes
Division: Cyprini
Sub-order: Cyprinoidei
Family : Cyprinidae
Sub-family: Abramidinae

Chela atpar (Hamilton), C. laubuca (Hamilton), C. argentea (Day)

Sub-family: Rasborinae

Barilius gatensis (Valenciennes) Danio malabaricus (Jerdon), Esomus danrica (Hamilton)

Sub-family: Cyprinidae

Tor khudree (Sykes), Acrossocheilus hexagonolepis (McClelland), Catla catla (Hamilton), Cirrhinus mrigala (Hamilton), C. cirrhosa (Bloch), C. reba (Hamilton), Labeo rohita (Hamilton); L. calbasu (Hamilton), L. bata (Hamilton), L. kontius (Jerdon), L. fimbriatus (Bloch), Puntius dubius (Day), P. carnaticus (Jerdon), P. sarana (Hamilton), P. sophore (Hamilton), P. puckelii (Day), P. dorsalis (Jerdon), P. mahicola (Valenciennes), P. melanompyx (Jerdon), P. ticto (Hamilton), P. filamentosus (Valenciennes), P. micropogon (Cuv. & Val.), Osteochilus thomassi (Day), Schizmatorhynchus (Nukta) nukta (Sykes), Osteobrama cotio (Hamilton), O. vigorsii (Sykes), Garra jerdoni (Day), Cyprinus carpio var. communis (Linn.).

Family : Cobitidae

Lepidocephalichthys thermalis (Cuv. & Val.)
Noemachilus beavani (Gunther)

Division : Siluri
Sub-order: Siluroidei
Super family: Siluroidae

Family : Siluridae

Ompok bimaculatus (Bloch), Wallago attu (Schneider)

Family : Bagridae

Mystus aor (Hamilton), M. cavasius (Hamilton), M. tengra (Hamilton), M. punctatus (Jerdon).

Order : Anguilliformes
Sub-order: Anguilloidei
Family : Anguillidae

Anguilla bengalensis (Gray and Hardw.)

Order : Beloniformes
Sub-order : Scomberesocoidei
Family : Belonidae

Xenentodon cancila (Hamilton)

Order : Ophiocephaliformes

Family : Ophiocephalidae (Channidae)

Channa marulius (Hamilton)

Order : Perciformes
Sub-order: Percoidei
Family : Cichlidae

Etroplus suratensis (Bloch), Tilapia mossambica (Peters)

Sub-order: Gobioidei
Family : Gobiidae
Sub-family: Gobiinae

Glossogobius giuris (Hamilton)

Order : Mastocembeliformes
Family : Mastocembelidae

Mastocembelus armatus (Lacepede), M. pancalus (Hamilton)

13 UTILISATION OF FOOD RESOURCES BY THE FISHES

Detritus was the chief food for the fish population in the reservoir. It occurred predominantly in the guts of L. calbasu (95%), C. mrigala (87.5%), P. dubius (94.9%),

C. catla (55%), M. aor (64.9%) and W. attu (59.3%) along with various quantities of zoo- and phytoplankton in the case of carps and fishes in the case of M. aor (27.7%) and W. attu (40.7%). Cannibalism was also observed in W. attu and M. aor. Bottom macrofauna formed a part of the diet in P. dubius, L. calbasu and M. aor. Aquatic insects and insect larvae formed the main food of O. bimaculatus and insects, crustaceans and algae in P. dorsalis.

A study of the food hebits of the fishes of Bhavanisagar reveals that all the available food resources of the reservoir are utilised by the existing fish populations except Anacystis and gastropods. Though Anacystis is not being utilized directly it might be forming one of the main constituents of the detritus on which the fishes mainly subsist.

14 BREEDING BIOLOGY OF FISHES

14.1 L. calbasu

With a view to find out the extent of spawning periodicity in different age groups within the species, studies on the breeding biology of L. calbasu were conducted from December 1977 to November 1979. Specimens collected for the study were divided into four size groups viz., Size group I (301-400 mm), Size group II (401-500 mm), Size group III (501-600 mm) and size group IV (601 mm and above).

Size group I (301-400 mm) : A total of 84 specimens were studied in this size group. Sex ratio between males and females was found in the ratio of 1 : 1.2. During most of the months of the year, gonads, both testes and ovaries, were in the immature stages thereby showing that L. calbasu in this reservoir does not enter life as a breeder unless it attains a growth in length of 400 mm at least. However, some specimens during the month of April/May possessed ovaries in maturing stage. Gonado-somatic index however was the maximum during May both in 1977-78 and 1978-79, being 3.84 and 5.83 respectively.

Size group II (401-500 mm) : About 194 specimens were studied in this group. Sex ratio between males and females was in the order of 1 : 1.06. Males with immature and maturing gonads were available during November to February, with mature gonads during April to June and with spawning and spent gonads during July to September. Females had their gonads in the immature and maturing conditions during the period from October to March, in the mature condition during January to June and the spawning or spent

condition during July to September. Maximum gonado-somatic index obtained was 6.5 and 7.5 during May in 1977-78 and June in 1978-79 respectively.

Size group III (501-600 mm) : A total of 218 specimens were studied in this group. Sex ratio studies revealed that females were more in number than males, with a male : female ratio of 1 : 1.66. Both males and females were in the immature and maturing conditions during September to March, mature condition during April to August and in the spawning or spent conditions during July to October. However, in some specimens, mature gonads were noticed during December and January also. But gonado-somatic index showed a single peak value during May 1977-78 (15.9) and June 1978-79 (12.4).

Size group IV (601 mm and above) : Out of the total 128 specimens studied in this group, 112 were females thereby showing a highly skewed sex ratio between males and females (1 : 9.5). Due to the limited number of males obtained in this group, the occurrence of testes in different maturity stages could not be clearly presented. In females, immature and maturing ovaries were noticed during the period from October to April. Mature ovaries were obtained during May to August and again during December and January. Ovaries in the spawning or spent condition were available during August and September and again in January and February. Maximum gonadosomatic index values were obtained once in May/June and again in December/January. However, the gonado-somatic index values obtained during December/January showed lesser values being 12.3 and 8.0 during 1978-79 and 1979-80 respectively. During May/June, the maximum gonado-somatic index obtained was 22.2 during June, the value and month being the same during both the years.

It may hence be concluded that L. calbasu does not breed in this reservoir before attaining a minimum length of 400 mm. Further the main breeding season of the species in this reservoir is during south-west monsoon extending from April to August. Based on the occurrence of mature ovaries during December/January and spent ovaries thereafter and also the comparatively high values of gonadosomatic indices during these months in advanced size groups (III & IV), it may be inferred that there is a possibility of at least some individuals breeding once again during the north-east monsoon season also.

14.2 C. mrigala

This fish in the range of 246-963 mm (numbers examined, 207) had a sex ratio of males to females 1 : 1.4. Mature gonads were noticed during April-September and spent fish from October. Gonado-somatic index showed a single peak indicating a single breeding season during south-west monsoon. Fecundity range was 1,17,468 (530 mm/1600 g) - 2,77,129 (963 mm/12,100 g).

14.3 C. catla

This fish in the size range of 804-1,082 mm (numbers examined, 74) had a male:female ratio of 1 : 2. Mature gonads were observed during April-May and November. The main breeding season appears to be during south-west monsoon. Fecundity was in the range of 89,902 (807 mm/11,500 g) to 46,29,570 (1,075 mm/29,000 g).

14.4 P. dubius

Fishes in the size range of 412-610 mm were studied. Sex ratio of males to females was 1 : 1.9. Mature fishes were observed during February-June and August-November. The fish breeds during both the monsoon seasons. Fecundity range was 5,544 (435 mm/850 g) - 25,440 (610 mm/3,000 g).

14.5 M. aor

The specimens in the size range of 546-830 mm (numbers examined, 261) showed a sex ratio of 1 : 2 (male : female). Fishes with mature gonads were observed during most of the months. Breeding appears to be round the year. Fecundity range was 22,061 (590 mm/1,100 g) - 27,240 (830 mm/4,200 g).

14.6 W. attu

Sex ratio of male to female of the fish in the size range of 411 - 1,335 mm (numbers examined, 163) was 1 : 3. Mature gonads were observed during July, September, December, February and March indicating round the year breeding. Fecundity ranged between 9,944 (610 mm/ 1,000 g)-5,33,950 (1,335 mm/15,500 g).

14.7 O. bimaculatus

A total of 324 specimens of O. bimaculatus, ranging in length from 140 mm to 398 mm (25 to 198 g) were studied. Sex ratio between male and female was found to be 1 : 1.1. Males with immature gonads were encountered during the period from January to August and again during December. Males with maturing gonads were also obtained during the same period from February to August, while those in the mature condition were noticed during February, July, September and October. Males with spawning and spent gonads were encountered almost throughout the year with a higher percentage during September to November. Females in different stages of maturity were also found to follow almost a similar sequence as that of the males, with the incidence of spawning or spent ovaries occurring in a higher percentage during the period from September to November. It was thus apparent that O. bimaculatus in the reservoir breeds mainly during the North-East monsoon season with stray individuals breeding during the other months also. This can be further supported by the three peaks shown by the gonadosomatic indices during February, May and September in males and during February, July and October in females, with the third peak during September/October showing highest values in both the sexes.

14.8 P. dorsalis : 230 specimens ranging in length from 110 to 192 mm (20 to 100 g) were studied. Sex ratio between males and females was 1 : 75.6 probably due to the small size of the males enabling their escapement from the gear used. Immature ovaries were noticed during January, March and May, while maturing ovaries were obtained during April, May, August and September. Mature and ripe ovaries were noticed throughout the year, while a fully spent ovary was seldom obtained. This and the trimodal peaks of gonadosomatic indices indicate an intermittent breeding habit of the species in the reservoir.

It is interesting to note that mature individuals of most of the fishes were available during a greater part of the year. This seems to be related to the two monsoon seasons that the reservoir is subjected to and the absence of winter with extreme fluctuations in temperature.

15 RECRUITMENT

Spawn survey work was conducted at Moolathurai, about 33 km upstream of the dam site on Bhavani river, during mid-June to mid-September in 1975, 1976 and 1977. Dominant spawn spurts in the form of eggs were observed in the last weeks of July during all the three years. The composition of the spawn on rearing in 1975 was made of L. bata 60.7%, L. calbasu 3.1%, L. fimbriatus 4.1%, C. mrigala 0.1%, P. carnaticus 10.1%, and miscellaneous 21.9%. During 1976, the reared spawn showed a composition of L. bata 90%, C. reba 4.37%, C. catla 0.54%, L. fimbriatus 0.65%, L. rohita 0.12%, L. calbasu 0.82%, L. kontius 1.55% and miscellaneous 0.98%. In 1977, the composition was L. bata 83.0%, L. calbasu 15.0%, C. reba 0.6%, L. fimbriatus 0.16%, L. kontius 0.19%, C. catla 0.04% and miscellaneous 1.01%. The spawn index was not reflected proportionately in the commercial catches of L. calbasu and L. bata. The stray occurrence of spawn of C. catla, L. rohita and C. mrigala and their limited abundance in the catches indicated that there was no large scale breeding and recruitment of these fishes in the reservoir. Hence intensive sustained stocking of these species is necessary to improve their fishery.

Shore collections were made to obtain fry using drag nets of 1.6 mm mesh during 1973 to 1977. However, no fry of commercially important fishes could be obtained except during the first week of May 1977 when fry of L. calbasu measuring 13-21 mm were obtained, indicating that spawning of calbasu occurred in late April.

The floods generally experienced in the Bhavani river are mainly the result of the discharge of water from the Pillur dam - a hydro-electric project about 20 km above Moolathurai. The available breeding grounds cover a stretch of about 5 km between Moolathurai and Nellithurai, the river bed above Nellithurai being steep. Shortage of sufficient migratory space for large size carps like catla, rohu and mrigala may be a reason for their unsuccessful breeding on a large scale. Even the restricted available breeding grounds seem to have been monopolised by medium and small sized fishes like L. bata, C. reba, etc.

16 LENGTH-WEIGHT RELATIONSHIP OF ECONOMIC FISHES

The length-weight relationship of economic fishes based on the study upto 1976 are as under :

Fish species	Length-weight relationship	Correlation Co-efficient (r)
C. catla	$W = 10^{-6} \times 2.3911\ {}_{L}3.2995$	0.703
C. mrigala	$W = 10^{-6} \times 1.6978\ {}_{L}3.2864$	0.9658
L. calbasu	$W = 10^{-5} \times 1.2809\ {}_{L}2.9885$	0.9237
M. aor	$W = 10^{-6} \times 3.0207\ {}_{L}3.0977$	0.9334
W. attu	$W = 10^{-7} \times 7.5875\ {}_{L}3.2846$	0.8206

Further studies on the above species and L. rohita and L. bata gave the following relationships.

C. catla	$W = 3.37 \times 10^{-6}\ {}_{L}3.2561$	r = 0.98
C. mrigala	$W = 2.08 \times 10^{-6}\ {}_{L}3.2642$	r = 0.74
L. rohita	$W = 2.36 \times 10^{-6}\ {}_{L}3.2565$	r = 0.97
L. calbasu	$W = 1.84 \times 10^{-6}\ {}_{L}3.3006$	r = 0.98
M. aor	$W = 7.75 \times 10^{-6}\ {}_{L}2.8420$	r = 0.94

It was found that the values were not significantly different from 3 in all the above cases.

L. bata $W = 4.36 \times 10^{-3}\ {}_{L}2.0219$

On testing the exponent against the value 3 it was observed that $t_{16} = 2.86$ was highly significant showing departure of the relationship from cube law.

The length frequency analysis following Petersen's method showed that C. mrigala reaches a size of 540 mm in 2nd year, 640 mm in 3rd year, 740 mm in 4th year and 820 mm in 5th year. The fish reaches asymptotic length (l_∞) at 1243 mm.

L. calbasu reaches a size of 320 mm in $2^2/3$ years, 420 mm in $3^2/3$ years, 500 mm in $4^2/3$ years, 560 mm in $5^2/3$ years and 630 mm in $6^2/3$ years. The fish reaches asymptotic length (l_∞) at 869 mm.

P. dubius reaches a length of 397 mm at $1^3/4$ years, 457 mm at $2^3/4$ years and 517 mm in $3^3/4$ years.

M. aor reaches the size of 470 mm in 2nd year, 590 mm at 3rd year, 710 mm in 4th year and 790 mm at 5th year. The fish reaches asymptotic length (l_∞) at 1230 mm.

W. attu reaches a size of 500 mm in $1^3/4$ years, 675 mm in $2^3/4$ years, 801 mm in $3^3/4$ years and 900 mm in $4^3/4$ years.

17 FISH CATCH AND CATCH STRUCTURE

The fish yield from the reservoir during the period 1971-72 to 1979-80 (Fig.11) showed a steady increase from 94.462 to 294.12 t in 1976-77. Thereafter it declined to 215.69 t in 1977-78, 196.63 t in 1978-79 and again increased to 210.42 /

The important species encountered in the catch were L. calbasu, C. mrigala, C. catla, L. rohita, P. dubius and L. fimbriatus among carps and M. aor and W. attu among cat fishes.

17.1 Trends in individual fishery

The contribution of different species to the total fishery is given in Table X.

17.1.1 L. calbasu

L. calbasu was the most dominant species throughout the period and its contribution varied between 27.05% (1979-80) to 47.28% (1971-72). The yield of this species was maximum in 1976-77 with 123.14 t and minimum in 1971-72 with 44.66 t.

/ and 251.33 t during 1979-80 and 1980-81 respectively.

TABLE X

ANNUAL YIELD (TONNES) AND YIELD STRUCTURE BHAVANISAGAR (1971-72 TO 1980-81)

Species \ Years	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
L.calbasu	44.663 (47.28%)	46.353 (38.11%)	59.029 (41.08%)	79.771 (38.92%)	71.293 (38.11%)	123.137 (41.86%)	85.280 (39.53%)	84.017 (42.73%)	56.937 (27.05%)	79.956 (31.8%)
C.mrigala	6.193 (6.56%)	12.822 (10.54%)	18.121 (12.60%)	24.141 (11.78%)	24.737 (13.29%)	35.519 (12.07%)	24.382 (11.51%)	9.233 (4.68%)	7.793 (3.70%)	10.148 (4.0%)
C.catla	8.753 (9.26%)	12.099 (9.95%)	7.793 (5.40%)	5.162 (2.52%)	6.589 (3.52%)	19.902 (6.77%)	8.111 (3.76%)	1.999 (1.02%)	3.058 (1.45%)	2.821 (1.1%)
L.rohita	- -	1.406 (1.16%)	1.813 (1.30%)	1.794 (0.87%)	4.809 (2.57%)	22.660 (7.68%)	25.600 (11.86%)	6.613 (3.36%)	8.392 (4.00%)	16.212 (6.4%)
P.dubius	6.640 (7.03%)	9.040 (7.43%)	6.045 (4.21%)	7.438 (3.63%)	9.435 (5.04%)	15.280 (5.19%)	6.038 (2.79%)	5.568 (2.83%)	7.092 (3.37%)	9.979 (4.0%)
L.fimbriatus	- -	- -	1.545 (1.98%)	3.941 (1.92%)	2.960 (1.58%)	2.680 (0.91%)	1.312 (0.60%)	3.789 (1.93%)	13.160 (6.25%)	8.208 (3.2%)
L.bata	- -	- -	6.710 (4.67%)	1.335 (0.65%)	2.484 (1.33%)	5.064 (1.72%)	3.273 (1.51%)	4.096 (2.08%)	1.709 (0.81%)	10.114 (4.0%)
M.aor	14.582 (15.44%)	22.489 (18.49%)	24.119 (16.81%)	58.288 (28.44%)	36.096 (19.30%)	39.432 (13.41%)	25.868 (11.90%)	41.290 (21.00%)	43.923 (20.81%)	64.687 (25.7%)
W.attu	11.235 (11.89%)	13.370 (10.99%)	10.332 (10.33%)	13.684 (6.68%)	22.598 (12.08%)	23.957 (8.14%)	29.198 (13.53%)	20.135 (10.24%)	26.660 (12.67%)	25.598 (10.2%)
Miscellaneous*	2.396 (2.54%)	4.064 (3.34%)	8.152 (6.40%)	9.419 (3.95%)	6.055 (3.42%)	6.484 (2.20%)	6.624 (3.04%)	19.889 (10.11%)	41.699 (19.82%)	20.814 (8.5%)
Total	94.462	121.643	143.659	204.973	187.055	294.115	215.686	196.679	210.423	248.537

*Miscellaneous : I.C.A.R. (Experimental fishing) catch, spoiled & raised fish

17.1.2 C. mrigala

The species contributed only 6.19 t in 1971-72. Its catch increased steadily to a maximum of 35.52 t in 1976-77 and declined thereafter. Its percentage contribution varied between 3.70 and 13.29.

17.1.3 C. catla

The landings of C. catla were maximum in 1976-77 with 19.90 t and minimum in 1978-79 with 1.99 t. The fluctuations in the catches were erratic and its percentage contribution varied between 1.02 to 9.95.

17.1.4 L. rohita

This species contributed meagrely in the initial years of investigation. From a mere 1.4 t in 1972-73 it increased to 25.60 t in 1977-78 but declined in the subsequent years. The percentage contribution was in the range of 0.87 to 11.86.

17.1.5 P. dubius

The catch of P. dubius ranged between 5.57 t in 1978-79 and 15.28 t in 1976-77. The trends in the catches were irregular and the percentage composition varied in the range of 2.79 to 7.43.

17.1.6 L. fimbriatus

This species was almost negligible in the early years. Upto 1978-79 its contribution varied from 1.31 t in 1977-78 to 3.94 t in 1974-75. In 1979-80 the fishery of this species remarkably improved to 13.16 t forming 6.25% of catch.

17.1.7 L. bata

The catches of this species were meagre throughout the period. The catch was significant (6.71 t) in 1973-74 when it formed 4.67% of the total yield. The highest landings (10.1 t) were recorded during 1980-81 but it constituted only 4.0% to the total catches.

17.1.8 M. aor

The species was next to L. calbasu in the total yield. It contributed a maximum of 54.89 t in 1980-81 and a minimum of 14.58 t in 1971-72. The percentage contribution was in the range of 11.90 to 28.44.

17.1.9 W. attu

W. attu was the second important catfish yielding from a minimum of 10.33 t in 1973-74 to a maximum of 29.20 t in 1977-78. Its percentage contribution ranged between 6.68 and 13.53.

17.2 Fishing effort, catch per unit effort and yield

Fishing effort was increased in a phased manner during the period 1971-72 to 1979-80 (Fig. 12). The effective fishing effort (in terms of 50 m hung length of the gill net) was of the order of 30 x 10^3 units in 1971-72, 34 x 10^3 units in 1972-73, 71 x 10^3 units in 1973-74, 103 x 10^3 units in 1974-75, 112 x 10^3 units in 1975-76 and 1976-77, 107 x 10^3 units in 1977-78, 164 x 10^3 units in 1978-79, 202 x 10^3 units in 1979-80/ Taking 1971-72 as the base year the fishing effort was increased by 13% in 1972-73, 136% in 1973-74, 243% in 1974-75, 273% in 1975-76 and 1976-77, 257% in 1977-78, 447% in 1978-79, 573% in 1979-80// Corresponding to the increase in the fishing effort the fish yield increased by 29% in 1972-73, 53% in 1973-74, 117% in 1974-75, 98% in 1975-76, 211% in 1976-77, 128% in 1977-78, 108% in 1978-79, 123% in 1979-80# The low yield in 1978-79 and 1979-80 inspite of the increased effort is probably due to the high water levels maintained during these years (average water level 279.71 and 278.16 m respectively).

/ and 244.10^3 units in '80-81.

// and 713% in 1980-81.

and 128% in 1980-81.

The overall catch/unit effort after increasing to 3.58 kg in 1972-73 from 3.15 kg in 1971-72 declined till 1975-76 (Fig. 12). But it increased again in 1976-77 and dwindled subsequently till 1979-80. It was 1.13 kg in 1980-81.

17.2.1 L. calbasu

The species contributed 44.66 t in 1971-72 with an increase in fishing effort as mentioned above. The annual yield of L. calbasu increased by 14% in 1972-73, 32% in 1973-74, 71% in 1974-75, 60% in 1975-76, 176% in 1976-77, 90% in 1977-78 and 1978-79 and 27% in 1979-80. The catch (kg)/unit effort (50 m length unit) was 1.477, 1.363, 0.827, 0.774, 0.637, 1.099, 0.790, 0.510 and 0.822 during 1971-72

to 1979-80 respectively. The increase in fishing effort thus positively contributed in increasing its yield. The fluctuations in catch/unit may be attributed to normal yearly recruitment variations. This is also reflected by the fact that for identical effort density in 1975-76 and 1976-77 the catch/unit fluctuated as much as 0.637 kg and 1.099 kg respectively. The steep decline in 1979-80 may probably be attributed to the rise in the catch of L. fimbriatus. The annual mean length of the fish varied in the range 465 - 530 mm in the size range of 309-790 mm.

17.2.2 C. mrigala

The annual yield was only 6.19 tonnes in 1971-72. With an increase in effort the yield increased to 107% in 1972-73, 193% in 1973-74, 290% in 1974-75, 299% in 1975-76, 477% in 1976-77, 293% in 1977-78, 49% in 1978-79 and 26% in 1979-80. The catch/unit indices in the above years were 0.205, 0.377, 0.254, 0.234, 0.221, 0.317, 0.227, 0.056 and 0.039 kg respectively. This is a clear case where increased fishing effort coupled with stocking increased the productivity. Low productivity in 1978-79 and 1979-80 is probably due to high water levels and poor stocking. The fish occurred in the size range of 380-980 mm and the annual mean length varied between 623-807 mm.

17.2.3 C. catla

The yield of C. catla was 8.753 t in 1971-72. With an increase in fishing effort its catch registered an increase of 28% in 1972-73, a decrease of 11% in 1973 -74, 41% in 1974-75, 25% in 1975-76 and again an increase of 127% in 1976-77, 7.87% increase in 1977-78, a decrease of 77% in 1978-79 and 65% in 1979-80. The catch/unit indices for the above years were 0.289, 0.356, 0.109, 0.050, 0.063, 0.177, 0.076, 0.012 and 0.015 kg respectively. The catch/unit index clearly points to the fact that the stock is subjected to extreme annual recruitment variations and on that score alone needs intensive stocking over the years till its establishment. The stock density variations are not governed by the fishing effort as the catch/unit index varied from 0.060 kg in 1975-76 to 0.177 kg in 1976-77 even when the effort was the same in both the years. The fish occurred in the size range of 396-1390 mm with the annual mean length varying from 606-913 mm.

17.2.4 P. dubius

In 1971-72 the yield was 6.640 t. With an increase in fishing effort the yield registered an increase of 36% in 1972-73, a decline of 9% in 1973-74, an increase of 12% in 1974-75, an increase of 42% in 1975-76, an increase of 130% in 1976-77, a decline of 9% in 1977-78, a decline of 16% in 1978-79 and an increase of 22% in 1979-80. The catch/unit indices during the above years were 0.220, 0.266, 0.085, 0.072, 0.084, 0.136, 0.056, 0.034 and 0.035 kg and indicate sharp annual recruitment variations. The size range of the fish was 270-770 mm with annual mean length varying from 415-463 mm.

17.2.5 M. aor

In 1971-72 the yield was 14.582 t. With an increase in fishing effort the catch increased by 54%, 65%, 300%, 148%, 175%, 77%, 183% and 202% from 1972-73 to 1979-80. The catch/unit indices during the above years were 0.482, 0.661, 0.338, 0.556, 0.322, 0.352, 0.241, 0.252 and 0.218 kg respectively. The decline in the catch/unit index during 1973-74, 1975-76, 1977-78 and 1979-80 may partly be attributed to inter-generic competition with W. attu which showed increasing trend of productivity with increase in fishing effort. As the fish is capable of breeding in the reservoir itself the possibilities of its being subjected to remarkable recruitment variations is minimal. The fish occurred in the range of 350 mm-890 mm with the annual mean length varying from 631-675 mm.

17.2.6 W. attu

The catch was 11.235 t in 1971-72. Consequent to the increase in the fishing effort the catch registered an increase of 19% in 1972-73, a decline of 8% in 1973-74, an increase of 22% in 1974-75, an increase of 101% in 1975-76, 113% in 1976-77, 160% in 1977-78, 79% in 1978-79 and 130% in 1979-80. ∠ 0.133, 0.202, 0.203, 0.272, 0.113, and 0.132 kg respectively. The higher catch/unit indices in 1971-72 and 1972-73 may be due to the lower fishing effort. The fish occurred in the size range of 412-1725 mm with annual mean length varying from 743-831 mm.

∠ The catch/unit indices in the above years were 0.372, 0.393, 0.145,

18 IMPACT OF STOCKING ON YIELD

Details of stocking during 1971-1980 are presented in Table XI. Both C. catla and P. dubius showed marked changes in recruitment as reflected by catch/unit indices. These fishes require intensive sustained stocking.

18.1 C. catla

The average stocking rate for this fish during 1970-71 to 1974-75 was 3,125 fingerlings/year (less than 1/ha/annum). The stocking was continued again from 1977-78 with 12,000 fingerlings (3/ha), 25,330 (7/ha) in 1978-79 and only 100 in 1979-80. The impact of stocking in 1977-78 and 1978-79 is yet to be felt.

18.2 C. mrigala

It was stocked at the rate of 2,49,070 fingerlings/year (67/ha) during 1970-74. The size range of mrigal in Bhavanisagar was 300-980 mm with the mean length varying in the range of 623-759 mm. The age of this mean size can be attributed to 3+ and 4+. Thus the fingerlings stocked in 1971-72 probably resulted in the catch of 24.1 t in 1974-75. And the heavy stocking in 1972-73 yielded a catch of 24.7 t in 1975-76 and 35.5 t in 1976-77. The results of the stocking in 1974-75 (47/ha) has resulted in 24.4 t in 1977-78. Low stocking in 1975-76 and 1976-77 has resulted in a poor fishery in 1978-79 and 1979-80. The results of stocking in 1977-78 and 1978-79 are yet to be reflected in the fishery. Hence stocking of this species is to be continued to improve the yield.

18.3 L. rohita

The average stocking rate for L. rohita from 1972-73 to 1975-76 was 77893 fingerlings/year (21/ha/year). This appeared to have improved the fishery from 1.4 t in 1972-73 to 22.66 t in 1976-77 and 25.6 t in 1977-78. After 1975-76 the stocking rates of fingerlings were only 2/ha in 1976-77 and 5/ha in 1977-78, with the result that the catches declined to 6.66 t in 1978-79 and 8.4 t in 1979-80. This species also needs stocking support.

18.4 L. fimbriatus

The stocking of this fish was 1,52,386 fingerlings/annum from 1972-73 to 1976-77 (41/ha/year). The

TABLE XI

DATA ON STOCKING OF FISH SEED IN BHAVANISAGAR

	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
C.catla	283	1,975	3,695	5	9,669	-	-	12,000	25,330	100	1,700
L.rohita	-	-	96,752	27,000	32,810	1,54,630	7,000	20,000	49,170	1,89,729	
C.mrigala	1,31,235	71,940	7,65,108	28,000	1,72,447	90,562	18,000	98,400	1,25,350	29,484	1,14,770
L.fimbriatus	-	-	2,46,177	3,45,725	16,408	94,118	59,500	-	71,520	-	-
C.carpio	-	-	1,750	5,11,870	1,71,815	30,499	11,800	-	25,590	-	-
L.calbasu	2,454	1,19,730	-	19,000	21,254	1,26,957	-	-	-	-	-
L.bata	8,589	30,000	-	-	2,074	1,197	-	-	-	-	-
	1,42,561	2,23,645	11,13,482	9,31,600	4,26,477	4,97,963	96,350	1,30,400	2,96,960	2,19,313	1,16,470

(* 3,000 silver carp (32-66 mm) were also stocked during 1980-81)

stocking did not have the desired effect and the catches fluctuated at lower levels between 1.3 t in 1977-78 and 3.9 t in 1974-75. Persistent stocking, however, does not seem to have improved the catch to 13.2 t in 1979-80. As the catch of L. calbasu declined to 56.9 t in 1979-80, it needs to be seen whether the increase in stocks of L. fimbriatus have affected the fishery of L. calbasu .

18.5 C. carpio

It was stocked continuously from 1972-73 to 1976-77 at 1,45,547/annum (39/ha/annum) but the yield has been rather poor. It contributed only 1.2 t in 1979-80. The reasons for its failure could be possible heavy mortality of the seed which was stocked in an advanced fry stage, overlapping of its food habits with the established stocks of L. calbasu and its sluggish nature falling an easy prey to the catfishes.

19 TAGGING AND CLIPPING

About 42,477 fingerlings of L. fimbriatus of average size 34 - 67 mm (0.5 - 2.5 g) in 1972-73 and 13,480 fingerlings of 58-65 mm (2.2-2.4 g) in 1973-74 were clipped and released. The recoveries after a free life ranging from 455-764 days revealed that the fish grows to a size of 257 mm and 391 mm at the end of first and second years respectively. This compares with the sizes attained in Nagarjunasagar of 260 and 370 mm for the identical periods.

Tagging experiments on L. calbasu, L. fimbriatus, P. dubius, C. mrigala and M. aor were however suspended as the tagged fishes were caught within a few hours of their tagging.

20 EXPERIMENTAL FISHING

20.1 Fish distribution in space and time

Fig. 13(a) depicts the catches/50 m net from the four sectors of the reservoir during the years 1978-79 and 1979-80. During both the years the Lotic sector yielded the maximum catches of 2.70 kg and 2.31 kg/50 m net respectively. During 1978-79, the Intermediate sector closely followed the Lotic yielding 1.49 kg while the Moyar sector followed the Intermediate with 1.30 kg. During both the years, the Lentic sector yielded the lowest catches of 0.88 kg and 0.78 kg. Taking the Lentic sector as base the catches during

1978-79 and 1979-80 from the Intermediate sector were 210% and 160%, from the Moyar sector 167% and 210% and from the Lotic sector 306% and 296% respectively. The average catches from the reservoir during 1978-79 and 1979-80 were 1.85 and 1.46 kg/50 m net. A similar decrease in the catch/unit was noticed in the commercial catches also during the period.

Fig. 13(b) shows the quantitative abundance per 50 m net during various months in the two years (data not shown relates to months when fishing could not be conducted). During 1978-79 November, when only Moyar sector was covered, maximum catch of 2.46 kg was obtained. However, in December, when all the four sectors were covered, a maximum catch of 2.19 kg was noticed. In 1979-80, the maximum catch of 2.7 kg was observed during August. It is interesting to note that the maximum catches were during the north-east monsoon in 1978-79 and during south-west monsoon in 1979-80.

20.2 Yield composition - sector-wise and species-wise

Table XII presents the details of the species composition in the four sectors during both the years. In general, all the species were represented in all the sectors during both the years. At the same time the four sectors showed clear variations in the abundance of commercially important fishes. Thus C. catla was abundant in both the years in the Lotic sector followed by Moyar. C. mrigala during the first year showed the same pattern of distribution but during the second year it was more abundant in the Intermediate sector than Moyar. During both the years, L. rohita was more common in Intermediate sector . L. calbasu which forms the most important fishery of the reservoir showed an equal abundance in the Lotic and Intermediate sectors during the first year whereas in the second year it was maximum in the Lotic sector followed by Moyar sector. L. bata, which constituted a major portion of the experimental fishing catches but not properly exploited by the commercial nets, showed a high concentration in the Lotic sector and was fairly abundant in the Intermediate sector also during both the years. P. dubius was more abundant in the Intermediate sector followed by the Lotic sector during first year and during the second year it was more abundant in the Moyar sector followed by the Lotic sector. During both the years, P. sarana was maximum in the Moyar sector. M. aor did not show any clear

TABLE XII

SECTOR-WISE TOTAL CATCH (KG) OF VARIOUS SPECIES IN EXPERIMENTAL FISHING DURING 1978-79 AND 1979-80

Sectors	Moyar		Lentic		Intermediate	
	1978-79	1979-80	1978-79	1979-80	1978-79	1979-80
C.catla	47.050	44.250	13.650	8.000	5.700	12.450
C.mrigala	46.655	43.400	43.675	41.905	32.490	53.490
L.rohita	19.950	-	-	37.000	35.125	49.150
L.calbasu	172.785	266.070	104.180	62.475	480.475	104.505
L.bata	127.865	80.505	53.020	39.670	365.045	195.040
L.kontius	1.680	7.490	1.360	3.100	3.750	0.710
L.fimbriatus	19.210	19.490	4.400	20.795	9.865	4.300
P.dubius	53.675	144.585	31.095	53.565	138.975	59.505
P.carnaticus	11.170	11.900	2.085	1.750	3.285	1.930
P.sarana	137.490	122.755	46.275	69.350	116.455	31.055
M.aor	234.670	183.255	204.620	210.030	242.075	120.000
W.attu	79.635	73.225	32.810	26.390	69.000	24.405
O.bimaculatus	124.645	10.415	80.825	7.185	96.595	4.800
C.reba	46.365	0.270	45.800	0.880	45.190	1.030
Puntius sp.,	43.380	0.520	26.725	0.910	40.605	0.765
Mystus sp.,	4.405	4.530	8.385	1.120	12.980	1.055
T.mossambica	4.385	2.705	0.860	8.545	1.470	2.985
M.armatus	5.305	22.400	3.820	1.735	10.945	5.075
Miscellaneous	0.135	0.470	3.010	0.470	2.535	0.050

(Contd. next page)

(Table XII contd.)

Sectors	Lotic		Total	
	1978-79	1979-80	1978-79	1979-80
C.catla	116.350	137.500	182.750	202.200
C.mrigala	65.300	131.900	188.120	270.695
L.rohita	15.300	17.600	70.375	103.750
L.calbasu	479.105	427.520	1236.545	860.570
L.bata	696.145	454.550	1242.375	769.765
L.kontius	3.890	7.000	10.680	18.300
L.fimbriatus	3.625	13.550	37.100	58.135
P.dubius	116.083	123.720	339.830	381.375
P.carnaticus	3.710	0.950	20.250	16.530
P.sarana	74.825	73.850	375.045	297.010
M.aor	200.670	132.105	882.035	645.390
W.attu	142.135	75.705	323.580	199.725
O.bimaculatus	131.920	12.915	433.985	35.315
C.reba	76.560	0.775	213.915	2.955
Puntius sp.,	30.315	0.840	141.025	3.035
Mystus sp.,	4.890	0.180	30.660	6.885
T.mossambica	2.785	8.800	9.500	23.035
M.armatus	6.185	8.165	27.005	36.625
Miscellaneous	2.455	6.405	8.135	7.395

sectoral variation during both the years. W. attu was more common in the Lotic sector followed by Moyar during both the years. O. bimaculatus showed a slight abundance in the Lotic and Moyar sectors whereas C. reba was more common in the Lotic sector.

20.3 Fish size - mesh bar size relationship

The relationship between length/weight/girth at dorsal fin of fish with mesh bar for the commercially important species is given in Table XIII.

20.4 Effective mesh size for different species

Data on mesh-wise catch of various species during 1978-79 and 1979-80 are given in Tables XIV and XV respectively. When examined in relation with the average total length of individual species obtained in various meshes it is observed that the effective mesh bar ranges from 130-150 mm for C. catla (750-842 mm) in Bhavanisagar. The effective mesh bar for C. mrigala (605-757 mm) and L. rohita (548-929 mm) ranges from 60-85 mm; for L. bata (362-385 mm) from 38-50 mm; for L. calbasu (541-608 mm) from 60-80 mm; for P. dubius (337-377 mm) and P. sarana (247-360 mm) from 35-50 mm; for M. aor (511-644 mm) from 50-70 mm. For smaller fishes like O. bimaculatus, C. reba and Puntius sp., the effective mesh bars are 20-30 mm.

The vulnerability of various species of fish in relation to their weight in nets of different mesh bars has been worked out statistically and is given in Table XVI to enable a fisherman to catch fish of desired weight by operating nets of appropriate mesh bar.

20.5 Percentage species composition in experimental nets and commercial fishing

Percentage species composition of experimental and commercial fishing during 1978-79 and 1979-80 is given in Table XVII. Though much difference is not noticed in the composition of major carps except in C. catla and C. mrigala in second year, significant variations are seen in L. calbasu and L. bata. L. calbasu formed only about 21% in experimental fishing during both the years whereas in commercial fishing it formed 42.7% and 27% during the first and second years respectively. L. bata formed 21.5 and 19.5%

TABLE XIII

RELATIONSHIP BETWEEN LENGTH/WEIGHT/GIRTH AT DORSAL OF FISH WITH MESH BAR OF COMMERCIALLY IMPORTANT FISHES OF BHAVANISAGAR

Species	Regression between length & mesh bar	Regression between weight & mesh bar	Girth and mesh bar
C.catla	L=295.584 + 1.774 M	W=51.006 M - 4541.952	G=0.4192 M + 528.7586
C.mrigala	L=239.379 + 2.867 M	W=45.635 M - 2606.084	G=2.1418 M + 73.1759
L.calbasu	L=283.978 + 1.851 M	W=20.749 M - 778.514	-
L.rohita	L=249.383 + 2.382 M	W=49.362 M - 4041.391	G=2.5966 M - 3.6698
L.fimbriatus	L=198.710 + 1.895 M	W=10.355 M - 222.461	-
P.dubius	L=204.851 + 1.894 M	W=12.348 M - 365.275	-
P.carnaticus	L=102.351 + 2.682 M	W=11.796 M - 403.980	-
L.bata	L=284.107 + 0.988 M	W= 6.771 M - 11.249	-
P.sarana	L=180.562 + 1.000 M	W= 4.995 M - 109.509	-
C.reba	L= 89.005 + 2.518 M	W= 3.789 M - 89.782	-
O.bimaculatus	L=176.376 + 1.675 M	W= 2.555 M - 35.449	-
M.aor	L=350.359 + 1.809 M	W=15.001 M - 418.384	G=1.7641 M + 74.3156

L= Length of fish in mm
M= Mesh bar in mm
W= Weight of fish in gm
G= Girth of fish at dorsal fin in mm

TABLE XIV

MESH-WISE CATCH (kg) OF VARIOUS SPECIES IN BHAVANISAGAR DURING (1978-79)

Species	Mesh-bar (in mm)							
	20	25	30	35	37	45	50	60
C.catla	-	-	-	-	-	-	-	-
C.mrigala	-	-	0.820	5.090	4.045	7.465	10.750	34.050
L.rohita	-	-	-	-	1.150	0.900	3.045	11.780
L.calbasu	2.500	7.650	5.655	13.985	36.730	47.960	85.875	191.660
L.bata	3.900	23.920	149.045	211.540	320.360	306.285	202.685	23.840
L.kontius	-	-	0.930	0.915	1.390	1.655	3.940	1.850
L.fimbriatus	-	0.075	0.140	2.630	3.390	8.090	5.575	5.600
P.dubius	2.710	15.765	49.870	51.970	59.025	39.990	44.130	26.195
P.carnaticus	0.195	0.065	1.635	1.700	3.380	5.550	2.825	3.800
P.sarana	1.175	7.845	39.970	68.745	108.465	87.270	56.695	3.230
M.aor	12.595	14.450	38.645	38.215	65.645	74.885	83.690	92.010
W.attu	12.785	17.175	11.145	17.495	19.150	13.555	8.655	44.490
O.bimaculatus	85.380	239.105	94.740	11.505	2.650	0.415	0.190	-
C.reba	127.390	74.645	10.865	0.390	0.625	-	-	-
Puntius sp.	70.050	60.130	9.190	1.445	0.210	-	-	-
Mystus sp.	9.940	11.895	7.070	1.755	-	-	-	-
T.mossambica	-	0.280	1.395	1.655	1.845	2.970	1.355	-
M.armatus	4.690	7.650	8.980	5.685	-	-	-	-
Miscellaneous	3.310	0.515	0.290	1.195	0.980	0.845	-	1.000
Total	336.620	481.165	430.385	435.915	629.040	597.835	509.410	439.505
Percentage	5.83	8.33	7.45	7.55	10.89	10.35	8.82	7.61

TABLE XIV (CONTD.)

MESH-WISE CATCH (kg) OF VARIOUS SPECIES IN BHAVANISAGAR DURING (1978-79)

Species	Mesh-bar (in mm)								
	65	70	75	80	85	130	135	150	Total
C.catla	-	4.700	8.15	-	-	89.15	48.25	32.50	182.750
C.mrigala	31.450	20.650	22.10	22.70	13.30	15.70	-	-	188.120
L.rohita	8.450	12.100	-	12.45	20.50	-	-	-	70.375
L.calbasu	272.440	199.430	146.76	133.80	92.10	-	-	-	1236.545
L.bata	0.800	-	-	-	-	-	-	-	1242.375
L.kontius	-	-	-	-	-	-	-	-	10.680
L.fimbriatus	6.500	4.000	1.10	-	-	-	-	-	37.100
P.dubius	13.100	15.475	16.75	3.35	1.50	-	-	-	339.830
P.carnaticus	1.100	-	-	-	-	-	-	-	20.250
P.sarana	0.750	0.550	-	-	0.35	-	-	-	375.045
M.aor	103.095	121.345	100.72	68.69	62.20	4.85	-	1.00	882.035
W.attu	22.000	32.040	5.74	30.60	15.85	42.25	13.65	27.00	323.580
O.bimaculatus	-	-	-	-	-	-	-	-	433.985
C.reba	-	-	-	-	-	-	-	-	213.915
Puntius sp.	-	-	-	-	-	-	-	-	141.025
Mystus sp.	-	-	-	-	-	-	-	-	30.660
T.mossambica	-	-	-	-	-	-	-	-	9.500
M.armatus	-	-	-	-	-	-	-	-	27.005
Miscellaneous	-	-	-	-	-	-	-	-	8.135
Total	459.685	400.290	301.32	271.59	205.80	151.95	61.90	60.50	5772.910
Percentage	7.96	6.93	5.21	4.70	3.56	2.63	1.07	1.04	

TABLE XV

MESH-WISE CATCH (kg) OF VARIOUS SPECIES IN BHAVANISAGAR DURING 1979-80

Species	Mesh-bar (in mm)							
	30	35	37	45	50	60	65	70
C.catla	-	-	-	-	-	-	1.000	4.700
C.mrigala	-	0.290	4.855	2.600	5.450	13.950	25.300	37.150
L.rohita	-	-	-	-	2.400	-	5.300	14.800
L.calbasu	6.120	16.945	16.870	13.945	38.790	146.750	127.300	154.100
L.bata	55.855	125.750	199.610	189.170	168.955	28.425	-	2.000
L.kontius	3.830	2.240	5.410	2.615	3.855	0.350	-	-
L.fimbriatus	1.350	2.850	3.020	3.795	7.830	8.970	12.050	15.720
P.dubius	35.280	54.385	69.080	68.370	67.000	48.640	17.080	16.550
P.carnaticus	0.125	0.580	0.935	5.870	3.120	2.150	2.650	1.100
P.sarana	48.085	80.265	77.885	50.360	34.355	5.390	-	-
M.aor	29.380	58.790	52.130	49.585	71.515	98.910	74.800	98.180
W.attu	15.595	14.220	8.120	5.230	15.025	31.150	22.950	8.185
O.bimaculatus	29.540	5.275	0.325	0.075	0.100	-	-	-
C.reba	2.835	0.120	-	-	-	-	-	-
Puntius sp.	2.845	0.190	-	-	-	-	-	-
Mystus sp.	3.765	0.470	-	-	2.650	-	-	-
T.mossambica	3.670	5.250	6.500	4.205	2.265	4.145	-	-
M.armatus	23.845	11.780	1.000	-	-	-	-	-
Miscellaneous	0.940	1.555	-	-	-	-	-	4.900
Total	263.060	380.955	445.740	395.820	423.310	385.830	288.430	357.385
Percentage	6.67	9.67	11.31	10.05	10.74	9.79	7.32	9.07

TABLE XV (CONTD.)

MESH-WISE CATCH (kg) OF VARIOUS SPECIES IN BHAVANISAGAR DURING 1979-80

Species	Mesh-bar (in mm)						
	75	80	85	130	135	150	Total
C.catla	3.200	9.400	-	84.850	76.550	22.500	202.200
C.mrigala	41.350	70.150	69.600	-	-	-	270.695
L.rohita	12.750	24.500	18.500	25.500	-	-	103.750
L.calbasu	145.500	96.300	97.950	-	-	-	860.570
L.bata	-	-	-	-	-	-	769.765
L.kontius	-	-	-	-	-	-	18.300
L.fimbriatus	1.450	1.100	-	-	-	-	58.135
P.dubius	1.510	3.480	-	-	-	-	381.375
P.carnaticus	-	-	-	-	-	-	16.530
P.sarana	0.670	-	-	-	-	-	297.010
M.aor	41.250	30.000	30.900	8.700	1.250	-	645.390
W.attu	13.300	8.200	30.000	18.400	4.600	4.750	199.725
O.bimaculatus	-	-	-	-	-	-	35.315
C.reba	-	-	-	-	-	-	2.955
Puntius sp.,	-	-	-	-	-	-	3.035
Mystus sp.	-	-	-	-	-	-	6.885
T.mossambica	-	-	-	-	-	-	23.035
M.armatus	-	-	-	-	-	-	36.625
Miscellaneous	-	-	-	-	-	-	7.395
Total	260.980	243.130	246.950	137.450	82.400	27.250	3938.690
Percentage	6.62	6.17	16.26	13.48	2.09	0.69	

TABLE XVI

VULNERABILITY OF FISH (gm) VIS-A-VIS MESH BAR (mm) OF GILL NETS

Species	Mesh bar (mm)															
	20	25	30	35	38	45	50	60	65	70	75	80	85	130	135	150
C.catla	-		-	-	-	-	-	-	2089	2599	3109	3619	4129	8720	9230	10760
C.mrigala	-	-	132	508	816	1501	1957	2870	3326	3783	4239	4695	5152	9259	-	-
L.calbasu	-	259	466	674	778	1088	1296	1711	1919	2126	2334	2541	2749	-	-	-
L.rohita	-	-	-	-	339	401	895	1802	2376	2869	3363	3857	4350	8793	9286	10767
L.fimbriatus	-	295	399	502	554	709	813	1018	1121	1224	1328	1431	-	-	-	-
P.dubius	-	252	376	499	561	746	869	1116	1240	1363	1487	1610	1734	-	-	-
P.carnaticus	-	186	304	422	481	658	776	1012	1130	1247	-	-	-	-	-	-
L.bata	-	327	395	462	496	598	667	801	869	937	-	-	-	-	-	-
P.sarana	-	140	190	240	265	340	390	490	540	590	640	690	740	-	-	-
C.reba	61	100	133	175	194	251	289	-	-	-	-	-	-	-	-	-
O.bimaculatus	67	92	118	143	156	194	220	-	-	-	-	-	-	-	-	-
M.aor	-	332	402	632	707	932	1082	1381	1532	1682	1832	1982	2132	3482	3632	4082

TABLE XVII

PERCENTAGE CATCH COMPOSITION IN EXPERIMENTAL AND COMMERCIAL NETS DURING 1978-80

Species	1978-79		1979-80	
	Experi-mental	Commer-cial	Experi-mental	Commer-cial
C.catla	3.16	1.0	5.13	1.4
C.mrigala	3.25	4.7	6.87	3.7
L.rohita	1.21	3.4	2.63	3.9
L.calbasu	21.41	42.7	21.84	27.0
L.bata	21.52	2.1	19.54	0.8
L.fimbriatus	0.64	1.9	1.47	6.2
P.dubius	5.88	2.8	9.68	3.4
P.carnaticus	6.49	0.8	7.54	-
C.reba	3.70	-	-	-
O.bimaculatus	7.51	-	0.89	-
Puntius sp.	2.44	-	-	-
M.aor	15.27	21.0	16.38	20.8
W.attu	5.60	10.2	5.07	12.6
Miscellaneous	1.92	*9.1	2.96	*19.8

* I.C.A.R. Experimental catch, spoiled and seized fish

during the two years respectively in the experimental catches but it formed only 2.1 and 0.8% during the two years respectively in commercial fishing. Similarly P. dubius formed 5.9 and 9.7% in experimental fishing and 2.8 and 2.4% in commercial fishing during the two years respectively. P. carnaticus formed 6.5 and 7.5% in experimental fishing while it was meagre or absent in commercial fishing. The higher catches of cat-fishes in commercial fishing can be attributed to occasional use of hooks and lines. Smaller fishes like O. bimaculatus, C. reba and Puntius spp. were not at all represented in the commercial catches. Thus, it is evident that populations of L. bata, P. carnaticus, Puntius spp. and O. bimaculatus are not properly exploited.

21 FISHERY POTENTIAL OF BHAVANISAGAR RESERVOIR VIS-A-VIS PRESENT YIELD

It has been found from primary productivity studies that the energy fixed by producers is very high in the reservoir, 29,794 x 10^3 Kcal/ha/yr (average value from April 1973 to March 1977). The net energy assimilated by producers is of the order of 16,387 x 10^3 Kcal/ha/yr which shows that only 55% of the energy fixed is stored by the primary producers and is available for consumers. The net production studies have shown that the reservoir has a fishery potential of 155 kg/ha. Taking the average area as 3,695 ha, the reservoir has a fish potential of 572.7 tonnes/annum. The actual per hectare yield from the reservoir was 26 kg in 1971-72, 33 kg in 1972-73, 40 kg in 1973-74, 55 kg in 1974-75, 51 kg in 1975-76, 80 kg in 1976-77, 58 kg in 1977-78, 53 kg in 1978-79, 57 kg in 1979-80/(Fig.11). The average yield from the reservoir (1973-74 to 1976-77) works out to 207.9 tonnes. Hence it is clear that only 31.1% of the potential yield is being harvested and there is enough scope of increasing the yield. The above calculation of fish potential is based on the assumption that all the energy available for the consumers comes from sun through conversion of light energy to chemical energy by primary producers. However, the reservoir receives a good amount of energy from allochthomous source and taking this source also into account the reservoir can sustain more fish than shown above. Comparison of energy output from the reservoir (55.34 x 10^3 Kcal/ha/yr) with energy fixed by producers reveals that 0.2% of the energy at producer level is harvested as fish.

/ and 68 kg in 1980-81

22 PEN CULTURE

Acute shortage of rearing space for raising fingerlings for stocking the reservoirs is a great constraint. To circumvent this problem, experiments on pen culture were undertaken on rearing hatchlings to fingerlings stage. The pen was managed following the pond culture principles. In 1979, five days' old C. mrigala hatchlings (7 mm) numbering 65,000 and 3 days' old hatchlings of L. fimbriatus (5 mm) numbering 50,000 were stocked in a 0.028 ha pen installed in Poongar swamp at Bhavanisagar. The area was enclosed using bamboo frames and nylon netting (0.78 and 1.56 mm mesh). The hatchlings were artificially fed on groundnut oil cake and rice bran (1 : 1). Partial harvesting of 12,210 advanced fry of L. fimbriatus (28 mm) and 7,875 advanced fry of C. mrigala (38 mm) was made after a month's rearing. Final harvest yielded 1,550 fingerlings of L. fimbriatus (75 mm) and 10,851 fingerlings of C. mrigala (88 mm) after a further rearing of two months. The production rate thus was 7.83 lakhs of advanced fry and 4.96 lakhs of fingerlings/ha. The overall survival rate of hatchlings to advanced fry and fingerlings was 27.8%. The input-output ratio worked out to 2.58.

During 1980, the pen was stocked with 1,40,000 hatchlings of C. mrigala at 5 million/ha. While a compounded feed comprising ground nut oil cake, rice bran, fish meal, soyabean, vitamin B_{12} and mineral mix was used as feed during the first month, ground nut oil cake and rice bran (1:1) alone were used during the second and third months. A total of 300 kg of feed was used. The pen was harvested after 90 days' of rearing and a total of 14,022 fingerlings (96.5 mm/9.5 gm) obtained, the yield working out to 0.5 million/ha or 4,750 kg/ha. The carrying capacity of the pen thus seems to be about 0.5 million/ha and in this context, the stocking density could be reduced and a higher survival obtained.

23 ACKNOWLEDGEMENTS

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

24 REFERENCES

Chacko, P.I. and P. Dinamani (1949). Preliminary report on the fishery resources of the Bhavani river in relation to the Lower Bhavani Project. Indian Sci. Congr., 36(3) : 166

Devaraj, M. (1973). Biology of the large snake-head, Ophicephalus marulius (Ham) in Bhavanisagar waters. Indian J. Fish., 20(2) : 280-307

Dorai Raj, K.H. and N. Pankajam (1956). Limnology of Bhavanisagar (Reservoir). Fish.Sta. Report. 1954-55, Department of Fisheries, Madras, 323-345.

Franklin, T. (1969). Phytoplankton of Bhavanisagar Reservoir. Madras J. Fish. 5 : 112-118.

Government of India (1976). Report of the National Commission on Agriculture. Part VIII Fisheries. Ministry of Agriculture and Irrigation. New Delhi

Menon, M.D. and S.T. Chari (1959). Annual report of the Freshwater Biological Station, Bhavanisagar for the year 1955-56. Government of Madras, Fisheries Station Reports and Year Book. 20-44

Natarajan, V. (1971). Biology and fishery of L. calbasu (Hamilton) in Bhavanisagar reservoir. Mad. J. Fish., 6 : 14-56.

Ranganathan, V. and Radha, N.V. (1966). Biology and fisheries of Mystus (Osteobagrus) aor (Sykes) in the Bhavanisagar reservoir. Madras J. Fish., 2 : 11-14

_____ and E.R. Venkataswamy (1967). On the efficiency of the "Mettur Rangoon" nets in the Bhavanisagar reservoir. Ibid, 3 : 46-60

Ranganathan, V., V. Ramachandramenon and N.V. Radha (1962). Biology and fisheries of B. dubius (Day) in the Bhavanisagar reservoir Madras J. Fish., 1 : 1-24.

Sreenivasan, A. (1962). A note on the hydrology of Bhavanisagar reservoir for the years 1956-61. Madras J. Fish., 1 : 70-71

Sreenivasan, A. (1964). A hydrobiological study of a tropical impoundment, Bhavanisagar reservoir, Madras State, India for the year 1956 to 1961. Hydrobiologia, 24 (4) : 514-539.

Sreenivasan, A. (1970). Limnology of Tropical impoundments : a comparative study of the major reservoirs in Madras State (India). Hydrobiologia, 36 (3 & 4) : 443-469

Sreenivasan, A., R. Sundararaj and Felicy Antony (1969). Limnological studies of tropical impoundments. 11. Hydrological features and plankton of Bhavanisagar Reservoir (Madras State) for 1961-62. Proc. Indian Acad. Sci., 59 : 53-70.

25 SUMMARY

1 Bhavanisagar, constructed in 1953 on Bhavani river in Periyar district of Tamil Nadu with the twin objectives of meeting the irrigation needs and flood control, has an average water area of 3,695 ha.

2 The reservoir has a shore-line length of 125.5 km, shore development of 4.01 and volume development of 0.94 at Full Reservoir Level (FRL).

3 The water levels in the reservoir fluctuated between 256.64 to 280.42 m, the area and capacity of the reservoir between 745 to 7,877 ha and 2,501 to 92,889 ha-m respectively.

4 The inflow and outflow were the maximum during 1979-80, being 42,007 and 42,413 cusecs respectively, and, minimum during 1976-77, being 14,731 and 16,378 cusecs respectively. Though the reservoir is subject to both the monsoons, the maximum inflow is generally received during November-December (North-east monsoon). The inflow is also largely governed by the discharge from the Pillur Dam.

5 The basin soil of the reservoir is acidic (pH, 5.2-6.4) in nature and rich in organic carbon (1.83-2.68%) and available nitrogen (31.6-50.8 mg/100 g) but poor in available phosphorus (1.00-3.58 mg/100 gm).

6 Total alkalinity (41.6 ppm), calcium (15.5 ppm), organic matter and specific conductivity (263.4 µmhos) were 4 ppm high in the Intermediate sector in surface water.

7 Nitrate-nitrogen in the reservoir varied from traces to 0.34 ppm while phosphates from traces to 0.06 ppm. Ferric iron ranged from nil to 1.5 ppm and silica from 1.6 to 18.0 ppm. Seasonal variations in nutrient features of the reservoir were not marked.

8 The effluents of the Viscose Rayon Factory at Sirumughai affect both the plankton and fish resulting in kills especially when the inflow of water in the river is poor. The effluents adversely affect the water quality, though in a limited stretch, reducing the pH and oxygen levels to 4.0 and 1.0 ppm respectively and increasing the carbon dioxide concentration to 126 ppm.

9 No thermal stratification was observed in the reservoir, maximum difference between surface and bottom waters being 3°C. However, a strong oxycline and klinograde distribution of oxygen was noted.

10 A strong chemical stratification resulting in the decline in pH from surface to bottom and an increase in carbondioxide, bicarbonate, and specific conductivity indicating high photosynthetic and tropholytic activities point to the productive nature of the reservoir. The stratification is broken either by heavy monsoon inflow or heavy wind.

11 Marked diurnal variations in carbonate and bicarbonate were noted in September 1975 and March 1976 but the magnitude of variation was otherwise of a low order.

12 The average gross and net production during 1973-77 were 830.79 and 458.35 mg C/m^2/day respectively, both gross and net primary production being the highest in the Moyar sector. The photosynthetic efficiency in the reservoir works out to 0.412%.

13 Phytoplankton dominated throughout the year contributing about 90% to the total plankton production in the reservoir and was mainly represented by Anacystis. Its maximum abundance was recorded in the Lentic sector.

14 Lotic sector was by far the richest (3.83 gm/483 units/m^2) in abundance of bottom biota, oligochaetes being the main constituents.

15 No large aquatic plants are available in the reservoir.

16 The fish fauna of the reservoir comprised 50 species belonging to 11 families.

17 Detritus, however, formed the chief food of the fish population in the reservoir occurring to the extent of 87.5 to 95.0% in the guts of L. calbasu, C. mrigala and P. dubius. Even C. catla (55%), M. aor (65%) and W. attu (59%) were found to subsist on detritus. Anacystis, though not utilized by any fish directly, is probably taken as detritus.

18 While the Gangetic carps breed mainly during the South-west monsoon, L. calbasu seems to spawn during North-east monsoon also.

19 Studies on recruitment have indicated that L. bata spawns heavily in Bhavani river. While L. calbasu formed a sizeable percentage of the eggs collected at Moolathurai, occurrence of C. catla, L. rohita and C. mrigala was very scarce indicating their poor recruitment in the reservoir.

20 Certain aspects of the biology of L. calbasu, C. mrigala, C. catla, P. dorsalis, P. dubius, O. bimaculatus, M. aor and W. attu have been studied.

21 Fish yield from the reservoir increased as a result of increased fishing effort from 94 t in 1971-72 to an average of 233 t during the 5-year period from 1976-77 to 1980-81, the maximum being 294 t during 1976-77. L. calbasu was the most dominant species in the catch forming 27.05-47.28%. The catch/ha during 1980-81 was 68 kg.

22 The high catch/unit effort index for L. calbasu indicates abundance of its stocks with normal variations in yearly recruitment. The low and fluctuating catch/unit effort indices for C. catla and L. rohita show their poor abundance in the reservoir and extreme fluctuations in recruitment. Even the present increased density of fishing effort does not seem to affect the fishery of M. aor as indicated by high catch/unit-effort. There appeared to be some intergeneric competition between M. aor and W. attu but an increased fishing effort showed increased productivity of W. attu as well as that of M. aor.

23 The stocking rates of C. catla and L. rohita have been rather poor being 1-7 and 2-21 fingerlings/ha/yr respectively but they always had some effect on the fishery. Stocking of L. fimbriatus (41 fingerlings/ha/yr) and C. carpio (39 fingerlings/ha/yr) have however, had no effect on their fisheries.

24 Experiments on clipping of L. fimbriatus indicated that the species attains a size of 257 and 391 mm after a free life of 455 and 764 days in the reservoir.

25 Experimental fishing has indicated that L. bata, L. calbasu, C. catla, C. mrigala and W. attu form heavy catches in the Lotic sector followed by Intermediate/ Moyar sectors. The catch/unit effort is also the maximum in the Lotic sector.

26 Relationships between fish-mesh bar sizes have been established. Effective mesh bar for Catla fishing in the reservoir has been found to range from 130-150 mm, for L. rohita and C. mrigala 60-85 mm and for L. bata 38-50 mm. Vulnerability of various sizes of fish in relation to mesh bar has been worked out statistically.

27 A comparison of the catches of experimental and commercial fishing has indicated that while L. calbasu and L. bata are equally abundant in the reservoir, the population of L. bata remains commercially unexploited.

28 Based on productivity studies, the fish production potential of the reservoir has been estimated to be 155 kg/ha or 573 t/year. This does not include the energy entering the reservoir from allochthonous sources. A comparison of the energy output from the reservoir with energy fixed by the producers shows that only 0.2% of the energy at producer level is harvested as fish.

29 Experiments on pen culture in Poongar swamp, located in the fish farm adjoining the reservoir, have shown the possibilities of rearing about 0.5 million fingerlings/ha.

26 PUBLICATIONS

Published

1. Mathew Abraham (1979). Studies on the bottom macro-fauna of Bhavanisagar reservoir (T.N.). J. Inland Fish. Soc. India, 12(2) : 41-48

2. _____(1979). Seasonal distribution and quantitative distribution of plankton of a medium sized reservoir, Bhavanisagar. In Proceedings of Summer Institute on Capture and Culture Fisheries of the Man-made Lakes in India, Central Inland Fisheries Research Institute, Barrackpore. 7 July - 6 August 1979.

3. _____ and S. Sivakami (1979). Stock distribution in time and space in Bhavanisagar as reflected from the experimental fishing during the year 1978-79. Ibid.

4. Ch. Gopalakrishnayya and Mathew Abraham, 1979. The extent of utilization of fish food organisms by economic fishes of Bhavanisagar reservoir. Ibid.

5. Ch. Gopalakrishnayya, 1979. Role of tagging/clipping in evaluation of age and growth in fishes - A case study in respect of L. fimbriatus in Bhavanisagar. Ibid.

6. _____ 1979. Impact of stocking on yield trends in Bhavanisagar with particular reference to L. rohita and C. mrigala. Ibid.

7. _____ 1979. Fish production trend in relation to phased increase in fishing effort in Bhavanisagar reservoir. Ibid.

8. _____ . Age and growth rate of commercially important fishes of Bhavanisagar. Ibid.

9. Gupta, B.P. 1979. Soil characteristics of Bhavanisagar reservoir. Ibid.

10. _____ 1979. Impact of effluents of viscose industry on water quality and fish productivity. Ibid.

11. _____ 1979. Hydrological features of Bhavanisagar reservoir. Ibid.

Under publication

12. Mathew Abraham. Preliminary observations on rearing of hatchlings to fingerlings in pens. (MS).

13. _____. Breeding of carps in Bhavanisagar (T.N.) with special reference to the effect of Pillur Dam (MS).

15. _____ and S. Sivakami. Fisheries of Bhavanisagar reservoir (TN) as reflected by commercial fishing and experimental fishing with special reference to L. bata (Ham). (MS).

16. _____. Mesh selectivity of important fishes of Bhavanisagar reservoir (TN), with special reference to their vulnerability to gill nets. (MS)

17. S. Sivakami and Mathew Abraham. Studies on the fry of L. calbasu from Bhavanisagar reservoir. (MS)

18. _____. Biology of Puntius dorsalis from Bhavanisagar. (MS)

19. _____. Biology of Ompok bimaculatus with special reference to its abundance in Bhavanisagar. (MS)

20. S. Sivakami. Studies on the induced breeding and larval development of Rasbora deniconius. (MS)

21. Gupta, B.P. A limnological study of chemical stratification in Bhavanisagar reservoir (T.N.). (MS)

22. _____. Studies on primary productivity in Bhavanisagar reservoir (T.N.). (MS).

27 RECOMMENDATIONS ON CONSERVATION AND DEVELOPMENT OF THE FISHERIES OF BHAVANISAGAR

1 There are clear indications of extended breeding of economic carps covering south-west and north-east monsoons. Fishing intensity may be reduced to half the present level if not totally prohibited during the period.

2 The natural recruitment of the Gangetic major carps other than L. calbasu, is of rather low order as evidenced by an almost negligible percentage of their young ones in spawn collections made at Moolathurai from 1975-77. However, the three Gangetic carps viz. catla, rohu and mrigal have formed a good fishery in certain years depending on their stocking. Hence it is recommended that regular and intensive stocking of three major carps may be taken up on a priority basis with a view not only to augment the total yield but also help improve their recruitment and subsequent establishment.

3 The stocking rates of catla, rohu and mrigal work out to 1.8, 19.5 and 41.4 fingerlings/ha during the 9-year period from 1971-80. Even this rate of stocking has resulted in average yields of 8.2, 8.1 and 18.03 t/annum respectively. It is therefore recommended that stocking may be done at 50 fingerlings (150 mm)/ha in the proportion of 3 catla : 3 rohu : 2 mrigal : 1 P. carnaticus and 1 P. dubius.

4 The reservoir water is quite rich in calcium and would favour development of molluscan biota. Suitable species of molluscs adapted to lacustrine conditions be transplanted from Nagarjunasagar. In the long run this may facilitate development of Pangasius fishery like Nagarjunasagar.

5 The dominant plankton of the reservoir being Microcystis, it is suggested that C. catla with medium-sized pectoral fin (P_M) from Rihand reservoir, which is known to consume Microcystis may be transplanted for better utilization of this abundant food resource.

6 Bhavanisagar ecotope also favours introduction of catla x rohu hybrid which is as much detritophagic as it is phytoplanktophagic.

7 Stocking of L. fimbriatus has not improved fish yield of this species. Hence stocking of this species may be discontinued.

8 About 2,953,169 advanced fry of common carp have been stocked between 1972-73 and 1976-77 but the species has failed to establish its fishery.

9 Experiments on pen culture in a swamp adjoining Bhavanisagar have shown the possibilities of raising fingerlings on a large scale in a limited area. Adoption of this technology would help in raising the fingerlings for stocking the reservoir. The production could be as high as 0.5 million fingerlings/ha.

10 The reservoir has a production potential of 155 kg/ha i.e. 573 tonnes for the reservoir. As against this the present level of yield is 63 kg/ha or 233 t (1976-77 to 1980-81). To realise the potential yield the reservoir must be stocked with catla, rohu and mrigal. In addition fishing may be restricted to half the normal fishing intensity during south-west (June and July) and north-east (October and November) monsoon.

11 The existing fish farm may be suitably improved so that it serves the seed requirement of Bhavanisagar.

12 Cage culture experiments may be attempted with silver carp.

13 The results of experimental fishing indicate that the Lotic sector has the maximum stock abundance and as such the catches are the heaviest in this sector. It is recommended that fishing may be intensified in the Lotic sector and multi-meshed gill nets (mesh bar, 40-150 mm) operated to effectively exploit the different fish populations. Moyar and Intermediate sectors are the next best fishing areas which need intensive exploitation.

14 A comparison of the catches of experimental (20%) and commercial (1.5%) fishing has revealed that the abundant population of L. bata in the reservoir remains almost un-exploited. It is therefore suggested that nets with 38-50 mm mesh bar may be used for effective exploitation of L. bata in the size range of 362-385 mm/600 g. L. bata is especially abundant in the Lotic sector.

15 The present fishing effort in the reservoir, which is of the order of about 200,000 units*(each unit comprising 50 m hung length), may not be increased any further till suitable stocking measures to build up the stock strengths of various species are undertaken. Any increase in fishing effort is likely to result in a reduced catch/unit-effort thereby rendering it uneconomic to the commercial fishermen.

16 Nets with the following sizes of mesh bar are recommended for effective exploitation of commercially important species in the reservoir

Species	Mesh bar (mm)
C. catla	130-150
L. rohita	60-85
C. mrigala	60-85
L. calbasu	60-85
L. bata	30-50
P. dubius	30-60
P. sarana	35-50
M. aor	37-85
O. bimaculatus	20-30

17 L. bata, which is a choice fish and fetches a good market price, constitutes about 80% of the spawn collections at Mulathurai. The centre could be regularly exploited and the collections thus made utilized for culture.

18 Pollution caused by Rayon Viscose factory effluents at Sirumughai may be monitored periodically to keep the pollutional effects under control.

---

* Equivalent to an average of 40 fishing units/day as recognised by the State Department. It will, however, be advantageous if the present level of fishing effort is scaled down to an average of 30 fishing units/day until the reservoir is suitably developed by stocking as recommended.

28 SUGGESTIONS FOR FUTURE WORK

It is suggested that the following investigations may be continued/or taken up afresh :

(i) Collection of data on total and species-wise catch of all commercially-important species and catch/unit effort.

(ii) Length frequency of all commercially-important species

(iii) Assessment of index of spawn quality and quantity at Mulathurai during both the north-east and south-west monsoons.

(iv) Induced breeding of major carps during north-east monsoon to augment the seed resource.

TEXT FIGURES : 1 - 13

PLATES : Fig. 1 - 18

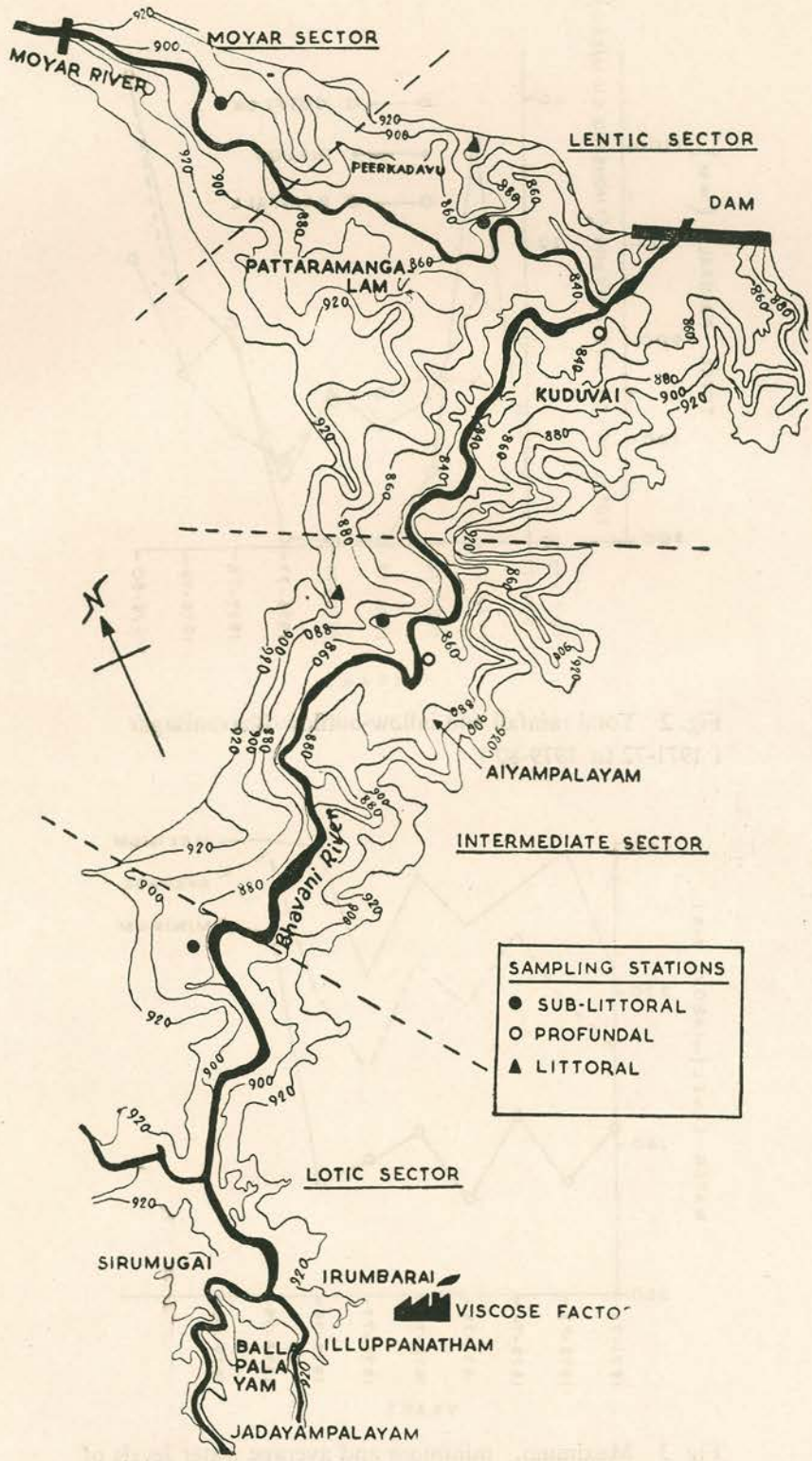

Fig. 1 Bhavanisagar reservoir showing sectoral demarcation and sampling centres

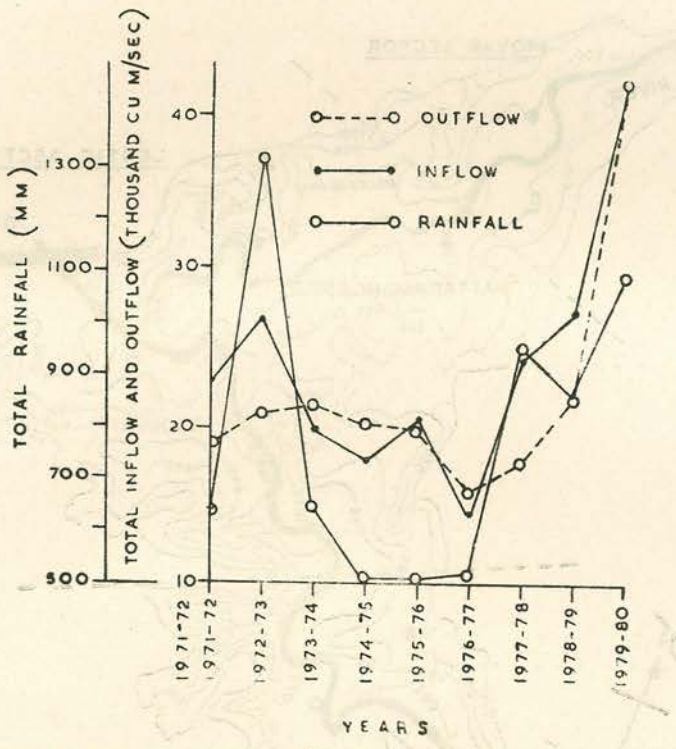

Fig. 2 Total rainfall and inflow-outflow-Bhavanisagar (1971-72 to 1979-80)

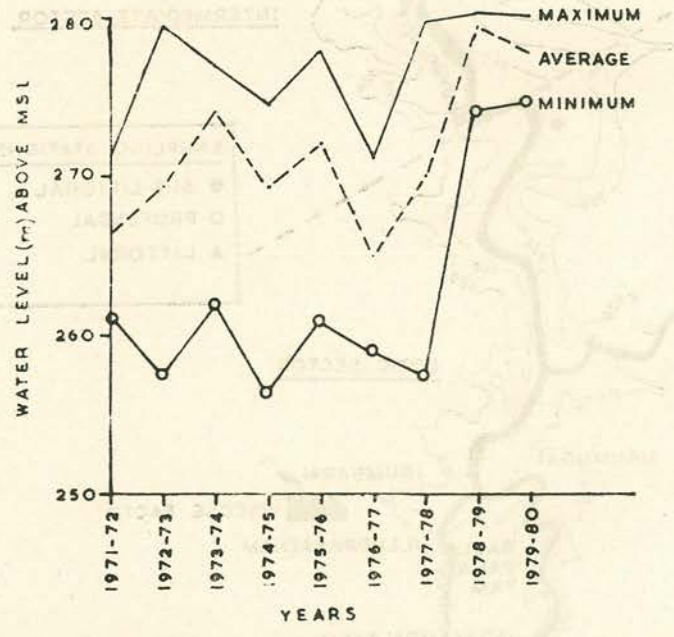

Fig. 3 Maximum, minimum and average water levels of Bhavanisagar (1971-72 to 1979-80)

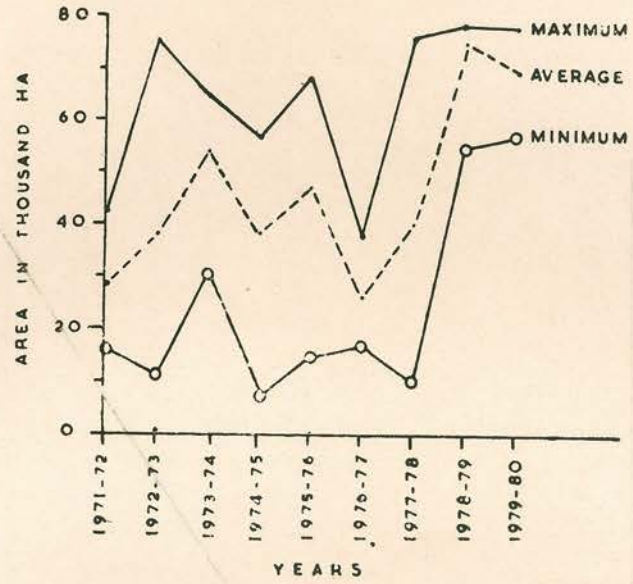

Fig. 4 Maximum, minimum and average area of Bhavanisagar (1971-72 to 1979-80)

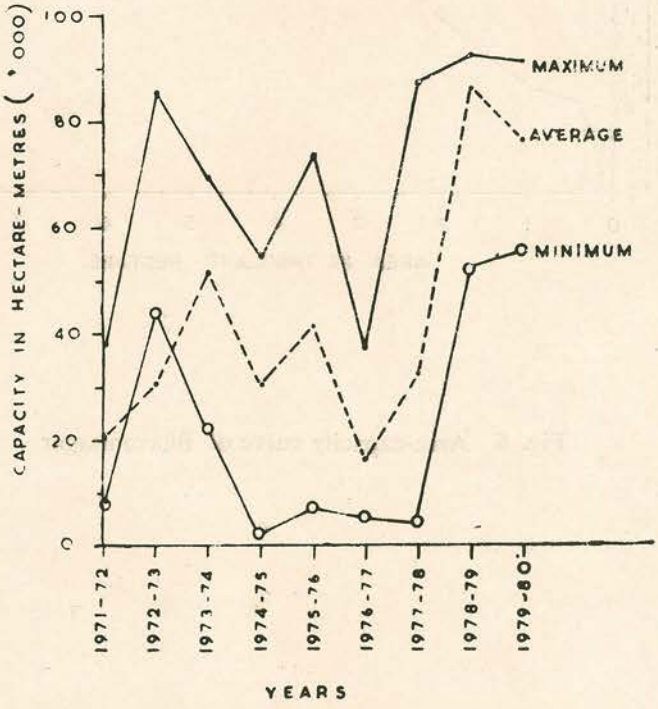

Fig. 5 Maximum, minimum and average capacity of Bhavanisagar (1971-72 to 1979-80)

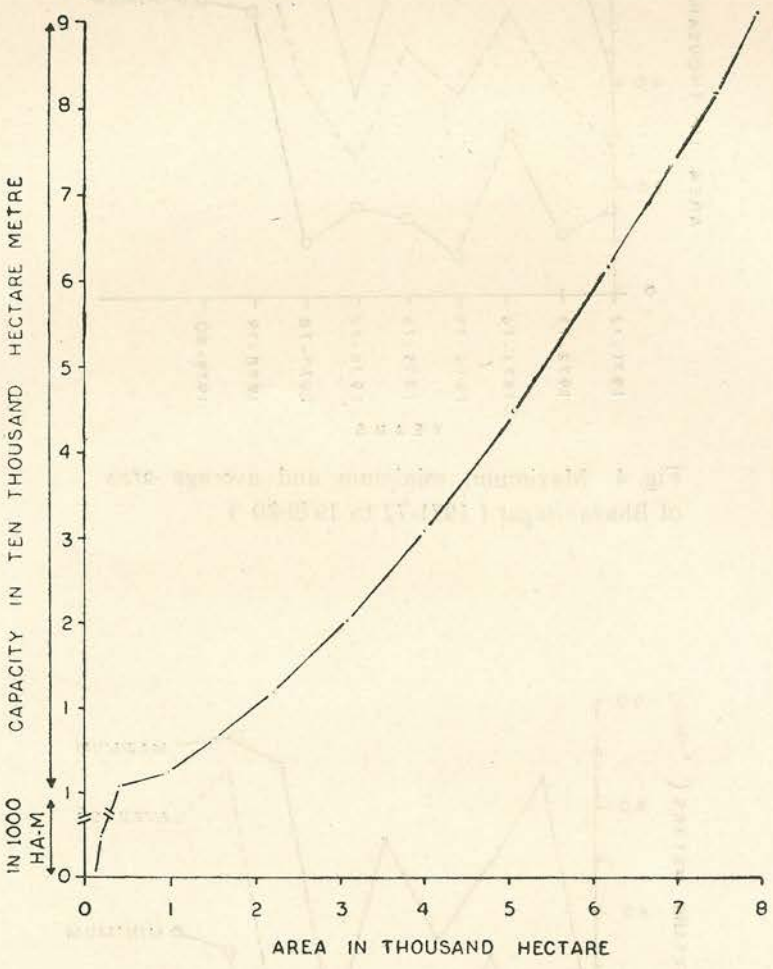

Fig. 6 Area-capacity curve of Bhavanisagar

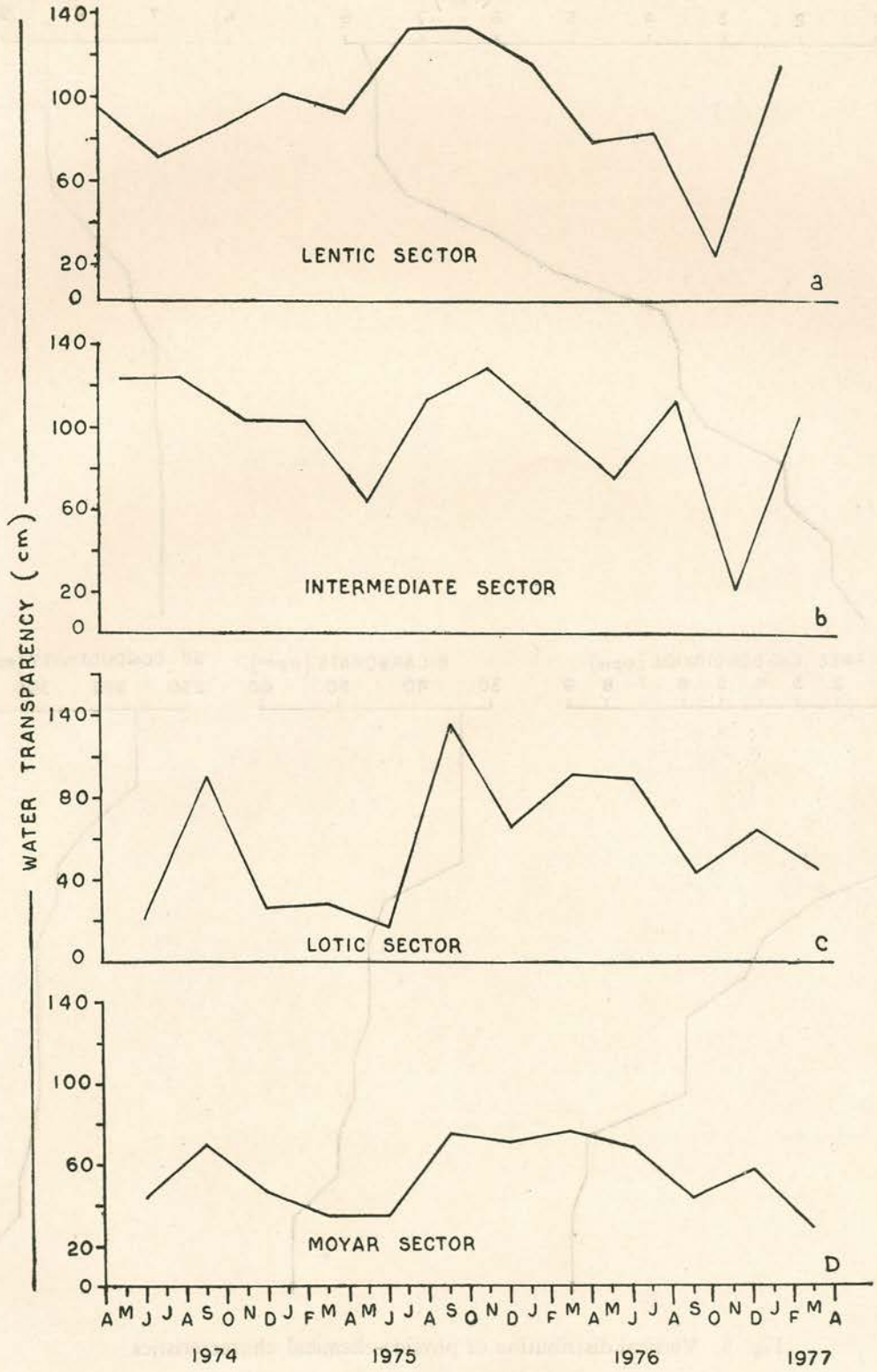

Fig. 7 Water transparency in Bhavanisagar reservoir

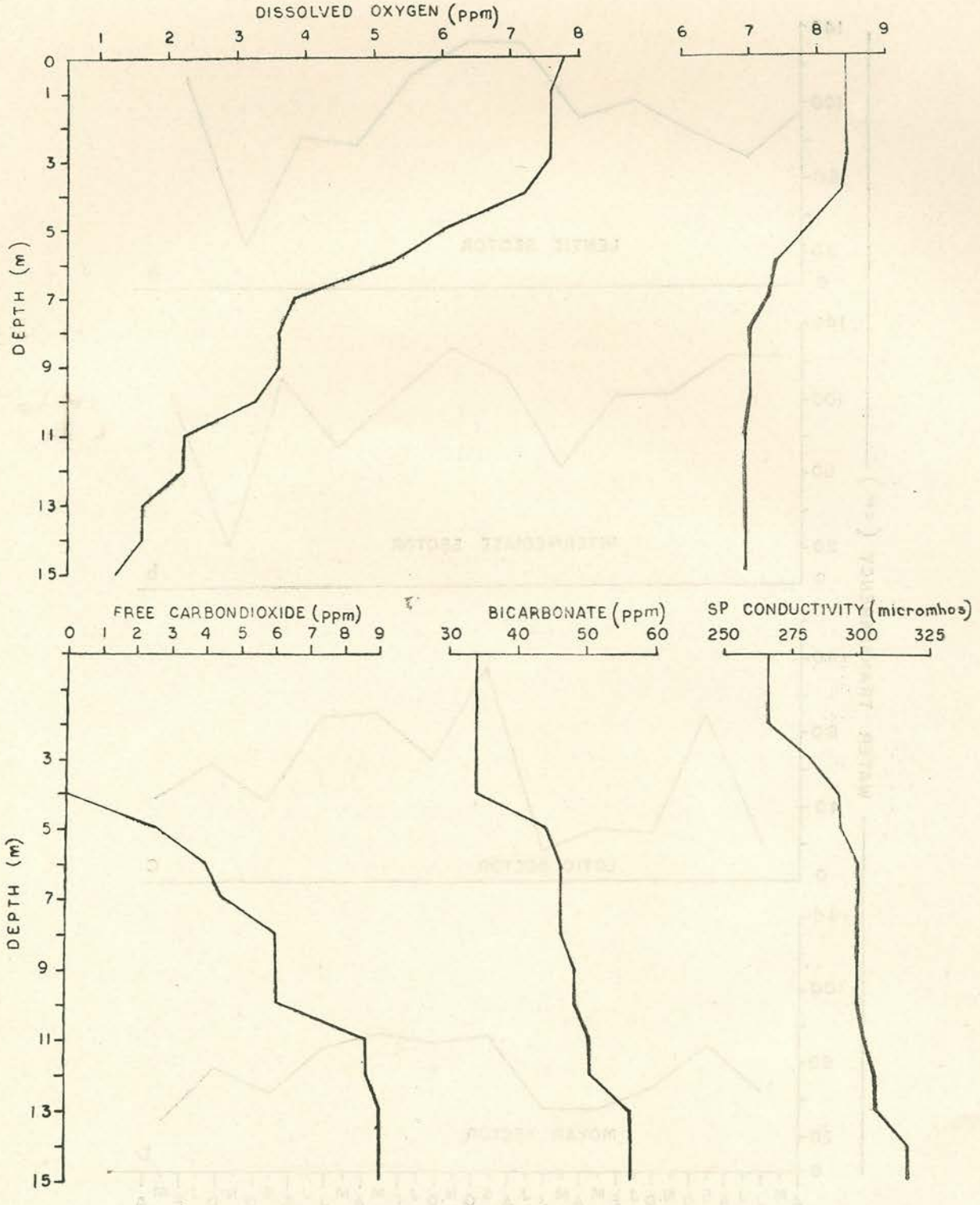

Fig. 8 Vertical distribution of physico-chemical characteristics

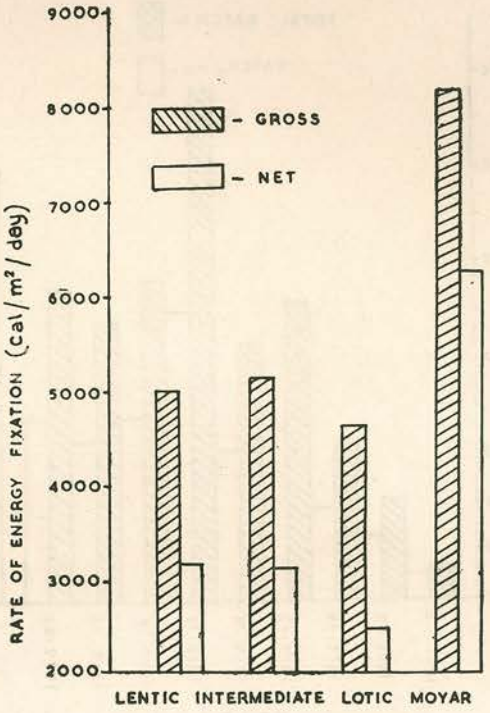

Fig. 9 Primary productivity in Bhavanisagar

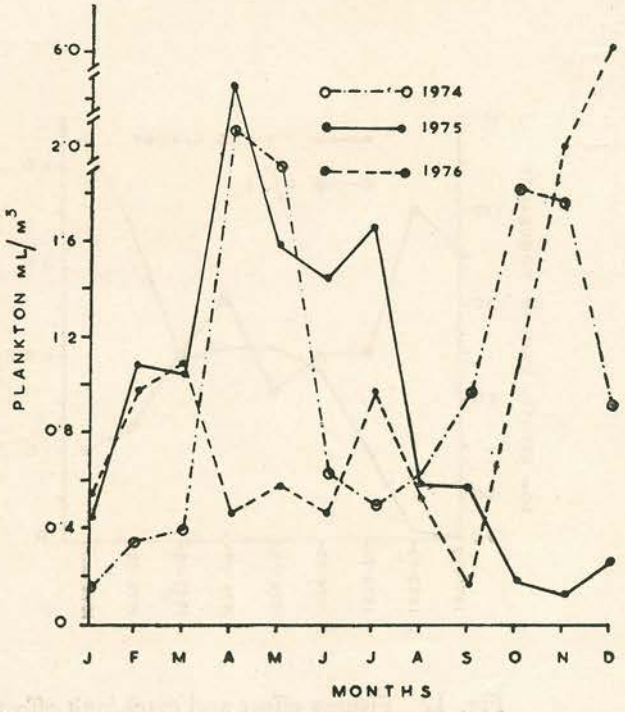

Fig. 10 Abundance of net plankton in Bhavanisagar during 1974-76

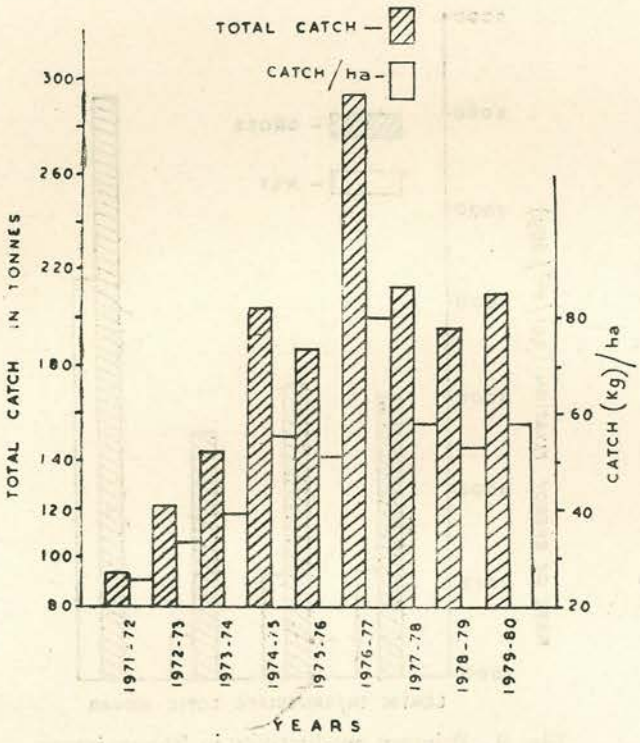

Fig. 11 Total catch and catch/ha from Bhavanisagar during 1971-72 to 1979-80

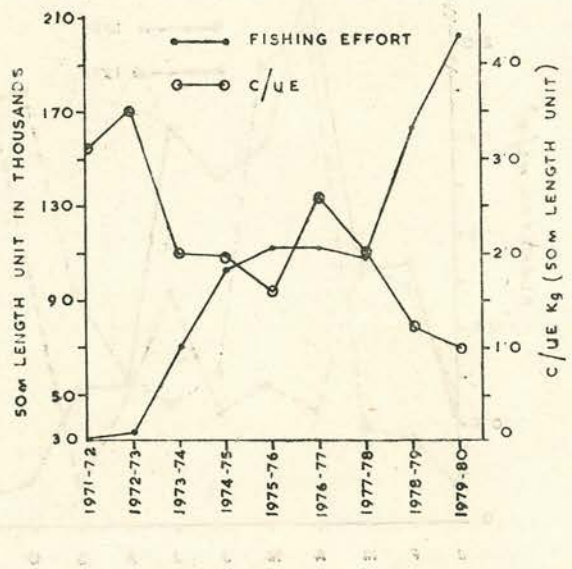

Fig. 12 Fishing effort and catch/unit effort during 1971-72 to 1979-80

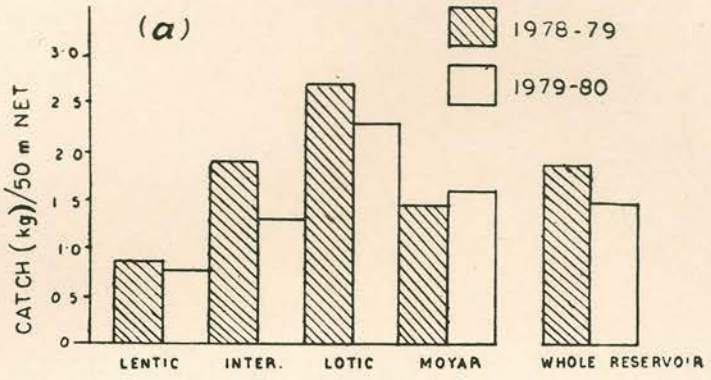

Fig. 13 (a) Yearly average catch per 50 m experimental fishing net in different sectors during 1978-79 and 1979-80

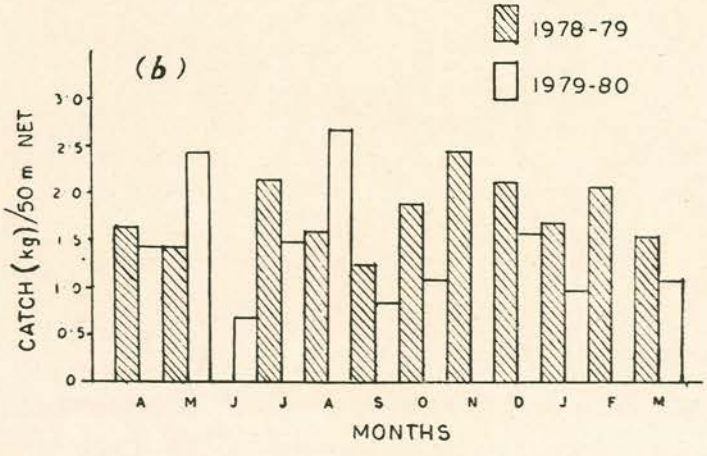

Fig. 13 (b) Monthly average catch in 50 m experimental fishing net during 1978-79 and 1979-80 in Bhavanisagar

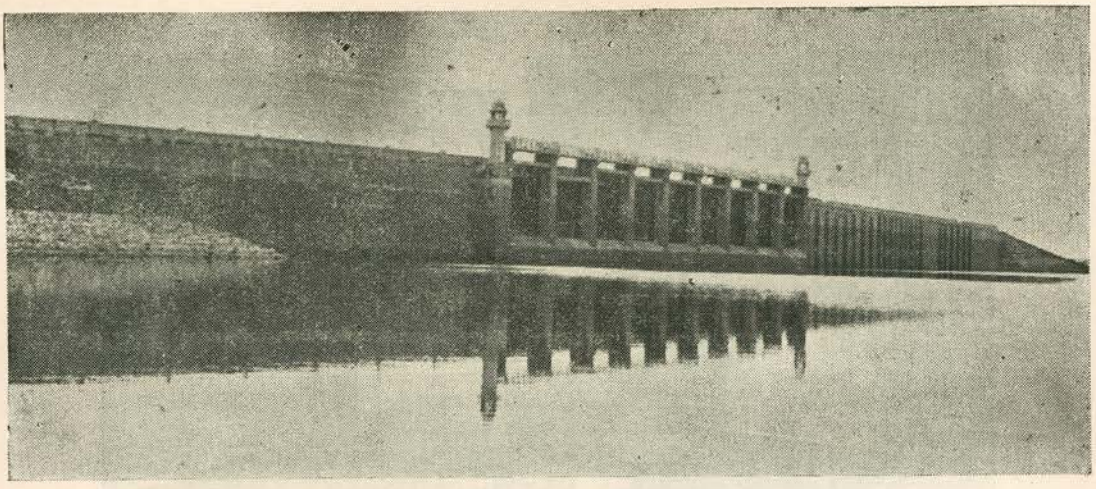

Fig. 1 An inner view of the dam

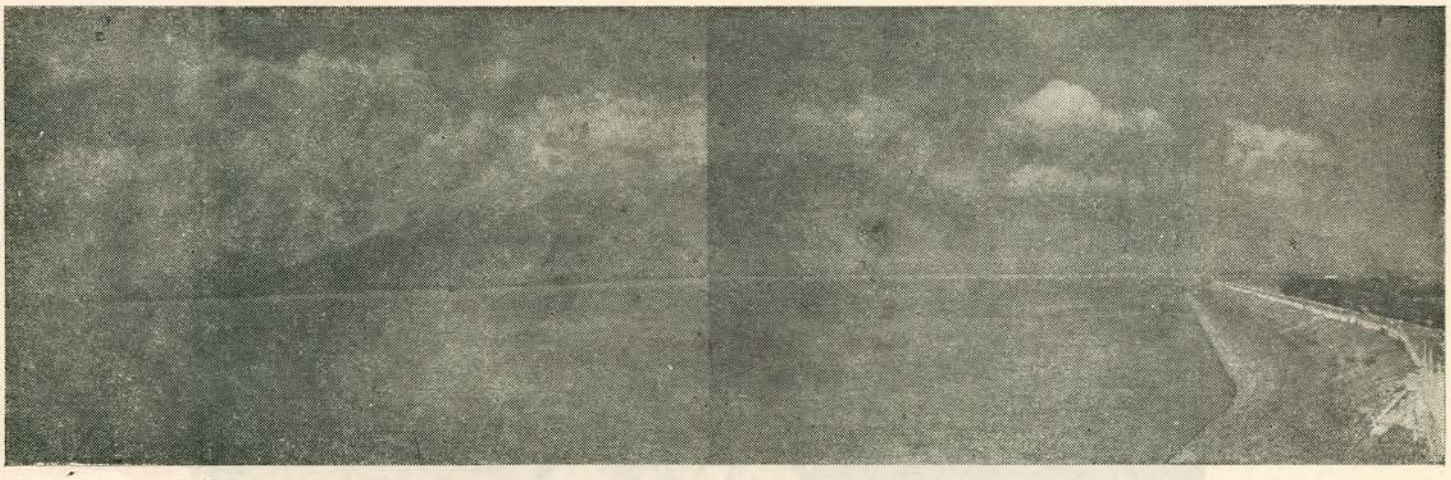

Fig. 2 The reservoir showing Bhavani and Moyar rivers

Fig. 3 Transporting the catches to Fish Stall

Fig. 4 A day's catch at the Fish Stall

Fig. 5 Fish Sale at the Stall

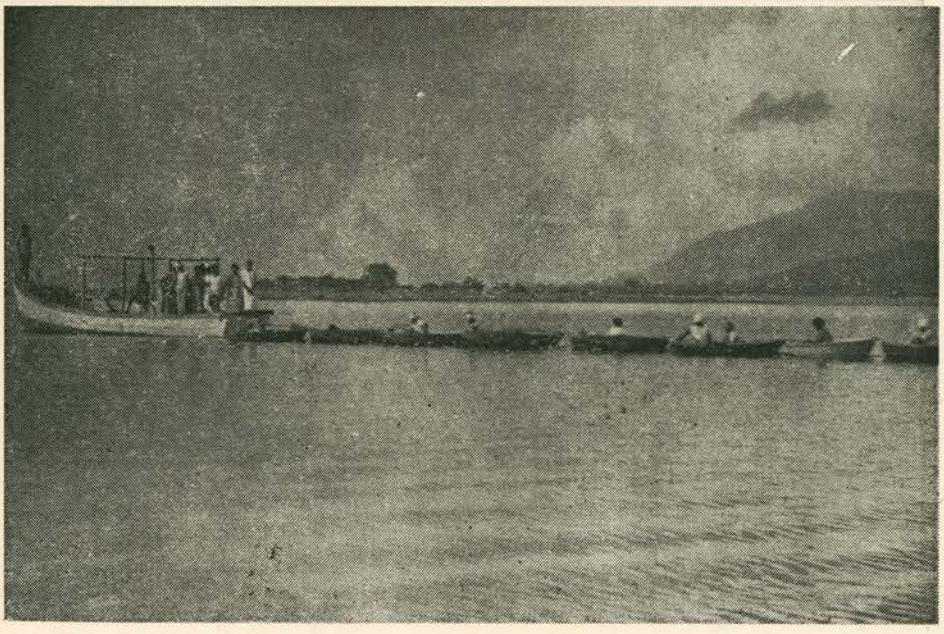

Fig. 6 Transportir g the fis'ıing units to Intermediate and Lotic sectors

Fig. 7 Commercial fishing

Fig. 8 Collecting plankton samples

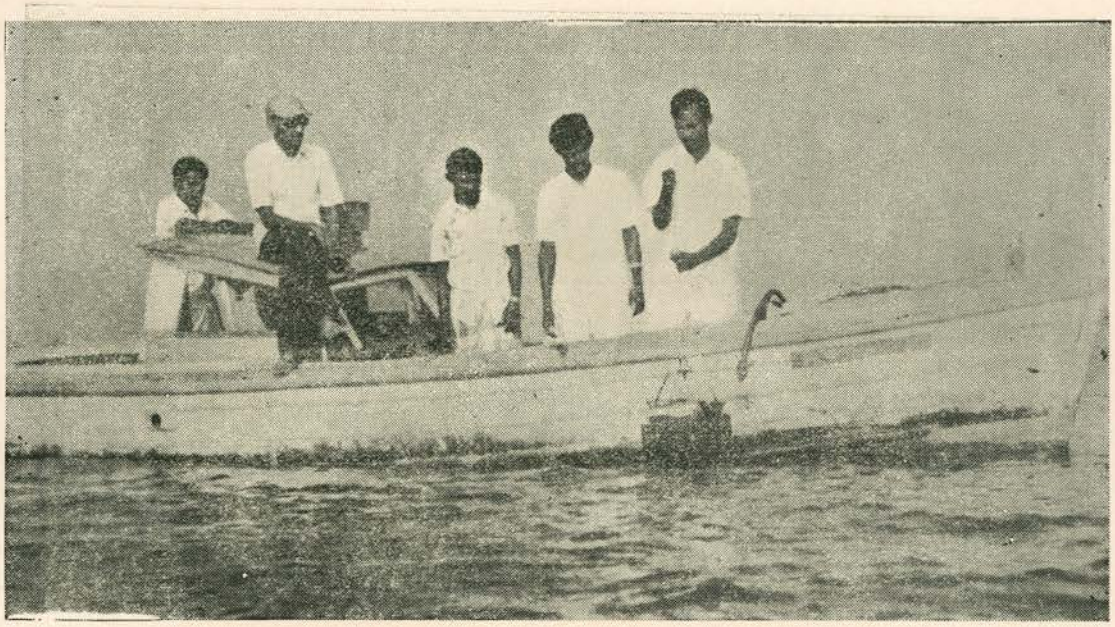

Fig. 9 Sampling for bottom biota

Fig. 10 Making shore collections for fingerling availability

Fig. 11. Sub-surface water sampling

Fig. 12 Measuring the primary productivity

Fig. 13 Laying the gill nets for experimental fishing

Fig. 14 Hauling the experimental fishing nets and recording data

Fig. 15 Prospecting investigations at Moolathurai for recruitment studies

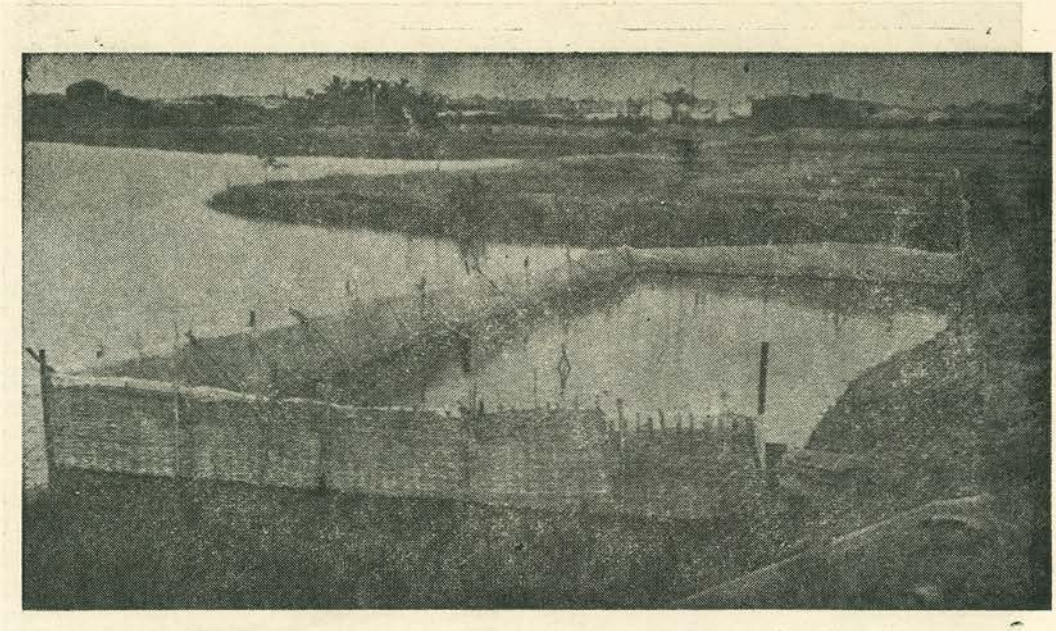

Fig. 16 A 'pen' in Poongar swamp

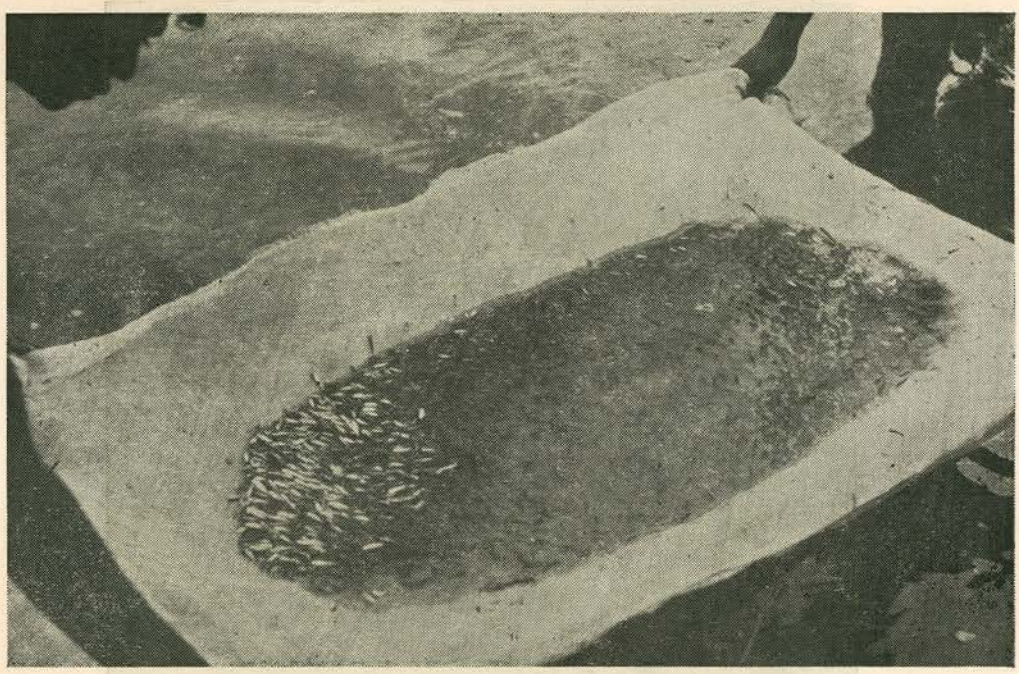

Fig. 17 A haul of fingerlings raised in the pen

Fig. 18 Demonstrating the pen culture programme to the farmers