Culture-based fisheries in a small reservoir in southern Karnataka

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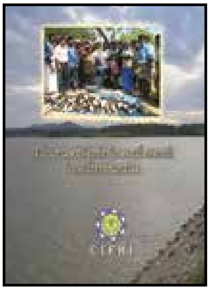

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We express our sincere thanks to the entire staff of Bangalore unit of CIFRI for their co-operation for smooth operation of the project.

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Foreword

Fisheries development in the reservoirs is gaining momentum in India and Asia, the region with highest reservoir acreage amongst all continents. Besides significantly contributing to the inland fish production, they are source of quality animal protein and and provide livelihood to rural people.

Out of over 3.0 million hectares of water spread area under reservoirs in India, small reservoirs numbering over 19, 000 constitute nearly 50% of the total area and offer excellent opportunities for culture-based fisheries through extensive and semi-intensive fish culture. Because of sheer magnitude of resource, a modest increase in fish yield in small reservoirs would considerably contribute to increase in fish production.

The present technical report describes a success story of culture based fisheries in a small reservoir, Suvarnavathy in Karnataka. The success was obtained as a result of partnership between Karnataka Cooperative Fisheries Federation, Mysore, Department of Fisheries, Karnataka, the Tribal Fishers's Society and Central Inland Fisheries Research Institute. The present study proves the validity of the 'culture based fisheries technology' developed by CIFRI, for the management of small reservoirs in different agro-climatic zones.

The present research bulletin will help in planning and execution of culture-based fisheries in small reservoirs elsewhere. I congratulate the project team for conducting the work successfully and bringing out the present publication.

Prof. A. P. Sharma
Director

Culture-based Fisheries in a Small Reservoir in Southern Karnataka

India has large reservoir resources constructed primarily for irrigation, hydropower, drinking water supply and flood control. Fisheries is recognized as an important secondary user of reservoir water resources. In the light of increasing human population, reservoirs are becoming increasingly important resource for quality fish protein and employment generation, particularly to the poorer sections of the community, which also happens to be rural.

Reservoir resource

The estimated area under reservoirs is about 3 million ha (Sugunan, 1995) in the country. The reservoir resource varies in size, shape, basin (soil, shape and depth), submerged vegetation, catchment characteristics and degree of water exchange. The nature of indigenous fish fauna also varies immensely. Based on surface area, the reservoirs are classified as small (< 1000 ha), medium (1000-5000 ha) and large (> 5000 ha). The country has 56 large reservoirs with a total water spread area of 5.3 lakh ha, 180 medium reservoirs covering 11.4 lakh ha and around 19,000 small reservoirs with a total area of 14.9 lakh ha. The state of Tamil Nadu leads both in number (8895) and area (3.1 lakh ha) with respect to small reservoirs followed by Karnataka with 4651 units and 2.3 lakh ha (Fig. 1).

Small reservoirs are constructed on small intermittent water-courses. These water sources may be seasonal or perennial. They trap the surface run-off mainly for irrigation / drinking water. Though individual reservoir is small in size, their number and collective water spread area offer immense potential for culture-based fisheries through extensive and semi-intensive fish culture. These water bodies are referred to as "*put and take systems*" as near complete harvesting is possible.

Culture-based fisheries, traditionally, are a form of extensive aquaculture, or a farming practice restricted to small water-bodies where yield is predominantly based on recapture of the stocked fish. These water-bodies would not be able to support a subsistence fishery due to lack of adequate natural recruitment of suitable species. Although culture based fisheries is in practice in water bodies ranging from 10 to 150 ha area, there are several instances of its success even in reservoirs up to 1000 ha area.

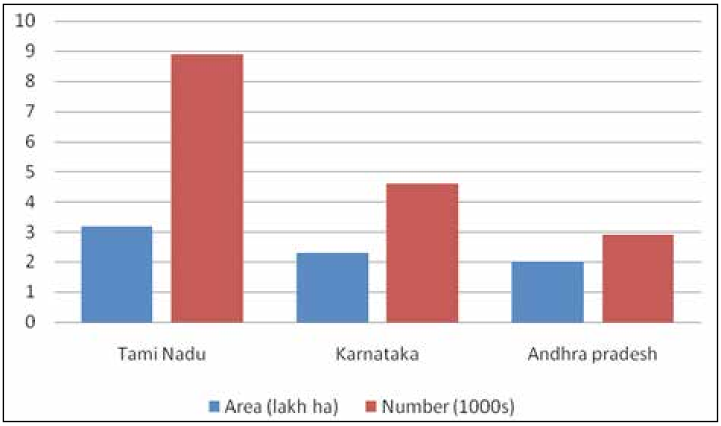

Fig. 1. Distribution of small reservoirs in southern states of India

Huge resource of small reservoirs both in area and numbers offer excellent opportunity for promoting culture-based fisheries.

Potential fish production from small reservoirs

In China, reservoir stock and capture fisheries (plus cage culture) activity yields an average of 743 kg/ha/yr. whereas the mean yield from small reservoirs of Sri Lanka is 283 kg/ha/yr. (De Silva, 2001). Based on fish yield data from 291 small reservoirs, the estimated annual yield in India is as low as 49.9 kg/ha. Applying this figure, the current fish production from small reservoirs in the country would be about 74,000 t. A moderate increase in yield up to 100 kg/ha would ensure doubling the production to 1,48,000 t (Sugunan, 1995).

Study site

Suvarnavathy reservoir, a perennial reservoir under small category and constructed across the river Suvarnavathy (a minor tributary of river Cauvery), is located in the southern tip of Karnataka State at an altitude of 662 m and towards the wee-ward region of the Nilgiri hills (Fig. 2). The area is semi-arid and the catchment area is forested. The region has reddish brown forest soil and yellowish grey to greyish sandy-loom soil. Mean minimum air temperature is 16.4°C (January) and mean maximum air temperature is 34.0°C (Fig. 3).Based on weather, four periods are observed *viz*. March to May – dry months; June to September – south-west monsoon period; October to November - post-monsoon retreating period; December to February – cool and dry period. The precipitation during south-west monsoon accounts for 61.2% and north-east monsoon 31.2%. September is the wettest month. Mean annual rainfall is 799.3 mm.

Fig. 2. The satellite imagery of the Suvarnavathy reservoir

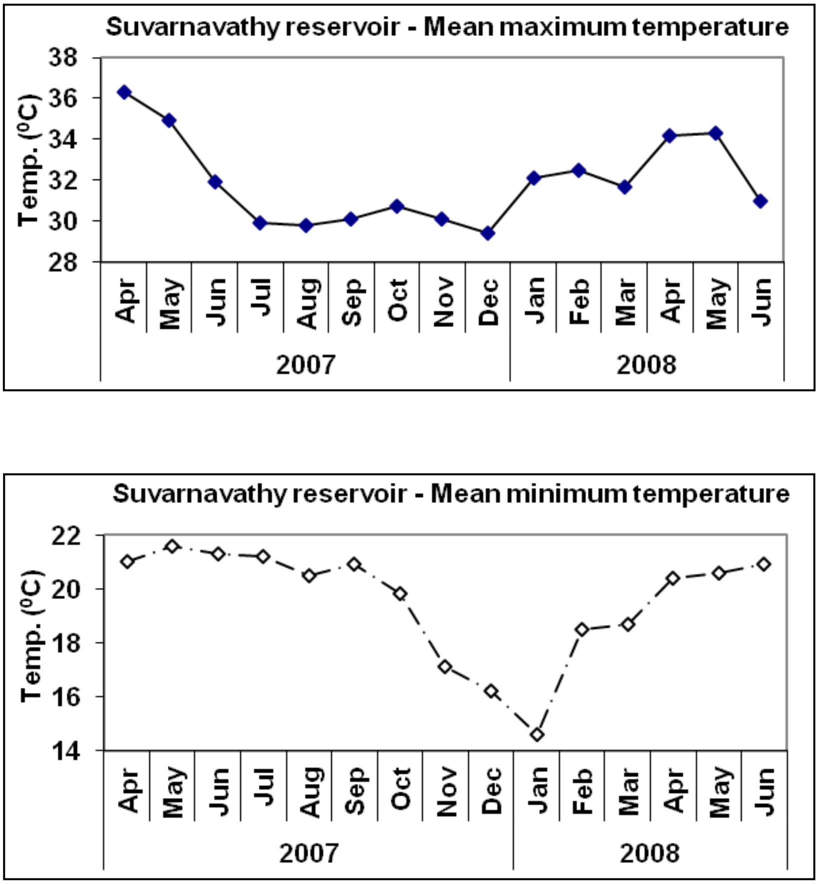

Fig. 3. Monthly variation in air temperature at Suvarnavathy reservoir site

The reservoir has two limbs – major right limb connected by Suvarnavathy river and minor left limb connected by Chikhole canal. Surplus water of nearby Chikhole dam is diverted to Suvarnavathy reservoir through a canal.

The principal morphometric features are- Latitude 10°49'N, Longitude 70°1'E, area at FRL: 490.57 ha, mean water spread area: 365.5 ha, maximum depth: 22.86 m, mean depth: 7.25 m, catchment area to water spread area ratio: 79.0, flushing ratio: 3.01, hydraulic retention time: 1.46 per year, shore-line development: 3.5 (Table 1). The reservoir is less dendritic and has high ratio of catchment area to water spread area.

Table1. Details of the Suvarnavathy reservoir

Particulars	Details
Name of river	Suvarnavathy
Name of river basin	Cauvery
Longitude	70° 1′ 51″ E
Latitude	10° 49′ 42″ N
Year of completion	1984
Type of dam	Composite dam with central masonry spillway and earthen flank
Purpose	Irrigation and drinking water
Catchment area	38800 ha
Full reservoir level (asl)	748.3 m
Dead storage level (asl)	742.2 m
River bed level (asl)	725.4 m
Water spread area	490.57 ha
Gross capacity	35.68 M m^3

Relationship of water level with area & capacity and, area with capacity

The relationships of water level with area & capacity and, area with capacity are presented in Fig. 3. The relationship between level (L in m asl) and area (A in ha) was linear and the relationship was

$$A= -26201 +35.6674\ L\ (r^2=0.99;\ N=41)$$

The relationship between water level (L in m asl) with capacity (C in Mm^3) and, area (A in ha) with capacity were exponential and the relationships were

$$\text{Log } C = -445.33 + 1555.51*\text{Log } L (r^2= 0.99,\ N = 41)$$

$$\text{Log } C = -2.1560 + 1.3568*\text{Log } A\ (r^2= 0.99,\ N = 41)$$

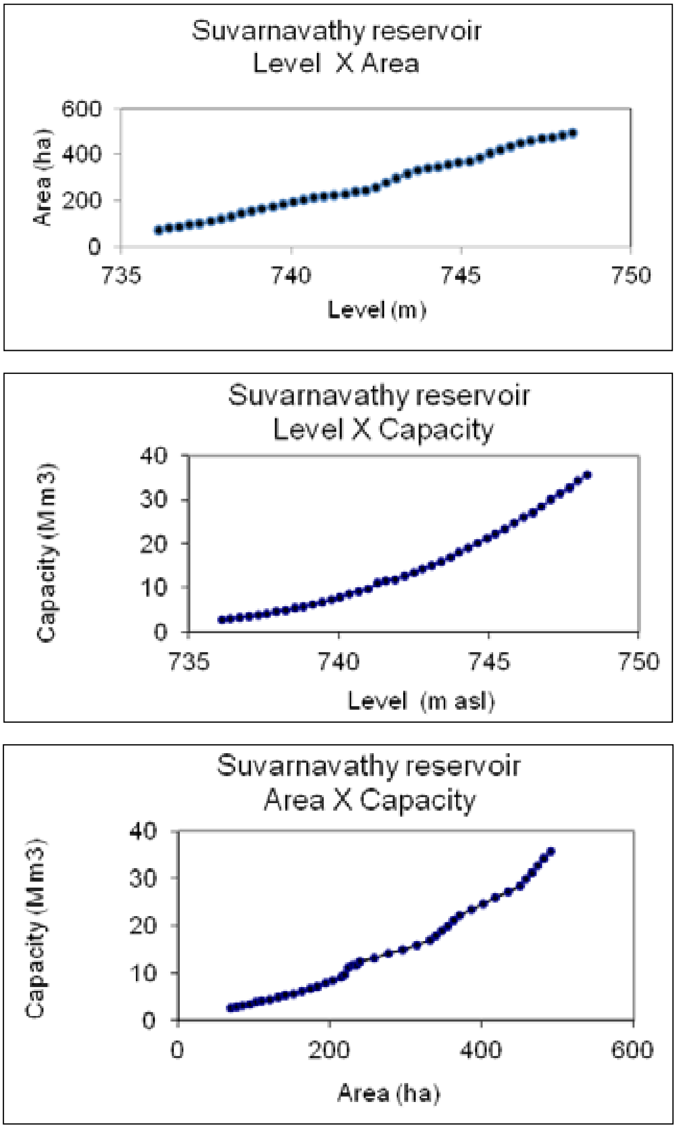

Fig. 4. Relationships of water level with area & capacity and, area with capacity

Abiotic factors

Inflow, outflow and water level

The monthly variation in water level, inflow and water level are presented in Figs. 5 and 6.

2007-08

Suvarnavathy reservoir received very good inflow with the annual total of 36.59 Mm^3 during the period April 2007 to March 2008 with the highest of 8.68 Mm^3 in November 2007. The total outflow from the reservoir was 31.58 Mm^3. The highest water level of 748 m asl was recorded in the months of November-December 2007 and the lowest in July 2007. The amplitude of variation was a high of 11.9 m with annual mean level of 742.6 m.

2008-09

The total inflow recorded during 2008-09 was a low of 16.91 Mm^3 with the highest of 7.13 Mm^3 received in September 2008. Unseasonal rains during pre-monsoon of 2008 brought good inflow in to the reservoir resulting in low variation in water level (6.2 m). The annual mean water level was a high of 744.7 m. The maximum water level of 747.9 m (FRL) was recorded in November 2008 and the minimum 742.8 m in July 2008.

2009-10

The year received a total inflow of 19.92 Mm^3 with the highest of 5.6 Mm^3 in November 2010. The fluctuation in water level was high and to the tune of 9.1 m. The annual mean level was the lowest of 740.3 m. The lowest and highest level recorded were 735.5 m (May) and 744.6 m (January). The troughs and peaks in water level are recorded around July and December – January respectively.

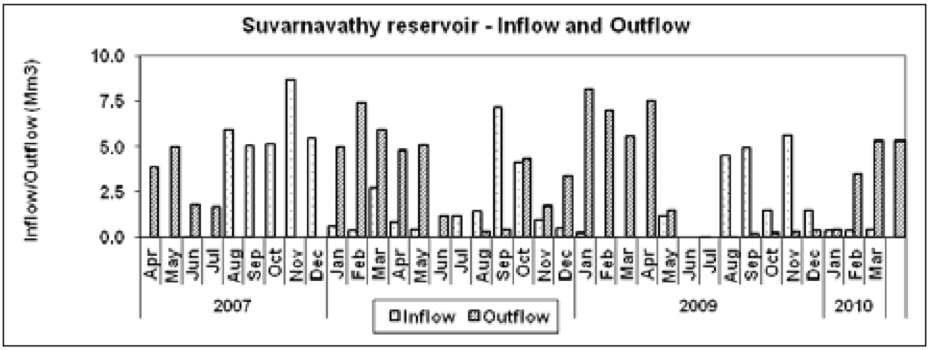

Fig. 5. The monthly variation in inflow and outflow into and out of the Suvarnavathy reservoir

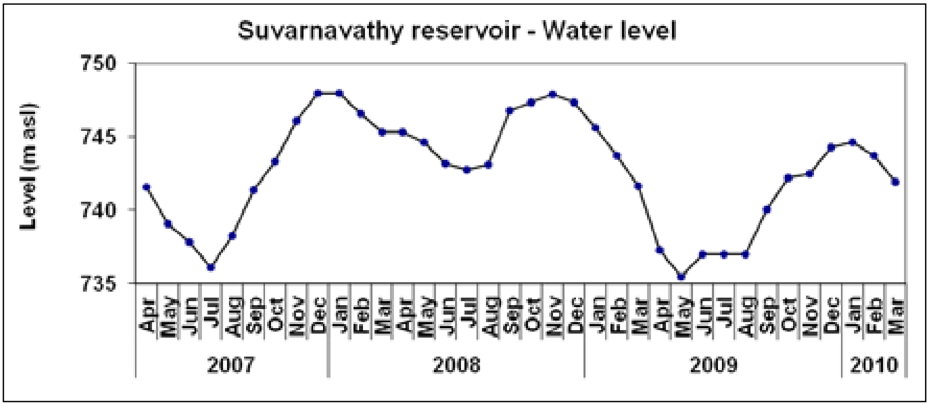

Fig. 6. The monthly variation in water level of the Suvarnavathy reservoir

Physico-chemical parameters of water

The monthly variation in physico-chemical parameters of water is presented in Fig. 7. The water temperature varied in the surface (top two meters) sinusoidally from a winter low of around 25.0° C to a summer high of winter 30.0° C. The summer peak was followed by a minor peak in September-October. The annual mean water temperature in first (April 2008 to March 2009) and second years (April 2009 to March 2010) was 27.3°C (± 1.7) and 27.8°C (± 1.8) respectively.

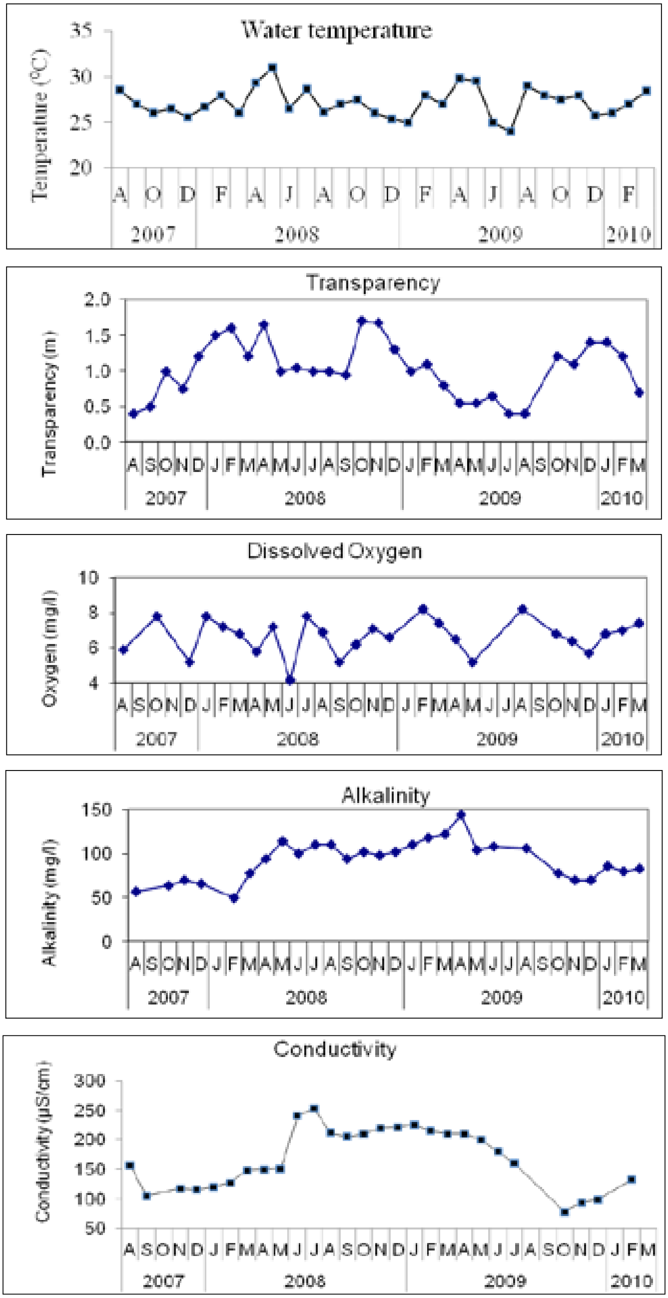

Fig. 7. Temporal variation in physico-chemical parameters of the reservoir water

Secchi disc transparency (m) exhibited variation with highest coinciding with high water level of post-monsoon season (some time during October to January) and lowest value during the beginning of the south-west monsoon when inflow laden with silt drained into the reservoir (August – September). The transparency ranged from 0.8 m to 1.7 m during first year and 0.4 to 1.4 m during second year. Mean transparency was higher in the first year (1.2 m ± 0.3) due to high mean water level as compared to the second year (0.8 ± 0.4).

Water was well buffered and on most occasions pH oscillated in a narrow range of 7 to 8 (Mean: I year – 7.5 ± 0.2; II year – 7.6 ± 0.2). Dissolved oxygen concentration did not exhibit clear seasonality and the values were in favourable range in upper mixed layers of 0 to 2 m (above 5.0 mg/l). Total alkalinity exhibited narrow fluctuation without significant seasonal variation and varied from 70 to 122 mg/l. The mean alkalinity being in medium range was relatively higher in the first year (106.2 mg/l ± 9.2) than the second year (96.3 mg/l ± 22.4). Specific conductivity (µS/cm) was in moderately high concentration and ranged from 78 to 253. Similar to alkalinity, the mean concentration was higher in first year (209.3 ± 30.7) than the second year (144.1 ± 50.8).

Vertical distribution of physico-chemical parameters

The depth-time distribution of temperature and oxygen is presented in Fig. 8. On most of the sampling days, Suvarnavathy reservoir exhibited thermal stratification. The thermocline was observed usually between 2.0 and 4.0 m with a minimum drop in temperature of 0.2°C or more. Strong stratification was observed during summer of 2008 and again in October-November of the same year when the difference in temperature from surface to bottom ranged from 1.1°C to a high of 4.0°C. Complete mixing of the water column was observed during June – August, characterised by low water level & high wind speed and again during December to February, due to convective cooling. A relatively high mean depth of 7.25 m and sheltered location of the reservoir are the primary reasons for the water body to show strong stratification. In 2009, we observed the same pattern similar to that of 2008.

During strong stratification with sharp thermocline, very low oxygen to anoxic hypolimnion with precipitous drop in metalimnion was noticed (e.g. April 2008), thus oxygen exhibiting strong clinograde distribution. This is due to high decomposition activity and high biological productivity of the reservoir. In April 2008, when the depth of water was 10 m, the water was anoxic below 5.0 m. Low oxygen concentration in the entire water column (3.4 to 8.2 mg/l) on the sampling day in June 2008 was certainly due to the mixing of the anoxic hypolimnion with the epilimnion in the past one or two days.

Though data on the depth-time distribution of temperature is not available at weekly intervals, we suspect that Suvarnavathy reservoir may exhibit stable stratification for two periods – February to April (summer stratification) and again October – November. The period July to December and December to February, the intervening periods, showing intermittent mixing and weak stratification. Suvarnavathy reservoir may be a warm dimictic reservoir like Nelligudda reservoir (Krishna Rao et al. 1999). During stratification, pH also showed positive clinograde distribution.

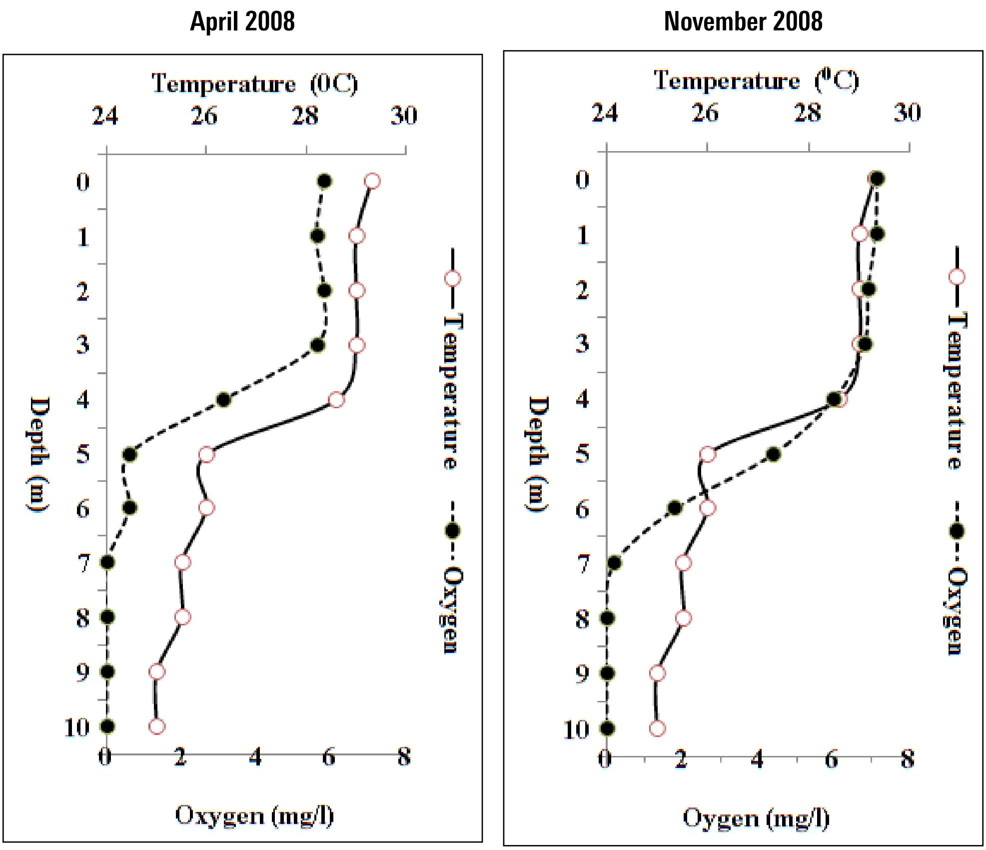

Fig. 8. Vertical distribution of water temperature and oxygen in the reservoir

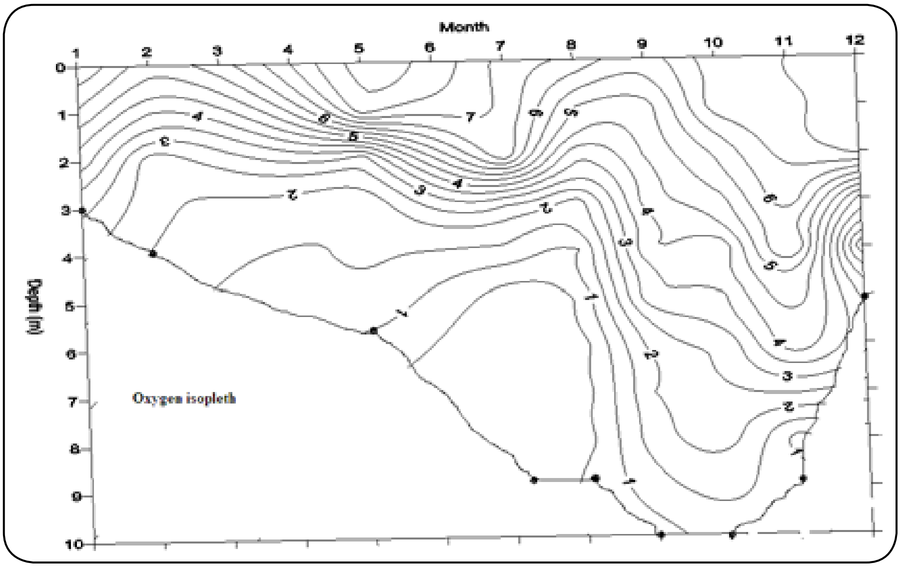

Fig. 9. Depth-time distribution of oxygen during April 2009-March 2010 (1 is April, 2 is May and so on)

Biotic communities

Phytoplankton

Phytoplankton community was represented by algae belonging to families - Chlorophyceae, Myxophyceae, Bacillariophyceae and Dynophyceae. Chlorophyceae was dominated mainly by the genus *Pediastrum*. Other genera observed were *Cosmarium, Closterium, Tabellaria, Ankistrodesmus* and *Coelastrum*. Myxophyceae was overwhelmingly dominated by *Microcystis* and *Anabaena*. Bacillariophyceae was mainly represented by *Nitzschia, Navicula, Synedra, Pleurosigma, Surirella* and *Cymbella*. Dinophyceae was mainly represented by *Ceratium* and *Peridinium*. The total phytoplankton density oscillated between 1000 and 10000 nos./l on most occasions and exhibited two peaks, the timing of which varied in 2008 and 2009. The primary and broad peak occurred during June to August in 2008 and during August to November in 2009. The secondary peak was observed in February-March in 2008 and April in 2009 (Fig. 10). The primary peak coincided with influx of nutrient rich water due to south-west monsoon rains and the secondary peak coincided with summer.

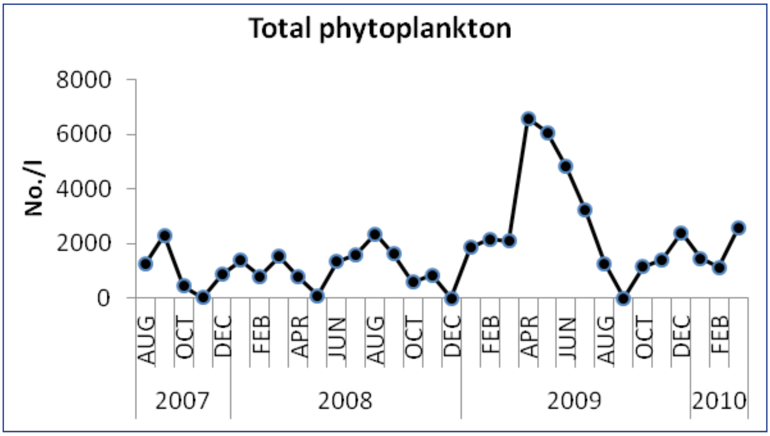

Fig. 10. Temporal variation in total abundance of phytoplankton

Zooplankton

The pelagic zooplankton community comprised mainly of copepod, cladoceran and rotifer groups and was represented mainly by small-bodied cyclopoid copepod, *Thermocyclops hyalinus*, large-bodied calanoid, *Heliodiaptomus viduus*, large bodied cladoceran, *Diaphanosoma excisum* and more than seventeen rotifer species. The temporal variation in abundance of copepods, cladocerans, rotifers and total zooplankton is presented in Fig. 11 Both the years, the abundance of all the three groups was higher during June to August, the period of low water level and lower during December to January, the period of high water level. The abundance of cyclopoids was distinctly greater than calanoids during both the years. Unlike calanoids, the density of cyclopoids, cladocerans and rotifers was significantly higher in 2009 than in 2008.The density of copepods on most occasions was within the range of 100 and 200 ind./l.

The abundance of rotifers was less than 500 ind./l during greater part of the study and only on one occasion the density exceeded 1400 ind./l (July 2009). *Keratella tropica* was the most dominant species in both the years and maximum density recorded was over 500 ind./l in April 2009 (Fig. 12). *B. forficula*, *Anuraeopsis fissa* and *Asplanchna* were present in the community on most occasions. *Trichocerca similis* and *Polyarthra vulgaris were r*are in first year but were all through present in the community in the second year. *B. calcyflorus* and *B. diversicornis* were rare in the community during both the years. *Brachionus falcatus, B. angularis, B. caudatus, Hexarthra mirabilis* and *Filinia longiseta* were common during some months and disappeared from the community during other months.

The Cladocerans were less abundant (< 100 ind./l) and the maximum density recorded was over 200 ind./l (July 2009). In general, zooplankton abundance hovered between 200 and 600 ind./l and the maximum recorded was about 1400 ind./l (April 2009).

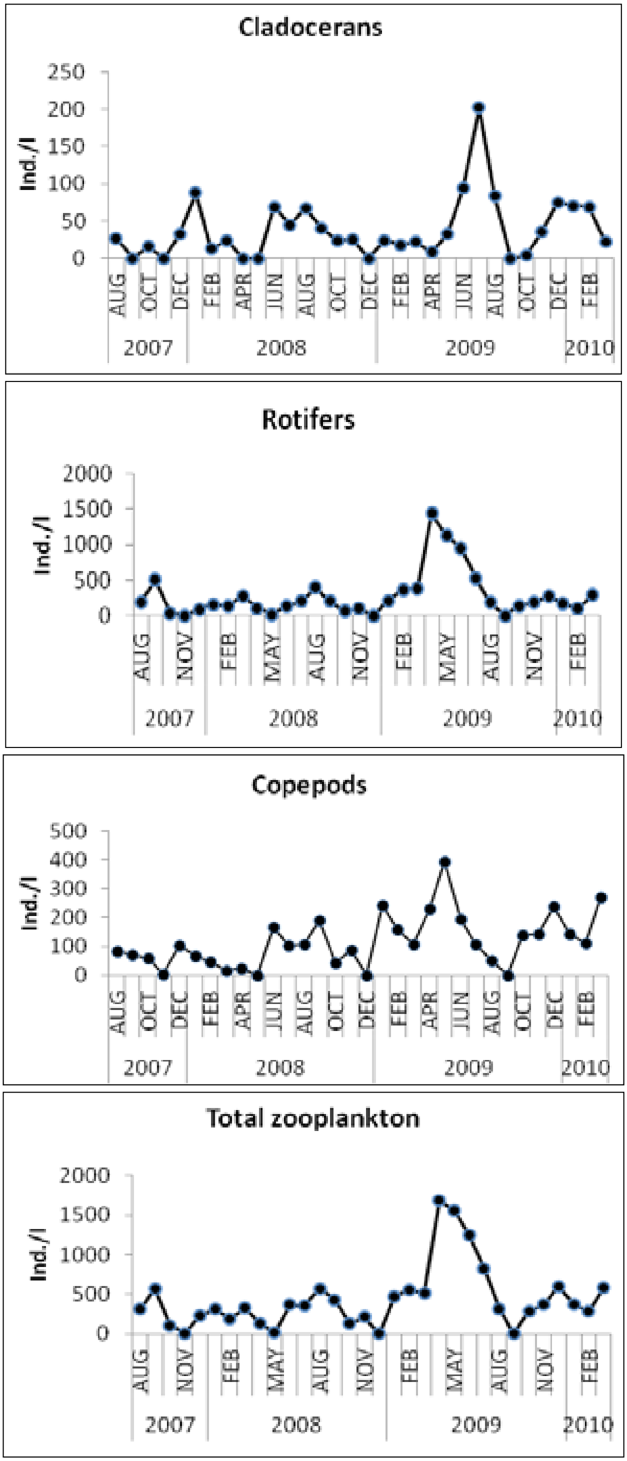

Fig. 11. Temporal variation in abundance of cyclopoids, calanoids, cladocerans, rotifers and total zooplankton.

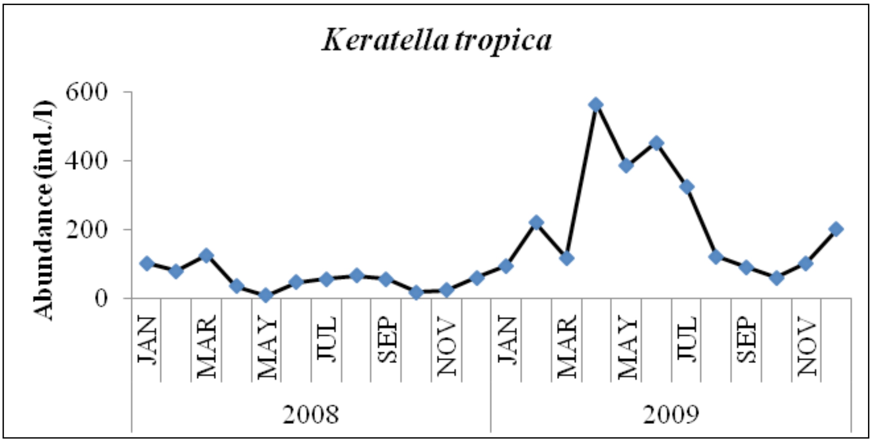

Fig. 12. Temporal variation in abundance of Keratella tropica

The annual mean biomass of calanoids and cladocerans did not vary much between the years whereas the biomass of cyclopoids and rotifers were more than two and four folds higher respectively in 2009 *vis-à-vis* 2008. The annual mean total zooplankton biomass was marginally higher in 2009 (Mean: 175.7 µg/l±116.0) than during 2008 (149.8 µg/l±120.3). The highest monthly biomass did not coincide with zooplankton abundance and was recorded in December 2009 (457.7 µg/l). Although cyclopoids and rotifers were more abundant, their contribution to biomass was lesser due to smaller body size (Fig. 13).

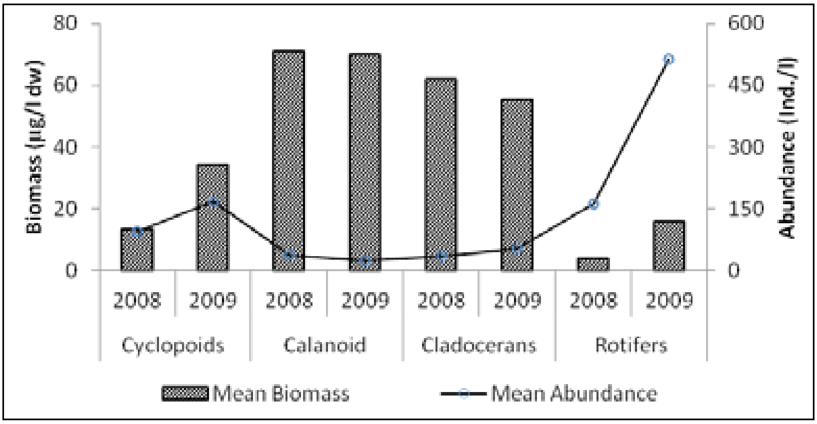

Fig. 13. Annual mean biomass and abundance of cyclopoids, calanoids, cladocerans and rotifers

Chlorophyll 'a'

Chlorophyll'a' (an indirect estimate of algal biomass) varied over 14 folds from a low of 16.7 µg/l (December 2009) to a high of 235.8 µg/l (August 2010). The annual mean concentration was a high of 70.9 µg/l (±57.4 µg/l). Chlorophyll 'a' exhibited bimodal fluctuation. The dominant and sharp mode in August 2009 coincided with low water level, concentration of nutrients due to evaporation and allochthonous input of nutrients brought into the reservoir by the inflow in previous months. The minor mode was observed in March 2009. A steep fall after an August high was due to dilution of algal concentration caused by high inflow (Fig. 14).

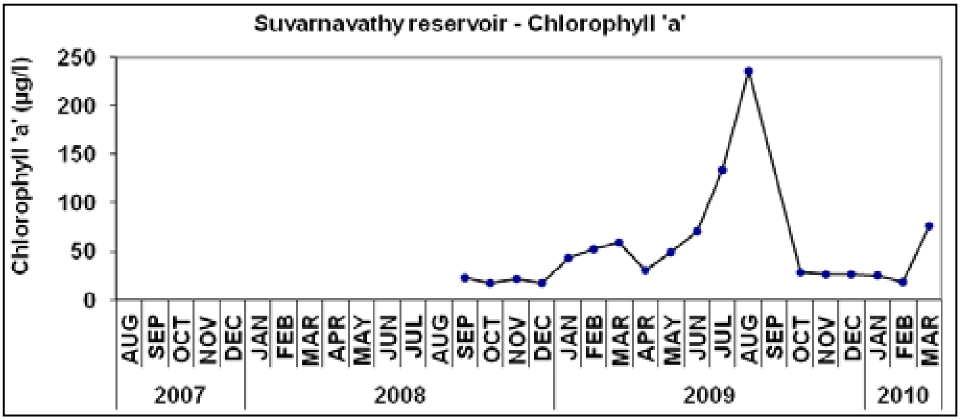

Fig.14. Temporal variation in chlorophyll 'a' in Suvarnavathy reservoir

Primary Production

Primary productivity was estimated by the oxygen difference method. Incubation was conducted for four hours, with mid-time of incubation being noon, at 1.0 m interval from surface up to 5.0 m.

Gross Primary Production

Select vertical profiles of gross primary production (GPP) are given in Fig.15. Most of the production-depth profiles confirmed to the pattern of smooth curve with a maximum at one depth (usually near the surface). However, two profiles (April and December 2008) were dichotomous with more than one maxima. Bimodal productivity is known to be common in stratified lakes and in shallow tropical lakes. A sub-surface maximum occurred on 8 out of 20 occasions and is explained as due to photo-inhibition. Most of the profiles were characterized by lower production per unit volume and absence of marked maxima. However, three profiles (November 2008, August 2009 and February 2010) were with higher production per unit volume and with marked maxima.

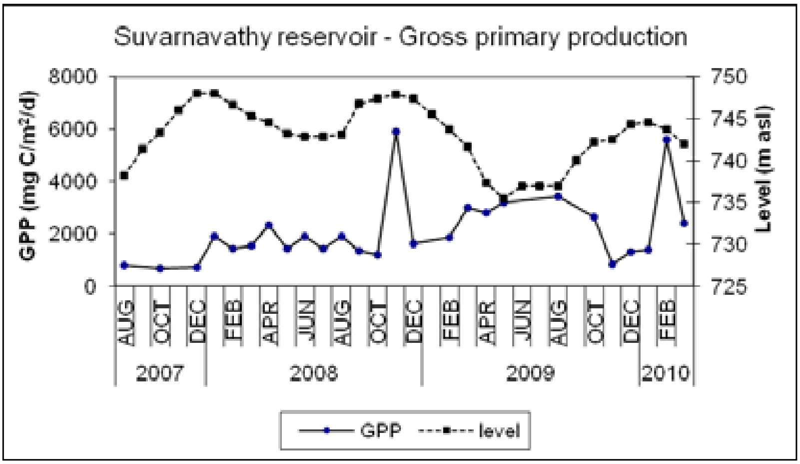

Fig. 15. Temporal variation in gross primary production

Light saturated rate of photosynthesis per unit volume (A_{max}) may be reported as a measure of the capacity of a lake to produce and sustain algae. The variation in A_{max} is illustrated in Fig. 16. The maximum value of A_{max} recorded was 412.5 mg C/m^3/h. A_{max} per unit volume of chlorophyll 'a' (P_{max}) varied from 3.2 to 51.4 mgo$_2$/ mg Chl 'a'/h (Fig. 17).

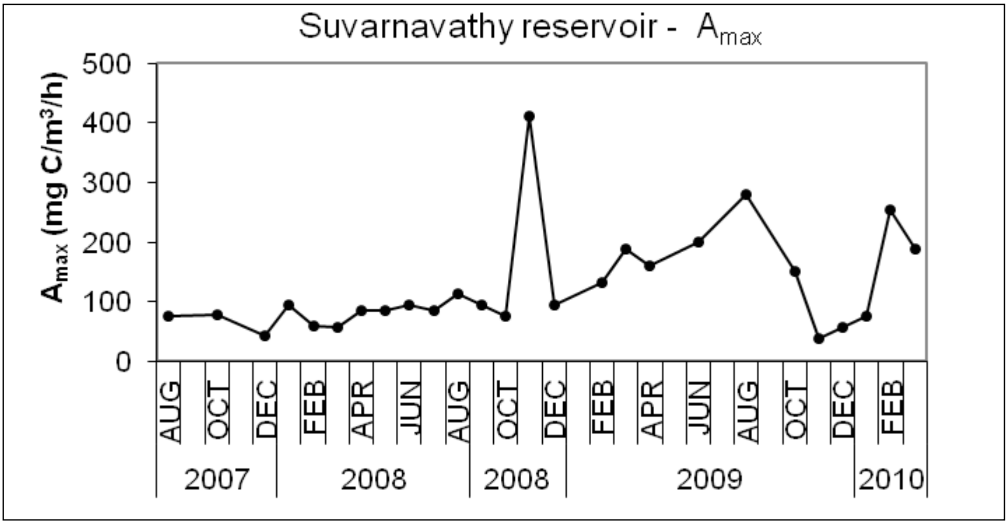

Fig. 16. Temporal variation in Amax

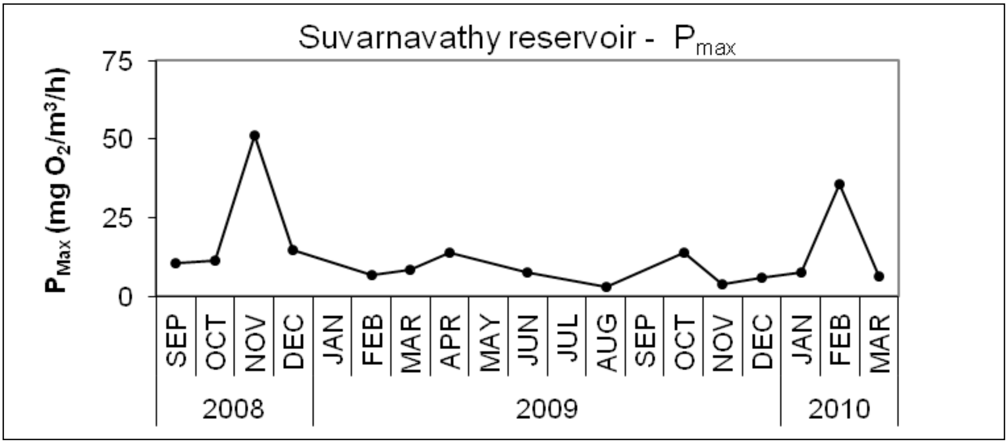

Fig. 17. Temporal variation in Pmax

Hourly integrated GPP ($\sum A$) showed nearly five-fold fluctuation from 149.9 to 740.4 mg C/m^2/h. Daily integral production ($\sum\sum A$) varied from 1199.2 to 5923.2 mg C/m^2/day for the first year (Mean ; 2139.7 ±1287.2) and 825.0 to 5580.0 mg C/m^2/day (Mean 2803± 1257.1) during the II year. $\sum\sum A$ was significantly higher in the second year. Annual GPP estimated from $\sum\sum A$ was 902.1 g C/m^2. Absence of clear seasonality in GPP variation was evident in I year as the water level, a decisive factor, did not vary much. In the next year, an inverse correlation between GPP and water level was observed due to significant water level fluctuation.

Net Primary Production

Net primary production (NPP) was distributed over a much narrower depth than GPP. Daily integral NPP ranged from 374.0 to 2022.9 mg C/m²/day (Mean: 937.1±526.3) for the I year and from 412.8 to 2100 mg C/m²/day (Mean: 1424 ±574.3) for the second year. Mean of daily integral NPP for the two years was 1180.7 mg C/m²/day. On an annual basis, NPP for the lighted period was 430.9 g C/m². NPP computed for the entire day would be negative as also observed by many workers.

Community respiration

Mean hourly integrated community respiration (CR) in the euphotic zone varied from 180.2 ± 145.6 mg C/m²/h in I year to 127.9±80.1 mg C/m²/h in II year (Fig. 18).

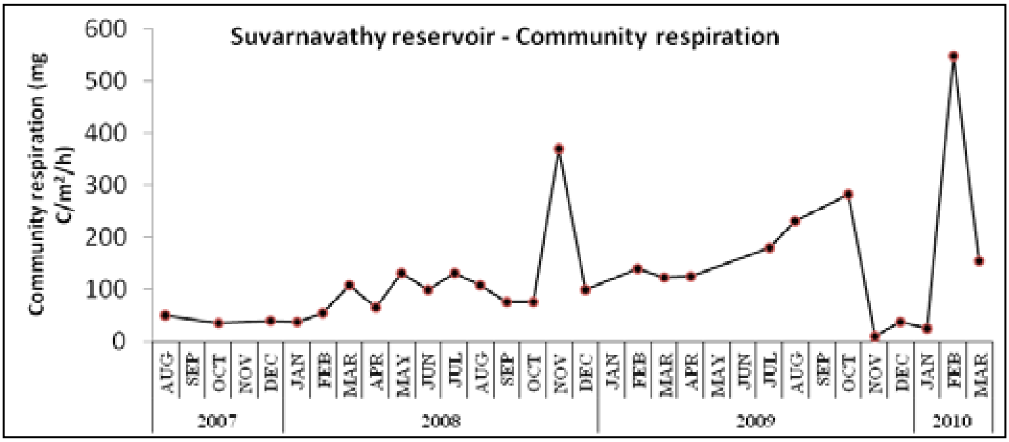

Fig. 18. Temporal variation in community respiration

P-R ratio

The GPP to CR ratio (referred to as P-R ratio), useful to monitor the trophic status, hovered around 1.0 on most occasions and suggest the productivity of the reservoir (Mean: 1.55). High influx of freshwater in November and to some extent in December 2010 was responsible for reduced heterotrophic activity and high P-R ratio in November 2009 to January 2010.

Trophic status

A frequently used biomass-related trophic state index is that of Carlson (1977). It is relatively simple to use, requires a minimum of data, and is generally easy to understand, both in theory and use. It is numerical, but the traditional nutrient-related trophic state categories fit into the scheme. Trophic state refers to the total weight of living biological material (*biomass*) in a water body at a specific location and time. Trophic state is understood to be the biological response to forcing factors such as nutrient additions (Naumann, 1919, 1929), but the effect of nutrients can be modified by factors such as season, grazing, mixing depth, etc.

In accordance with the definition of trophic state given above, the trophic state index (TSI) of Carlson (1977) uses algal biomass as the basis for trophic state classification. Two variables, chlorophyll pigments and Secchi depth, were used independently to estimate algal biomass. The Carlson's trophic index based on Secchi depth, is 61.52 and based on chlorophyll 'a' is 71.4. From these indices, Suvarnavathy reservoir can be categorised as eutrophic.

Fish and Fisheries

Fish Fauna

The fish species composition in a reservoir is a result of the different reaction of the species to varying environmental condition after impoundment. Some species not able to adapt to the changed condition may disappear while others may adapt to changes at varying degrees and may continue to exist at a changed abundance.

The fish fauna of Suvarnavathy reservoir reflects fauna of the Cauvery river basin. The fauna consists of 27 species belonging to 11 families and 5 orders (Table 2). The cyprinidae consisting of 12 species was dominant among species inhabiting the reservoir. Channidae was represented by 3 species followed by Mastacembelidae, Bagridae and Ambassidae with 2 species each and the rest of the families with single species. There are 14 commercially important high value spices of which only three species, all annually stocked, *Catla catla, Labeo rohita* and *Cirrhinus mrigal,* contributed to the main fish production. The other stocked species *viz.* grass carp and common carp have failed to contribute due to their poor survival and growth. Suvarnavathy reservoir exhibits thermal stratification with low dissolved oxygen concentration to anoxic hypolimnion and the survival & growth of common carp has been poor in such reservoirs (e.g. Nelligudda, Manchanbele). Grass carp, because of sparse density of aquatic macrophytes, do not get adequate food for fast growth. The rest of the high value endemic species (e.g. *Ompok bimaculatus, Clarias batrachus, Heteropneustes fossilis, Mastacembelus armatus* and *Channa marulius*) exhibit low natural recruitment and appear in sparse number. The only species that exhibit good natural recruitment and contribute to the fishery is low value economic species tilapia, *O. mossambicus.* The medium carps, *P. sarana* and *C. Reba,* also, do not contribute to fishery due to poor natural recruitment.

Table 2. Fish fauna of the Suvarnavathy reservoir

Sl. No.	Species	Family
	Cypriniformes	
	Catla catla	Cyprinidae
	Cirrhinus mrigala	Cyprinidae
	Cirrhinus reba	Cyprinidae
	Ctenopharyngodon idella	Cyprinidae
	Cyprinus carpio	Cyprinidae
	Garra mcclellandi	Cyprinidae
	Labeo rohita	Cyprinidae
	Puntius sarana	Cyprinidae
	Puntius sophore	Cyprinidae
	Puntius ticto	Cyprinidae
	Puntius vittatus	Cyprinidae
	Salmophasia belachi	Cyprinidae
	Siluriformes	
	Mystus cavasius	Bagridae
	Mystus vittatus	Bagridae
	Clarias batrachus	Clariidae
	Heteropneustes fossilis	Heteropneustidae
	Ompok bimaculatus	Siluridae
	Perciformes	
	Channa marulius	Channidae
	Channa orientalis	Channidae
	Channa striatus	Channidae
	Chanda nama	Ambassidae
	Pseudambassis ranga	Ambassidae
	Glossogobius giuris	Gobidae
	Orechromis mossambicus	Cichlidae
	Osteoglossiformes	
	Notopterus notopterus	Notopteridae
	Symbranchiformes	
	Mastacembelus armatus	Mastacembelidae
	Macrognathus aral	Mastacembelidae

Fisheries enhancement

The reservoir is leased to *Budakattu Soligara Meenugaara Sahakara Sangha*, Attugulipura (Soliga's Tribal Fishermen's Co-operative Society) by the Karnataka Co-operative Fisheries Federation (KCFF), Mysore. The annual lease amount is Rs. 50,000/-. The lessee has issued licenses to the fishers. The fishers get 50% of the value of fish as remuneration at weekly intervals.

Before commencement of the investigations, several rounds of discussion were held with the main stakeholders – the Lessor of the water body, Karnataka Co-operative Fisheries Federation (KCFF), Mysore and the Lessee, Attugulipura Tribal Fishermen's Society. The outcome of the discussion was:

- The KCFF agreed to stock the advanced fingerlings of carps under NFDB funds,
- The Society agreed to extend complete cooperation to collect data on fisheries, to share the data on fish harvest and follow guidelines of CIFRI for management and
- The CIFRI agreed to study the impact of stocking and give recommendations for better management practices.

Recommendations of CIFRI implemented by the society were:

- Regular stocking of fish seed of major carps both by the lessee as well as the KCFF. Though not the entire stock, part of the seed stocked was of advanced fingerling stage.
- The society enforced mesh-size regulation and a large share of gillnets operated was only of more than 5 cm mesh-bar to harvest fish of 1.0 kg and above.
- The society recorded the catch, craft-wise, on all the fishing days under two groups - high value (mainly major carps) and low value (mainly tilapia) fish.

The society had appointed personnel for watch & ward to control poaching. Operation of small meshed gillnets and shore seine to harvest minor cyprinids and other weed fish were not permitted. All the fishers had to bring the catch to a single point, located near the right bank of the dam and hand-over the entire catch to the Society.

Fish stocking

Stocking and introduction of fish are the frequently used management measures in reservoirs throughout the world (Cowx 1998; Welcomme 1998, 2001). Stocking is a management measure to enhance and optimise yield of lacustrine species. In Suvarnavathy reservoir, stocking has been a major management component. The main purpose of stocking is for introduction of fast growing species that could use the ecological niches more competitively and contribute to higher production. The series of measures for stocking are choice of suitable species, species combination, stocking size and measures for preventing harvesting of under-sized fish. Three indigenous (*C. catla*, *L. rohita* and *C. mrigal*) and three exotic fish species (*C. carpio, C. idella* and *O. mossambicus*) were introduced into the Suvarnavathy reservoir under this intervention.

The number stocked and stocking rate of fish seed is presented in Fig. 19 and the composition of fish seed stocked in Fig. 20.

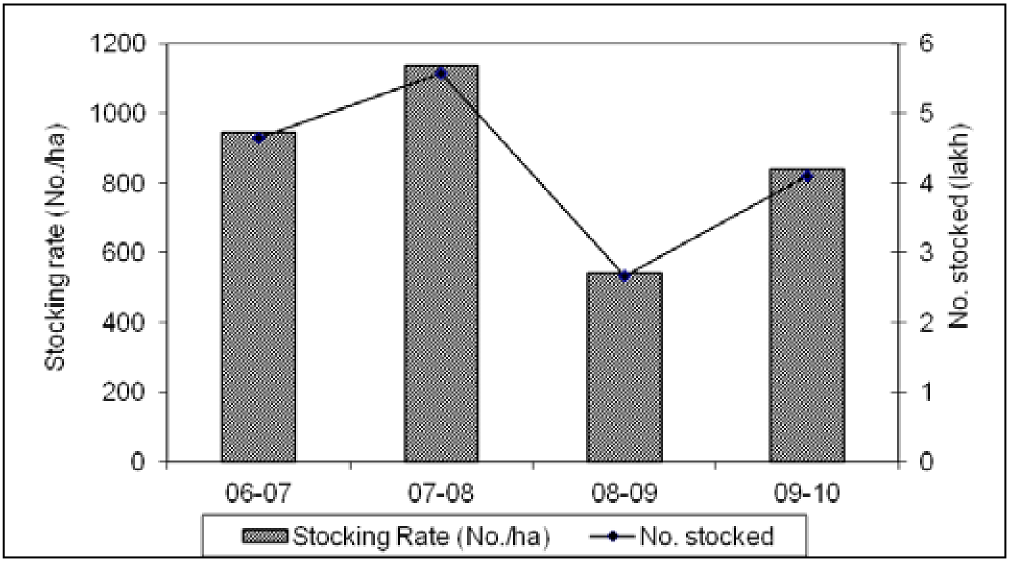

Fig. 19. Fish seed stocking in the Suvarnavathy reservoir

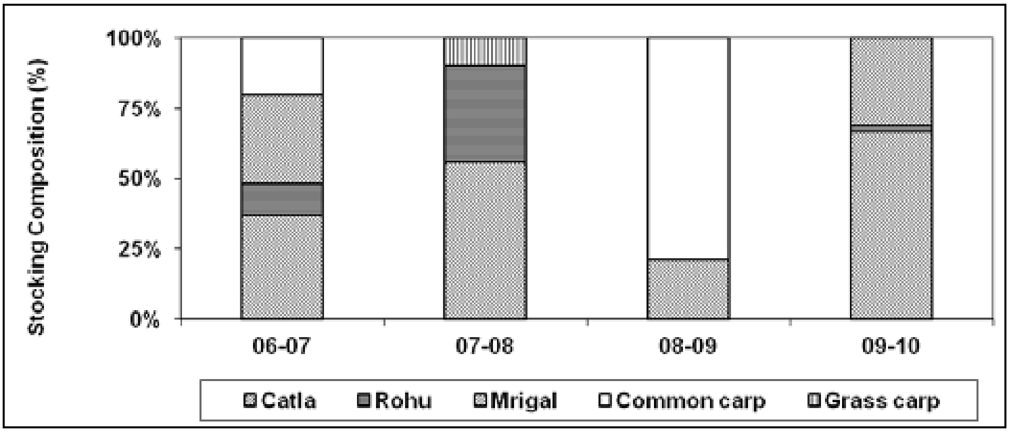

Fig. 20. Composition of fish seed stocked in the Suvarnavathy reservoir

For production enhancement, 4.64 lakhs fish seed were stocked into the reservoir in 2006-07 at fry stage (4.0 cm) at stocking rate of 946 No./ha. In 2007-08, for the first time in the history of the reservoir, the KCFF stocked 5.58 lakh seed (1137 No./ha) of advanced fingerlings of about 8.0 cm under NFDB funds. In 2008-09, lessee society reduced the stocking density to 542 No./ha and stocked 2.66 lakhs of seed (advanced fingerlings of catla 25% and advanced fry of common carp 75%). The seed of catla was stocked in all the years and the proportion varied from 20 to 55%. The seed of rohu and mrigal were not stocked every year, the former only in 2006-07 (11.2%) and 2007-08 (34.8%) and the latter in 2006-07 (31.5 %) and 2009-10 (31.6%).

Maturity and breeding of carps

The major carps, *Catla catla, Labeo rohita* and *Cirrhinus mrigal* reached ripening stage (stage IV stage) but did not breed in the reservoir, similar to many reservoirs in this region (Fig. 21).

Rohu Catla Mrigal

Figure 21. Gonads of catla, rohu and mrigal in Stage IV (July-August 2009)

Size structure of carps in commercial fishery

The modal lengths of catla recorded in the catch were around 32 to 40 cm and 50 to 56 cm. The modal lengths of rohu in the catch were around 36 and 56 cm. In the case of mrigal, the modal length observed was around 48 cm (Fig.22).

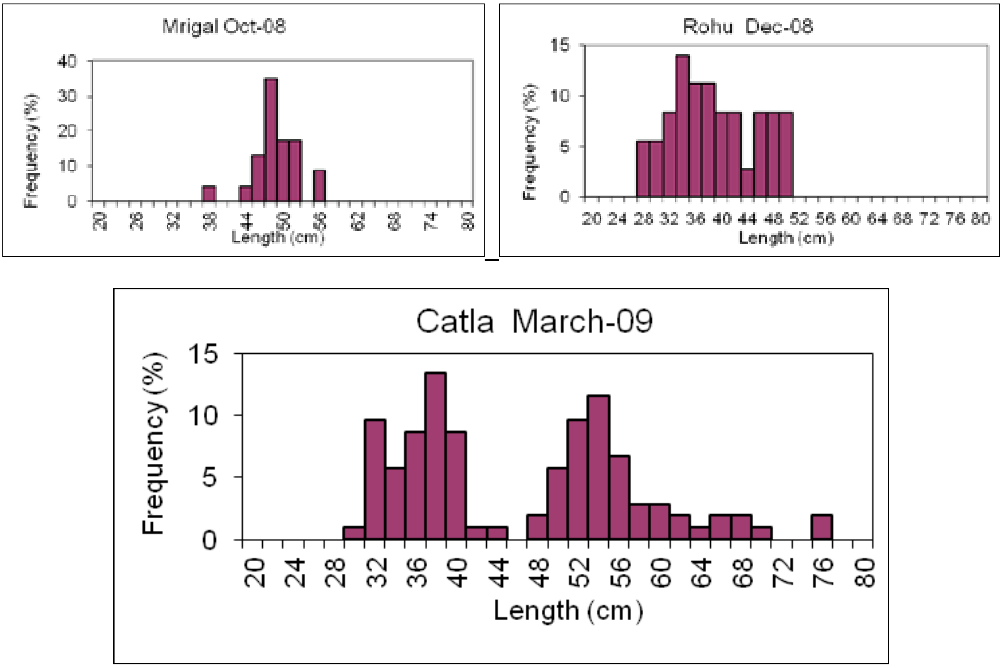

Fig. 22. Length-frequency of catla, rohu and mrigal in the commercial fishery

Growth rate of carps

Stocking in the reservoir is done every year around the month of September. Hence, it was possible to differentiate different year classes and to track the progress of modes. Catla attained lengths of 32.0 cm (around 700 g), 52.0 cm (2000 g), 66.0 cm (4000 g) and 73.0 cm (7000 g) at the end of I, II, III and IV years respectively. The growth rate was maximum in the first year and thereafter, it gradually declined. Rohu reached 32 cm (400 g) in I year, 46 cm (1000 g) in II year and 52 cm (2000 g) in III year. Mrigal grew to 32.0 cm (400 g), 46.0 cm (1000 g) and 58.0 cm (2500 g) in I, II and III years. The growth rates of rohu and mrigal were highest in the first year similar to catla (Fig. 23). Catla has been observed to exhibit good growth in most of the reservoirs in this region. About 80% of the harvest of all the three species of major carps takes place when the fish is between one to two years of age.

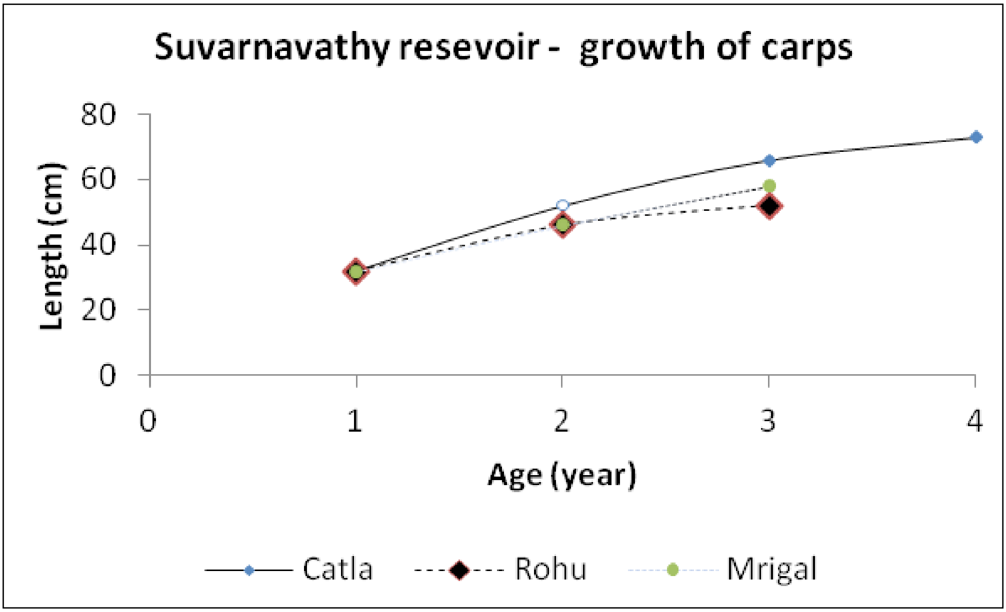

Fig. 23. Growth rate of major carps

Length-weight relationship of major carps

The length (L)-weight (W) relationships of catla (length range 28.5 to 74.5 cm), rohu (length range 30.0 to 58.0 cm) and mrigal (length range 31.5 to 60.0 cm) are exponential and are given below (Fig. 24)

Catla	LogW = -2.2359+3.2267 LogL	(r^2: 0.98, N=160)
Rohu	Log W = -1.7164+2.8596 LogL	(r^2: 0.95, N=47)
Mrigal	LogW = -2.1891+3.1261 LogL	(r^2: 0.96; N=61)

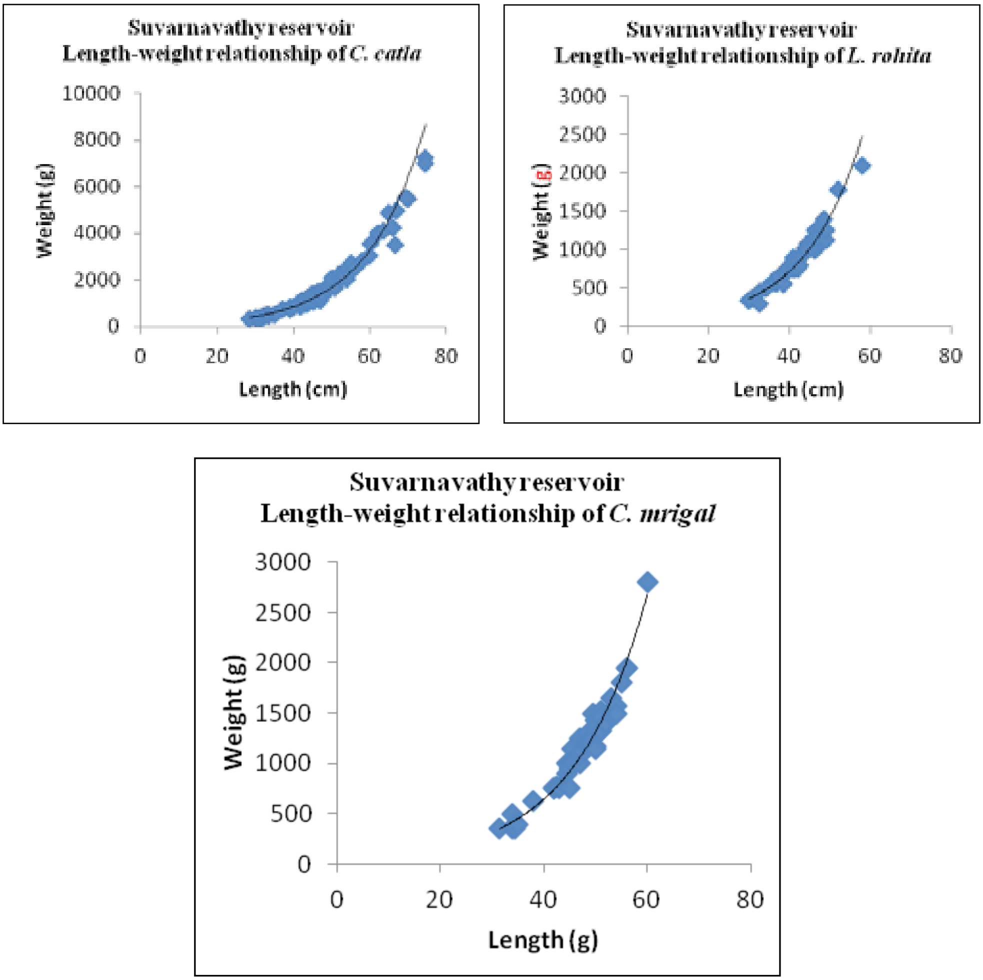

Fig. 24. Length-weight relationships of *Catla catla, L. rohita* and *C. mrigal*

Fish Production

The monthly variation in fish catch and CPUE is presented in Fig. 25. Highest landings were recorded in summer when water level was low and the lowest around December when water level was high and temperature low.

2007-08

An estimated catch of 42.5 t was recorded during April 2007 to March 08 with highest landings of 9.8 t in June 2007 and lowest of 0.7 t in January 2008. Maximum CPUE of 37.3 kg was recorded in February 2008 and the minimum of 5.2 kg in December 2007 (Mean CPUE 14.6 ±10.6). The total fishing effort exerted for the year was 2934 units. The fish yield for the year was 116 kg/ha/year.

2008-09

The estimated catch during April 2008 to March 09 was 63.0 t with highest landings of 13.2 t observed in March 2008 and lowest of 2.0 t in November 2009. Maximum CPUE of 26.9 kg was recorded in May 2007 and the minimum of 7.6 kg in November 2008. (Mean CPUE 13.4 ±5.5). The total fishing effort exerted for the year was 4349 units. The fish yield for the year was 172 kg/ha/year.

2009-10

During April 2009 to March 2010, an estimated catch of 71.8 t was documented with highest landings of 22.1 t recorded in April 2009 and lowest of 0.8 t in January 2010. Maximum CPUE of 61.7 kg was observed in April 2009 and the minimum of 4.9 kg in January 2010 (Mean CPUE 15.3 ± 19.2). The total fishing effort exerted for the year was 4536 units. The fish yield for the year was a high of 197 kg/ha/year.

Over all, the CPUE during the study period was high and hovered around a high of 10 kg during most of the months vis-à-vis less than 5 kg in unmanaged reservoirs. The CPUE was higher during low water level of summer months and was low during high water level of winter months.

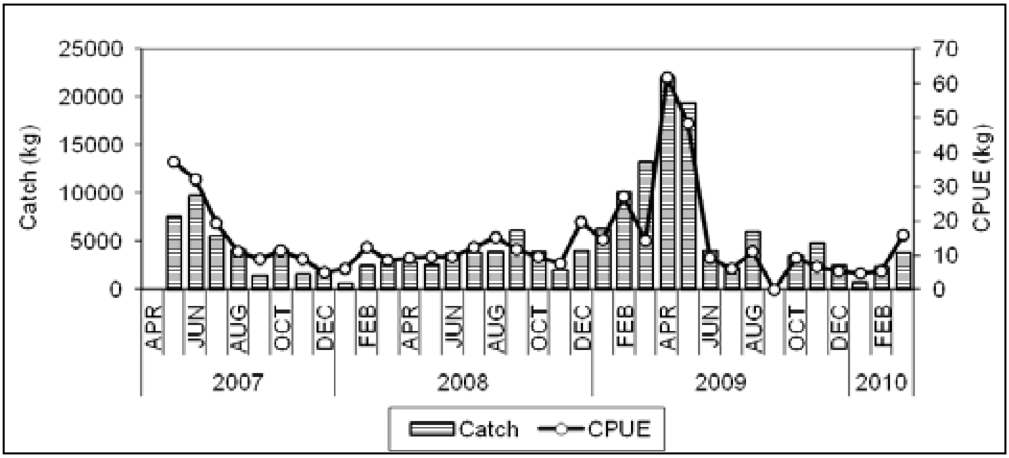

Fig. 25. Monthly variation in fish catch and CPUE

Seasonal variation in species composition

Seasonal variation in species composition was observed in the commercial catches. The contribution of tilapia was relatively high during October to December, coinciding with rising water level. Bottom feeding mrigal were most susceptible during the period of June to August characterized by lowest water level. Catla and rohu contributed to the catch significantly in all the seasons, the latter more abundant in post-monsoon season (Fig. 26).

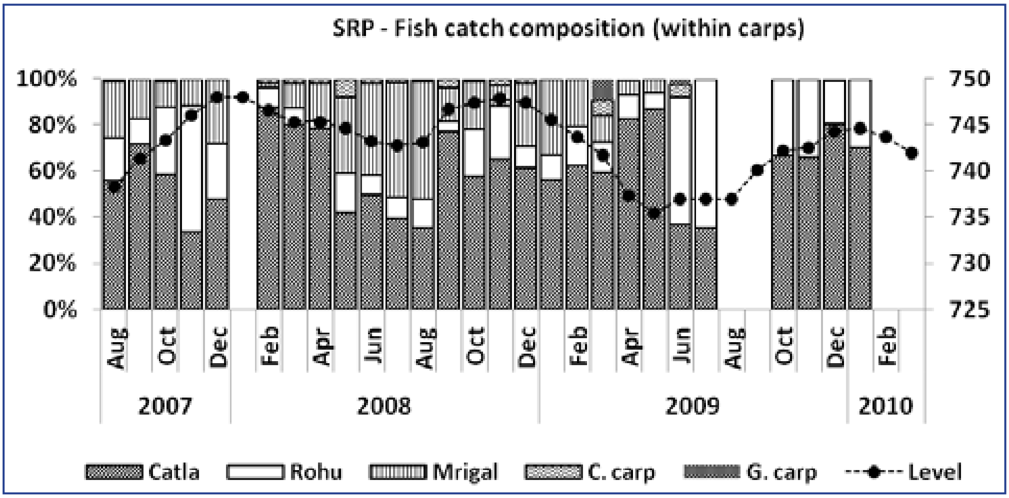

Fig. 26. Temporal variation in catch composition (within carps) in commercial fishery

Composition of commercial catch

High value economic carps contributed more than 90% to the total catch during the period 2007-2010 and the rest by the exotic tilapia, *O. mossambicus* (Fig. 27). Within carps, catla contributed 62.0%, rohu 13%, mrigal 22%, common carp 2% and grass carp 1% during 2007-09. In 2009-10, catla contributed 70%, rohu 27% and mrigal a mere 3%. The share of mrigal dwindled due to lack of stocking support and it disappeared from the catch completely from June 2009 onwards. The catch was dominated by fish that feed low in the food chain *viz.* herbivorous rohu, planktivorous catla and iliophagous mrigal.

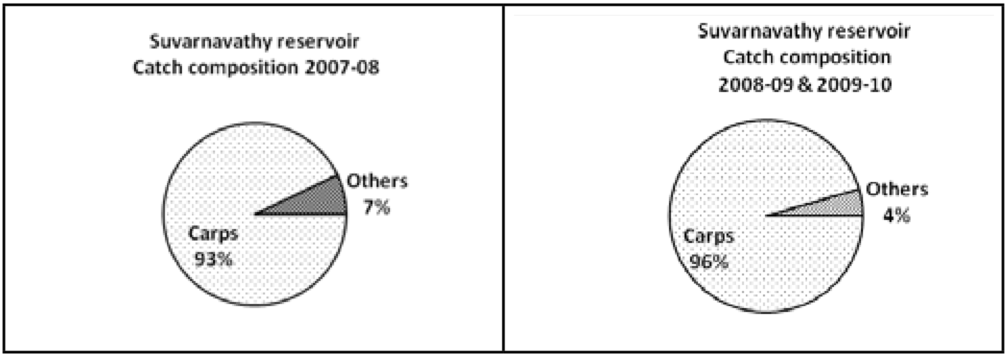

Fig. 27. Overall catch composition in commercial fishery

The native fish species like *P. sarana, C. reba, O. bimaculatus, M. cavasius* and *M. armatus* appeared in low numbers in the commercial catch, obviously due to poor natural recruitment and no artificial stocking.

Impact of stocking

Stocking of advanced fingerlings and mesh-size regulation had visible impact on fish production, fish yield and income (Fig. 28).

- The total fish catch increased considerably by 48.1% from 42.5 t in 2007-08 to 63.0 t in 2008-09 and by68.9% (*vis-a-vis* 2007-08) to 71.8 t. The fish yield increased impressively, per unit water area, by 48.3% from 116 kg/ha in 2007-08 to 172 kg/ha in 2008-09 and by 68.8% to 197 kg in 2009-10.
- Despite an increase in total effort by a significant 54.2%, the CPUE marginally increased from 14.6 kg in 2007-08 to 15.3 kg in 2009-10.
- The estimated increase in gross income to the society in 2009-10 over 2007-08 was to the tune of Rs. 11,72,000/- and Rs. 22,000/- to the individual fisher.

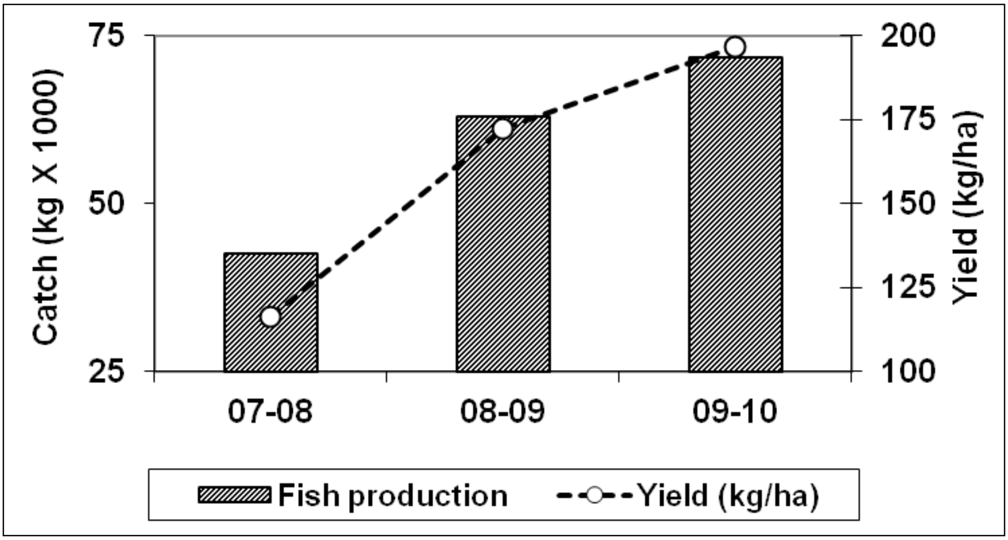

Fig.28. Annual variation in fish production and yield

Catch per unit effort – Overview

The average CPUE for the study period was about 10 kg during most of the months with the exception of January to May 2009 when CPUE was recorded up to 61.7kg. High CPUE coincided with low water level of summer. CPUE was relatively low during the winter months of December- January (around 5 kg) characterised by high water level and low activity of fish. The total fishing effort ranged from 2934 crafts in 2007-08 to 4349 crafts in 2009-10. The annual mean CPUE varied from 13 kg in 2008-09 to 15 kg in 2009-10. Fishing intensity was always high in the intermediate zone of the reservoir.

Minor cyprinids

Due to prohibition of operation of shore-seine, minor cyprinids (*P. ticto, P. sophore, S. belachi)* and other small size species (e.g. *C. nama)* were not properly exploited. In our experimental fishing, these species appeared in abundance. Under close supervision, this resource has to be exploited during summer, using shore seine and minnow gillnets (mesh-size: 20 mm), which may easily increase the fish yield by another 25 to 30%. Further, their exploitation would reduce the competition for food to major carps resulting in faster growth of major carps.

Fishing Holiday

The society does not fish all the days in a year (Fig. 29). Fishing is stopped almost every month for one or more reasons such as

- The suspension of fishing for few days after a period continuous fishing would ensure high catches
- To participate in village festivals and social events
- During harvesting of agricultural crops
- For a few weeks after stocking of the seed

The average days of fishing per year during the three years of 2007-10 were a low of 219 (60.1%).

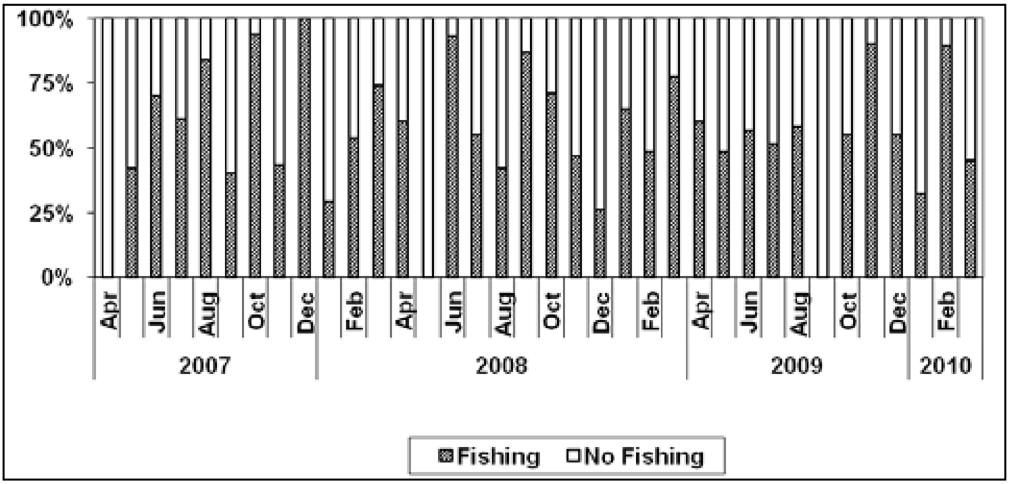

Fig.29. Monthly variation in fishing days (%)

Relationship of catch with effort and water level

A functional relationship of catch with effort and water level was estimated and the estimated multiple regression was

$$\ln Y = 71.38718 + 0.002905072\, X_1 - 0.026305230\, X_2 \quad (n=33\ ;\ R^2 = 0.52)$$

$$(0.000784)\ (0.007837)$$

where Y – Catch, X_1 – Effort and X_2 – Water Level

From the analysis of standard partial regression coefficients, it was observed that effort influenced the catch the most, followed by water level.

Fish production potential

Based on Morpho-edaphic index (conductivity: 209 µS/cm, Mean depth: 7.25), the predicted fish yield is 106 kg/ha/year, which is far less than the realised yield.

Morpho-edaphic index developed by Ryder (1965) has been successfully used to predict fish yield from temperate and tropical African lakes. But attempts to apply MEI to Asian reservoirs have not been very successful (De Silva, 1992). Using the relationship developed by Downing *et al.* (1990) between fish yield and primary production (GPP is 902.1 g C/m^2), the fish production potential of Suvarnavathy reservoir is predicted as 198.9 kg/ha/year and the observed yield is close to the predicted yield. However, the transfer efficiency from gross production to fish is found to vary from 0.1 to 1.6% in natural waters. Assuming a conversion efficiency of 0.5%, the fish production potential of Suvarnavathy reservoir would be around 450 kg/ha/yr.

Marketing

The marketing chain in the reservoir is as follows: the catch from different boats reaches the landing centre, located on the right bank of the reservoir, between 9.00 AM and 10.30 AM. The fishers from Kollur area require nearly an hour to reach the landing centre. The fishers hand-over the entire catch to the Society. The society sells apart of the catch to the consumers directly, a part to the local retail merchants and the rest to retail merchants who transport without icing to the nearby town Chamarajanagar (18 km away) in two wheelers. Wholesalers have no role in marketing. Occasionally, the KCFF purchases the fish, for their kiosks at Mysore, and transport in iced condition in truck. Demand for the fish is always more than the supply.

High value fish were sold to local consumers at Rs. 40/- per kg and to merchants at Rs. 30/- per kg. Low value fish were sold at Rs. 20/- per kg to merchants. Fishers get remuneration equivalent to 50% of the value of fish. The demand for low value fish by local consumers is negligible. The cost of carps in the nearby town Chamarajanagar was almost double and was around Rs. 70/- to Rs. 80/- per kg.

The fish marketing channels observed in the reservoir were:

(i) Fisher- Co-operative Society – Consumer

(ii) Fisher- Co-operative Society- Retailer- Consumer

Socio-economics of the fisher community

The fisher community is spread in two villages around the reservoir. The number of active fishers was around 20 and during peak season, the number may go up to 30. The socio-economic conditions of the fishers indicated that most of the families were joint with average family size of 5.8. In most of the families, the parents were living with children. The average age of the fishers was 32 years and the age ranging from 21 to 60 years. In three families, females help the males in fishing. About 60% of fishers belong to tribal community and are not fishermen by birth. The literacy rate was 50% with most of the fishers literate up to higher primary school and about 50% of their children at various level of schooling. Most of them owned *pucca* house with one room. Among them, 12.5% owned agricultural land and 18.5% of the fishers kept livestock. About 31.25% of fishermen belonged to fishermen community and about 50% of total fishers are members of co-operative society. The main occupation of all the fishers was fisheries. During fishing holidays, some fishers go for daily wages.

Craft and Gear

About 50% of fishers had their own craft (bamboo coracle) and those without craft shared with others. The coracle lasts for about a year. The cost of a coracle was around Rs. 2000/- and the fishers spent about Rs. 500/- on its maintenance. The only gear used was monofilament gillnet. Each family operates around 10 kg net and the longevity of the net is around six months. The annual expenditure on nets per family was around Rs. 20,000/-. Both coracle and fishing gears are available in nearby towns (Kollegal and Mysore).

Infrastructure available

The infrastructure facilities of the reservoir include excellent public transport connectivity as the reservoir is located adjacent to national Highway and in the vicinity of the district HQ. Other facilities are metal approach road to fishing villages, easy availability of fishery requisites (craft and gear) and ice for storage. The nearest major fish market is Chamarajanagar and is located at about 18 km from the reservoir.

Institutional arrangements

The ownership of the reservoir is with the Department of Irrigation, while Karnataka Cooperative Fisheries Federation has leased out the fishing rights to the fisher's co-operative for five years from 2007 to 12. The annual lease amount was Rs. 50, 000/- for 2007-08. As per the leasing terms, the lease amount is increased at an annual rate of 5%.

Recommendations suggested to the lessee society for further enhancement of fish yield

- *Although catla is being stocked every year, the stocking of rohu and mrigal has been irregular. Sustained annual stocking of all the three species of major carps – catla, rohu and mrigal in the ratio of 4:3:3 is to be followed to exploit the food niches.*
- *The size of fish seed stocked is not uniform and varies from fry to fingerlings. A stocking density of 500 fingerlings/ha of advanced fingerlings of 10 cm size is recommended. For Suvarnavathy reservoir, at mean water spread area of 365 ha, the total number of fingerlings required is 1,83, 000 . Out of this, the number of catla is 73,000, rohu 55,000 and mrigal 55,000.*
- *Carps of less than 500 g are common in catches. This is not economically beneficial to the society and fishers. Mesh-size regulation may be strictly enforced and operation of gillnets of 10 cm mesh size (stretched) and above may only be permitted so that carps of one kg and above weight are exploited. Mesh-size of 5.0 cm and less may be permitted in summer to exploit medium catfish and minor cyprinids.*
- *The number of days of fishing in a year is low of around 60% and has to be increased to 80%. As fishing is for livelihood, long period of fishing holidays extending from 3-4 weeks at a stretch will be difficult for fishers to manage financially. In reservoirs that thermally stratify and show low oxygen to anoxic condition (e.g. Nelligudda reservoir, Manchanbele reservoir), common carp has failed to establish. The survival and growth of common carp in such reservoirs is poor and stocking has not been reflected in the commercial catches. In Suvarnavathy reservoir a similar observation was made. The growth of grass carp has been poor because of lack of macrophyte beds. Hence, stocking of these two species may be given low priority and be restricted to less than 5% each of the total seed stocked. Freshwater prawn (M. rosenbergii and M. malcalmsonii), do not exhibit good growth in waters having low oxygen or anoxic condition in bottom layers. Hence, stocking prawn seed will not be beneficial.*
- *Harvesting of minor cyprinids and small fish like ambassids is not being done due to ban on operation of shore seines. In summer, operation of shore seine (20 mm mesh-size), under vigilance, may be permitted. The under-sized commercial carps caught in the nets may be released back to the reservoir*
- *Purchase and transport of advanced fingerlings from distant places (Andhra Pradesh) for stocking Suvarnavathy reservoir is expensive. In situ rearing of major carps seed in cages and peripheral ponds from fry to fingerling stage may be done. This will reduce the expenditure on seed as well as generate subsidiary employment to fishers.*

- *A motorised boat, with integrated insulated iceboxes, will help in quick transport of harvested fish from intermediate and lotic sectors (near Kollur) to the landing site. This not only keeps the quality of fish high but also saves time and energy to the fishers to get back to their village. At present, sale of fish is being completed at around 11.00 AM. By use of motorised boat, the sale could be finished before 8.30 AM, thus saving time of fishers for other works.*
- *A fibre-glass coracle of 2 m diameter costs around Rs, 12,000/- as compared to bamboo coracle that costs around Rs. 2000/-. Although the initial investment is high, fibre-glass coracle is more stable and the longevity is 8 to 10 years vis-à-vis one year for a bamboo coracle and is recommended. Further, the fishers have to spend around Rs. 500/- on maintenance of a bamboo coracle.*
- *Due to uncertain inflow and unstable water level, the reservoir is not congenial for pen culture.*

References

Carlson, R.E., 1977. A trophic state index for lakes. *Limnology and Oceanography*. 22(2): 361-369.

Cowx, I. G., 1998. Stocking strategies: issues and options for future enhancement programmes, In: I.G. Cowx (ed.) Stocking and Introduction of Fish. Oxford: Fishing News Books. pp. 3-13

de Silva, K. H. G. M., 1992. Limnology and fishery of three recently impounded reservoirs in Sri Lanka. In: Reservoir Fisheries of Asia (ed. S. S. De Silva), pp. 12-22. International Development Research Centre, Ottawa.

de Silva, S., 2001. Reservoir fisheries : broad strategies for enhancing yields, In: De Silva, Sena S. (eds), Reservoir and culture-based fisheries : biology and management : proceedings of an international workshop held in Bangkok, Thailand, from 15-18 February 2000, pp. 7-15, Australian Centre for International Agricultural Research, Canberra, A.C.T.

Downing, J. A., Plante, C. and Lalonde S., 1990. Fish production correlated with primary productivity, not the morphoedaphic index. *Can. J. Fish. Aquat. Sci.*, 47: 1929-1936.

Krishna Rao et al. 1998. Depth-Time Distribution of Photosynthesis in Nelligudda Reservoir. *Karnataka Journal of Agricultural Sciences*, 11 (3): 787-791.

Naumann, E., 1919. Nagra synpunkter angaende limnoplanktons okologi med sarskild hansyn till fytoplankton. *Sv. Bot. Tidskr.*, 13: 129-163.

Naumann, E., 1929. The scope and chief problems of regional limnology. *Int. Revue ges. Hydrobiol.*, 21: 423.

Ryder, R . A., 1965. A method for estimating the potential fish production of north-temperate lakes. *Transactions of the American Fisheries Society*, 94: 214-218.

Sugunan, V.V. 1995. Reservoir fisheries of India. FAO Fish Tech. Pap. No. 345. Rome, Italy.

Welcomme, R. L., 1998. Evaluation of stocking and introductions as management tools. In: I.G. Cowx (ed.) Stocking and Introduction of Fish. Oxford: Fishing News Books pp 397-401.

Welcomme, R. L., 2001. Inland fisheries: ecology and management. Fishing News Books, Oxford. 358 p.

Notes