CHAPTER III

HISTORICAL RESUME
Background

The evidence that people of Egypt were probably the first in the world to culture fish as far as back as 2500 B.C., comes from a pictorial engraving on an ancient Egyptian tomb showing Tilapia being fished out of an artificial pond (Marr et al., 1966). Carp culture was widespread in China 2000 B.C. Fish culture in the Indian subcontinent is undoubtedly hundreds of years old. Kautilya's Arthasatra, written between 321 and 300 B.C., mentions of Secret means of rendering fish in reservoirs poisonous in times of war (Book ZIV, Chapter I, pp. 478, 479, quoted by Hora and Pillay, 1962). This indicates that fish culture flourished at that time in reservoirs. Another document, which describes methods of fathering fish in ponds is the encyclopedia of King Somesvara, Manasolpara, compiled in 1127 A.D. (Hora, 1951). A notable advance in fish culture in Bengal was the construction of bundhs for carp breeding, coming down to modern times, where some of the riverine conditions are simulated.

Although aquaculture in India dates back to 1127 A.D., it remained at a subsistence level in the past, but in the last two decades India initiated a large number of programmes to increase her fisheries production by promoting aquaculture throughout the country. In order to provide proper scientific backstopping for
the intensification of freshwater aquaculture, the Indian Council of Agricultural Research (ICAR) established the Freshwater Aquaculture Research and Training Centres (FARTC) at Dhauli in Orissa in 1980 which became the Central Institute of Freshwater Aquaculture (CIFA) in 1985. It undertakes researches in disciplines like pond dynamics, fish nutrition and feed formulation, fish breeding and genetics, fish pathology and diseases and aquaculture economics. The centre is also functioning as a centre for Advanced study on Freshwater Aquaculture under another project of FAO/UNDP.

Inland Fisheries Resources and Production

As per the statistics available Inland Fisheries resources in the country are: Tanks and Ponds 0.75 million ha., Beels, Ox-bow lakes and derelict waters about 1.0 million ha., brackishwater and mangroves 0.9 million ha., reservoirs 1.45 million ha., rivers 29000 Km and canals 0.1 million km. Though no separate statistics are available on freshwater fish production through aquaculture, the very fact that inland fish production has increased from about 0.218 million tonnes in 1950-51 to over 1.40 million tonnes in 1989-90 is indicative of its increasing popularity especially when fish production from rivers, estuaries and other capture fisheries resources is declining (Tripathi et al. 1988). During this period the inland fishery production grew at the rate of 13.93% per annum.

Limnological Studies

Broadly Limnology is a 'study of fresh waters' and it deals with biological productivity of inland waters...." (Welch, 1952).
Waters are divided into two categories—Lotic or flowing waters (brooks, streams, rivers etc.) and Lentic waters (Ponds, tanks, closed lakes etc.). In contrast to the classical limnology of Europe, Asian Limnology is mostly applied, especially to fish production. As aptly remarked by Horie (1962), "Scanty distribution of glacial morphology formed by the Continental ice sheet must be kept in mind when we compare limnology of Asia with Europe and North America."

The physical and chemical parameters of water bodies are basic and essential constituents on which the aquatic productivity depends. Thermal relations are pivotal points in limnological investigations. The oxygen-rich surface waters carry oxygen to the depleted bottom layers. By acting as a barrier between surface and bottom waters permanent stratification can be responsible for the low productivity (Allanson, 1965). High bottom temperatures are characteristics of tropical waters (Ruttner et al., 1963).

Tropical waters are generally more productive due to high water temperature and the absence of a winter season (Worthington, 1943). Variation in water temperature has bearing on pond productivity (Jhingran, 1975). A limnologist can probably learn more about the nature of a lake from a series of oxygen determinations than any other kind of chemical data (Hutchinson, 1957). Free carbon dioxide content is of little value in assessing the productivity of waters (Moyle, 1946).
The usefulness of Electrical Conductivity measurements has been stressed (Edmondson, 1956).

Studies of rivers and streams in India have not been as intensive and wide as those of ponds and impoundments but considerable work has been done. Water quality varies from fast running, clear streams of uplands to turbid sluggish hard water of plans. The Cauvery River and its tributaries yield over 16,600 tonnes of fish per annum (Srinivasan and Sreenivasa, 1976). Limnology of river Yamuna was studied by Chakraborty et al., (1958).

Fish production significantly increases with increasing alkalinity (Carlander, 1958). Generally, high amount of alkalinity results in higher productivity (Ellis 1937; Hubbs and Eschmeyer, 1938). Alkalinity over 150 mg/l is conducive to higher production (Ball, 1948) and the hard waters are more productive than soft waters (Barrett, 1953). Alikunhi (1957), Hazelwood and Parker (1961) have also recorded the importance of alkalinity for productivity of water bodies.

Limnological studies on the fresh water impoundments in relation to fish production have received little attention in India. A few workers (Ganapati, 1955; Rao and Govind, 1964; Hussainy, 1967 and Vasisht, 1968) have studied the different limnological aspects or various impounded waters but no attempt has been made towards establishing a correlation between limnological features and the fish production.
Limnological studies of various water bodies have been done by number of workers. Some of the important among them are Forel (1892-1904), Lindeman (1942), Hutchinson (1944, 1957 and 1967), Wright (1958), George (1964), Prowse (1964), Sreenivasan (1964, 1967 & 1968), Lagler (1956) and Khan et al. (1974).

The hydrology of certain water bodies like reservoirs, lakes & ponds has been studied by workers with a view to study the inter-relationship of various physical and chemical factors and their influence on biological productivity. Some of the important among them are Ganapathi et al. (1948) studied the Stanley reservoir at Mettur, Madras and a typical microbiotal water in Madras (Ganapati, 1950). Dorai Rajah (1956) studied the hydrology of Bhavanisagar Reservoir. Sarkar and Rai (1960) studied the hydrobiology of Surajkund. Holden and Green (1960) studied the hydrobiology and plankton of river Sokoto, Japan, Subba Rao and Govind (1964) studied the hydrobiological features of Tungabhadra reservoir. Hosmani and Bharati (1975) made hydrological studies in pond and lakes of Dharwar and Raman et al. (1975) studied the hydrobiology and ecology of Pulicat lake.

**Ponds categorisation**

According to Welch (1952) "ponds represent that class of very small shallow bodies of standing water in which relatively quiet water and extensive plant occupancy are common characteri-
tics.* Ponds may be found most regions of adequate rainfall and are continually being formed. Tanks are man made ponds having cemented sides and bottom.

As per Forel's (1892) and Whipple (1898), the ponds represent lakes of third order. Small and shallow bodies of quiet standing waters with only slight wind action are ponds. There is generally extensive growth of higher aquatic plants. Ponds may be classified in various categories on the basis of their origin (i) natural developed from ox-bow lakes and (ii) artificial constructed, excavated or impounded by man. Fresh-water ponds and tanks lie scattered all over the country and constitute the country's most valuable water resources for culture fisheries. The ponds are of great importance to human population as they are most convenient source of water for domestic needs, serve as a very suitable and cheap disposal bins and have great potentialities for the development of inland fisheries.

**Supplementary Feed**

The available natural food in the ponds, rich in protein, may not meet the demands of the fish for growth. The food shortage is obviated in ponds under intensive culture by resorting to artificial/supplementary feeding. A mixture of mustard oil cake/groundnut oil cake and rice bran in the ratio 1:1 is the
recommended artificial feed. This mixture is now being provided in experimental ponds in different ratios keeping in view the requirements of the feed and economics of fish production. Ordinarily, supplementary feed equivalent to 5-10% of the body weight of the fish is provided. Prasad (1916) worked on the seasonal conditions governing the pond life in the Punjab.

Aquatic productivity factors

Aquatic productivity is dependent on its environment or the soil quality of the pond. Soil condition is an important environmental factor influencing water quality and controlling various production processes (Golterman, 1967; Wrobel, 1967; Jana et al. 1983). Pond productivity has been classified into three categories based on status of available nitrogen and phosphorous (Banerjex, 1967). Alikunhi (1957) has worked on pH range of soil. Some of the important workers are Meehan (1935), Nees (1946) and Hepher (1952).

Besides using the chemical fertilizers were used for increasing aquatic productivity with exceedingly good results (Saha and Chatterjee, 1974 and 1975; Saha et al., 1978). Cobalt and manganese resulted in greatly increased plankton production and survival rates. Nitrogen balance in composite Carp Ponds has been studied and found a large amount of nitrogen remaining
unutilized in the ponds with only a small portion being returned back as fish (Sinha et al., 1980). Organic fertilizers, especially cow dung, are used all over the country, dosage ranging from 5,000-10,000 kg/ha/year in ponds provided with supplementary feed or 10,000-20,000 kg/ha/year in ponds without the feed.

Maintenance of a healthy aquatic environment and production of sufficient fish food organisms in ponds are factors of primary importance for successful pond cultural operations. Physical and chemical factors like depth, temperature, turbidity, light, pH, dissolved gases like oxygen and carbon dioxide, carbonates, bicarbonates hardness, phosphate, nitrate, silicate, chloride etc. are some of the essential characteristics reflecting the water quality and its productivity.

Sewell (1927) conducted probably the first ever study of water quality of a fish pond in India while studying the mortality of fish in the Museum tank in Calcutta. This was followed by a detailed study of same tank by Pruthi (1932). Juday and Birge (1932) worked on the dissolved oxygen and oxygen consumed in lake water. Ellis et al. (1946) worked on the determination of water quality. Since then a number of workers have studied the physico-chemical condition of inland waters as part of general hydrological survey or productivity of ponds/tanks.

Hydrogen-ion concentration (pH) is one of the important
chemical factors of water affecting pond productivity. Huet (1965), Swingle (1967a) have indicated certain pH ranges of water favourable for fish culture. Some of the important workers on different Physico-chemical parameters of water bodies are: Alikunhi et al. (1948), Ganapti (1949 and 1950), Dickson (1950), Chacko and Srinivasan (1954), Ryther and Vaccaro (1954), Maan (1958), Sreenivasan (1964 and 1978), Upadhyaya (1964), Palmer (1968) and Khan and Siddiqui (1974).

Banerjee and Roy Chaudhury (1966) made observations on some physico-chemical factors in Chilka lake.

A number of workers have worked on the diurnal variations of physico-chemical factors in water bodies. Some of them are: Cerny (1948), Newell (1957), Hepher (1959), George (1962a) and George (1966). Vijayaraghavan (1971a) and Nasar and Munshi (1974) studied the diurnal and seasonal variations in physico-chemical and biological factors of ponds.

Pollution

Pollution experts have suggested that standards of pollution of air and water be specified for different ecoclimatic and geographical zones to fight the increasing menace. Direct effects of pollution on fish life are either catastrophic or gradual, depending on the amount and kind of the undesirable affluent in relation to the quantity of the recipient water mass. An ordinary pollutant harms a fish either indirectly or directly (Ellis, 1936 and 1944). The fishery biologist encounters several weighty impediments in his efforts to regulate pollution (Beatty, 1948). Sudden large mortalities involving several fish species are sometimes an evidence of man made pollution. At other times, they may arise from natural causes such as seasonal anaerobiosis (Moore, 1942), lightening striking the water (Raney, 1941), or water toxification by another organism (Mackenthum et al., 1948). The Aquatic Life Advisory Committee (1955) recommended certain measures to check pollution. Feeding in aquaculture also causes deposition of organic load and increased metabolic concentration.

Pollution may be detected and measured by various combinations of chemical, physical and biological means. A natural property of lakes and streams is to overcome the effects of pollution by self-purification. However, the extent to which the purifying process can be carried by these means is limited.
FAO (1967) gave a report to the Government of India on water pollution with respect to inland fisheries. It was based on the work of E.W. Surber, FAO/TA Inland Fishery Biologist. The other important workers are Das (1978), Das and Pandey (1978) and Pandey and Shukla (1982).

Carp Culture

Several species of carps of commercial value taking care of the various trophic levels have been used for culture in ponds. However, the Indian Major carps, *Catla catla*, *Labeo rohita* and *Cirrhina mrigala* that are the ideally suited and widely used in pond culture as they meet the qualities demand of fish for culture. *Catla*, is a surface dweller and predominantly a Zooplankton feeder. *Rohu*, a column browser is a herbivore subsisting on plankton, periphytic organisms and decaying vegetable matter. *Mrigal*, a bottom feeder is an illiophage drawing its nutrition from detritus and semi-decayed vegetable matter.

Traditional carp culture has been transformed into a scientific system. In fish culture with only Indian major carps, ratios of 4:3:3 of catla, rohu and mrigal have been observed to be quite favourable in so far as their survival and growth are concerned.

Swingle (1961) studied the relationship of pH of pond
waters to their suitability for pond fish culture. A number of workers have contributed regarding the pond as well as fish productivity in the development of aquaculture. Some of the important among them are: Botke (1954), Khan and Siddiqui (1971), Rai & Hill (1984), Jhingaran (1952 and 1976), Misra (1978), Nasar and Datta Munshi (1975), Ryther (1956), Schaperclauss (1933) and Talling (1966) have also worked on composite fish culture.

**Ecological Studies**

Odum (1959) defined Ecology as the study of structure and function of nature. Considerable work has been done on the freshwater ecosystem including ponds in temperate zone, but in tropics, specially in India not much work has been done. Ecological investigations of lakes, reservoirs and ponds dates back to 1887 with the work of Forbes, who regarded lakes as a 'Microcosm', as a structural and functional unit. Later a number of workers investigated different aspects such as, Rowson (1939) studied the cycling of inorganic and organic materials. Other important workers are Wetzel (1975), Berko and Smart (1981), Reddy (1981), Rai and Hill (1984). Some important reports available on freshwater ponds and lakes of India are those of Ganapati (1943 and 1960) and Sreenivasan (1963). Ganapati (1943) worked mainly on Zooplankton of ponds and ecology of tropical waters. Ganapati (1940) and Ganapati et al. (1948) worked on the ecology of tank and ponds. Ganapati (1941) also studied the chemistry and biology of ponds.
Sreenivasan (1963) studied the primary production in three lakes of Madras. Some other important workers on ponds ecology and productivity are Rao (1971 and 1972) and Mallick and Bose (1987).


George (1966) studied the ecology of five fish tanks of Delhi. Some of the other important workers are Munawar (1970), Ayyappan et al. (1980) and Adoni et al. (1985). Datta and others (1983 and 1986) worked on the diurnal variation in physico-chemical and Zooplankton population of two freshwater fish ponds and the effect of physico-chemical factors of abundance of cladocerans. The other important and recent workers are Fukusho et al. (1984), Senguin (1982) and Singh & Singh (1985). Ichimura (1960) studied the diurnal variation of chlorophyll content in lake water while Chaudhari and Rao (1985) studied on diurnal and vertical distribution of phytoplankton.

**Composite Fish Culture**

Bhimachar and Tripathi (1967) reviewed culture fisheries activities in India at a time when scientific brakishwater aquaculture was unknown and prawn farming non-existent. Only systems development in freshwater fish culture was known then and
scientific foundations were being laid. As evidenced by increased fish production, freshwater aquaculture is no longer in its infancy and appears to have come of age due to recent developments and associated activities. There is a growing awakening on the use of quality seed, good feed and maintenance of suitable water quality and healthy disease free environment. Alikunhi (1956 and 1971) studied the fish culture techniques and development of intensive fish culture practices in the country.

Stocking density is a function of the natural or inherent initially in the face of fertilisation and still further with provision of supplementary feeding. Densities from 3,000 (Alikunhi et al., 1971) to 13,320 fingerlings/hectare (Chaudhuri et al. 1978) have been tried with almost as many permutations and combinations of densities and species proportions as possible (Lakshmanan et al. 1971; Sinha et al., 1973 and Tripathi, 1984). Competition between Catla and Silver Carp (Sukumaran et al., 1968) and Silver Carp and Rohu (Day et al., 1979) being known, their proportions are adjusted properly. Intensive culture of Indian major carps at 3,750 to 15,000 fingerlings/ha. has also been tried, the proportion of Catla catla 4, Labeo rohita 3 and Cirrhina mrigala 3 being ideal. An ideal proportion in composite carp culture was found to be Silver carp 25 : Catla 10 : Rohu 25 : Grass carp 10 : mrigal 10 : common carp 20. This proption and densities of 5,000, 6,000 and 7,500/ha. were tried on a mass scale
in farmer's ponds under the Rural Aquaculture project in West Bengal and Orissa and fish production from an average of 3,000-4,000 kg/ha in Orissa and 4,000-6,000 kg/ha in West Bengal obtained in an year (CIFRI, 1979).

Under the All India coordinated Research Project on composite Fish Culture and Fish Seed Production, the percentage of Indian major carps was reduced to 30%, each of the three species catla, Rohu and Mrigla being equal (10%) and yet their growth was always poor, especially that of rohu in shallow farm ponds.

The aim of fish culture as being one to increase by all possible means the production of food for above the level of normal production (Hickling, 1962). The realisation of this objective on sound scientific basis is the essence of management. Manifold increases in fish production from ponds by proper management have been achieved in the last two decades from many parts of the world. Bardach et al. (1972) indicated the possibilities of fish production of 8,000 kg/ha/year. Production of 10,390 kg/ha/year was recorded in Burma (now called Myanmar) by Chaudhuri (FAO, 1971).

The size and depth of ponds or water level appear to play a significant role in the growth of Indian carps (Tripathi, 1982). This was further confirmed by growth of rohu in commercial farms.
of Andhra Pradesh where it attained a weight of over 1 kg in one year even when stocked at 70% of the whole stock of 5,000/ha. Though not always so, increasing stocking densities resulted in increasingly higher yields. High rates of production of the order of 5,175-5,334 kg/ha/year (Chaudhuri et al., 1975) and 3,232 kg/ha (Sinha et al., 1973) in 6 months were obtained in different places in the country. An increase in density to 7500-7840/ha. was followed by a further increase in the yield to 7500-8867 kg/ha/year (Chakraborty et al., 1980) and 7,000-9,389 kg/ha/year (Chaudhuri et al., 1974). The highest densities tried so far of 10,000-13,320/ha. resulted in both low (7,445-7,633 kg/ha/year), (Chaudhuri et al., 1978) and high (10,164-10,678 kg/ha/year, Rao and Singh, 1984) yields depending on water management.

While on the one hand, increasing densities were found to result in higher yields, even a low density of 4,000/ha. gave yields as high as 6,000 kg/ha/8 months (Shah and Tyagi, 1984) with addition of water in ponds with heavy seepage. About 20% of water losses were made good every day. Each of the six species registered a record growth, their average weight being silver carp 2.4 kg, Grass carp 3.3 kg., Catla, 1.6 kg, rohu 1.2 kg, mrigal 1.0 kg, and common carp 1.7 kg with a density of 10,000/ha a production 10,164-10,678 kg/ha/year was obtained with an average weight of 1 kg of each species. About 30% of the water in the pond lost due to seepage was made good every 25 days by drawing
water from a canal. Feed conversion ratio in the two cases was 1.5:1 and 1.9:1 respectively.

**Plankton**

The term plankton was first proposed by Hensen in 1887. Plankton, at the present time, is defined as free floating animal and plant organisms, whose intrinsic power of locomotions if present, is so feeble that they remain almost at the mercy of currents and waves. On the basis of the site of occurrence, the pond plankton are called *helicoplankton* comprises both the phytoplankton as well as zooplankton. **Phytoplankton** consists of chlorophyll bearing organisms (*Microcystis, Volvox etc.*) and the non-photosynthetic plants *saproplankton* (bacteria and fungi). It mainly pertains to the groups *chlorophyceae, Bacillariophyceae, Euglenophyceae* and *Myxophyceae* and rarely to a few *Dinophyceae*. **Zooplankton** consists of planters of animal origin and are mainly protozoans, rotifers and plantonic forms of *Crustacea*.

Important earlier works on plankton productivity have been reviewed by Pennak (1946) and Welch (1952). There is considerable variation in the quality and density of the plankton flora and fauna of small and big confined waters from season to season and from place to place during the same season.

From fish culture point of view, the importance of planktonic organism are immense because these being directly or indirectly
linked with the food for fish and also from hydrological angle these are useful indicator of water conditions of specific aquatic ecosystem. Phytoplankton are the main source for accelerating primary productivity of a pond ecosystem by utilizing inorganic salts, carbon dioxide, water and sunlight and thus are capable to produce its own food. While Zooplankton feeds on living or dead phytoplankton or other tiny particles or organic matter in the water.

A number of contributions are available on plankton. Atkins (1923 and 1926) has worked on phosphate and Silica contents in relationship to growth of plankton. While relationship of Silica content to phytoplankton growth was studied by King & Davidson (1933). Komarovsky (1953) made a comparative study of phytoplankton and essential constituents of water. Mc Combie (1953) studied the factors influencing growth of Phytoplankton. Eddy (1934) has studied the freshwater plankton communities. Smith and Swingle (1939) studied the relationship between plankton and fish production. Chandler (1942) and Chandler et al. (1945) studied the plankton production in relation to certain physico-chemical factors. Anderson et al. (1955) studied the relationship of Phytoplankton and Zooplankton in two lakes. Pearsell (1932) studied the phytoplankton in English Lakes. Paasche (1960) studied the relationship between production and phytoplankton.
Rawson (1953) studied the Canadian waters and concluded that the seasonal sequence of low-high, low-high in plankton abundance is common in natural waters. Fish (1956) studied the chemical factors limiting growth of Phytoplankton. Davis (1958) supported the traditional concept that zooplankton primarily consumes the phytoplankton. Seasonal abundance of Phytoplankton to differential grazing pressures by Zooplankton has been reported by Martin (1965). Talling (1957 and 1961) studied the diurnal changes of stratification and Photosynthesis in African waters and photosynthesis under natural conditions. The relation of Photosynthesis by Phytoplankton to light in lakes was studied (Edmondson, 1956). Green (1960) studied the Zooplankton of river. Ewing & Dorris (1970) studied the algal community structure in artificial pond. Schindler et al. (1971) studied the seasonal caloric values of freshwater zooplankton.

Ganapati (1940, 1941 and 1943) made simultaneous studies on three different ponds in Madras city laying emphasis on the hydrological factors. Mookherjee and Bhattacharya (1949) observed Plankton fluctuations in certain ponds in West Bengal. Chacko and Krishnamoorthy (1954) indicated the maximum and minimum production of plankton in June-July and November-December respectively. Flowering of a bloom of Volvex was reported in a freshwater tank (Das & Srivastava, 1955).

The knowledge of Plankton in India is still fragmentary.


A number of workers have made noteworthy contributions on the productivity of Phytoplankton and Zooplankton. Some of the
important among them are Singh and Sahai (1978), Kant and Anand (1978), Sharma and Saxena (1983), Bose et al. (1981a & b), Sharma et al. (1982), Shamsi (1983), Thakur and Bhas (1983), Adoni and Vaishya (1985) and Saran and Adoni (1985).

Phytoplankton and Zooplankton are usually inter-dependent parameters in the ecosystem. Zooplankton not only feed on Phytoplankton but also consume detritus (Naumann, 1923; Pennak, 1953 and Davis, 1955). There is an inverse relationship between Phytoplankton and Zooplankton as recorded by Harvey et al. (1935), Anderson et al. (1955), Wright (1958) and Patnaik (1973). However, Kow (1953), Prasad (1956) and Subramanyan (1959) have reported a direct relationship between two plankton groups.