Short Term Training for Progressive Fish farmers on Management of Open Inland Waters

25th August - 8th September, 1999

Bulletin No. 91 **September, 1999**

Central Inland Capture Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore - 743 101 : West Bengal

Short Term Training
for
Progressive Fish farmers on Management of Open Inland Waters

25th August - 8th September, 1999

Bulletin No. 91 **September, 1999**

Central Inland Capture Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore - 743 101 : West Bengal

Short Term Training for Progressive Fish farmers on Management of Open Inland Waters

ISSN 09.70-616X

Published by: **Director**
CIFRI, Barrackpore

CONTENTS

****

ESTIMATION OF PRIMARY PRODUCTION FROM OPEN WATER SYSTEMS AND ITS ROLE IN FISH PRODUCTION

D. Nath
Central Inland Capture Fisheries Research Institute
Barrackpore-743101: West Bengal

Introduction

Productivity is defined as the rate at which inorganic carbon is converted to an organic form. Chlorophyll bearing microscopic organism such as phytoplankton, periphyton, algae and submerged aquatic vegetation serve as primary producer in the aquatic food chain. Photosynthesis results in the formation of many complex carbohydrates, release of oxygen and absorption of carbon dioxide in the open water system. Rate of photosynthesis in the open water bodies are related to phytoplankton abundances, light intensity, water transparency and nutrient availability. Assuming equal light intensities, the photosynthetic production of dissolved oxygen will increase as a function of phytoplankton abundance. In many open water systems such as beels, reservoirs etc phytoplankton may be an important source of turbidity, so light penetration may be related to phytoplankton abundance. On clear sunny days photosynthesis rates increase rapidly after sunrise and remain high upto afternoon, although the afternoon rates may be slightly less than the morning rates. Cloudy skies always cause a sharp decrease in photosynthetic rates.

Primary production in open water system is generally maximum during summer or winter periods and minimum during rainy season. The primary productivity of oxbow lakes may be quite different to that of pond ecosystem. The oxbow lakes generally contains large amounts of submerged and floating macrophytes, so greater photosynthetic rates and oxygen concentrations were recorded in the weed beds of the system.

Factor regulating primary production

The factors which regulate the magnitude, seasonal pattern and species composition in photysnthesis are light, temperature, nutrients, physical transport process and herbivory. Photosynthetically active radiation (400-700 nm) is most important for photosynthesis which provides the major source of energy for these autotropic organisms. During sunny days the photosynthesis is generally poor at the surface layer. After a little depth, the photosynthesis was maximum. Photosynthetic rate diminish at higher depth due to low light availability.

At very high light levels, photosynthesis decreases due to light inhibition associated with photochemical destruction of nutrients.

The depth at which gross photosynthetic rate is equal to algal respiration rate is called the compensation depth which is equal to 2.5 times the Secchi depth

Phytoplankton require N, P, Si, Mo, Zn, Mn, Ca, CO_2 and vitamins for their growth and sustenance. However, the most important are the macronutrients (C, N, P, Si). Phytoplankton growth and photosynthesis are in general congenial at 20-25 °C. Above 30 °C the phytoplankton photosynthesis may be affected adversely.

Estimation of primary production (A. P. H. A., 1980)

a) Oxygen method by measuring the changes in oxygen and CO2 concentration (Light and Dark bottle method)
b) by recording the changes in pH.
c) Diurnal studies in D. O. concentration
d) The C-14 technique

a) Oxygen method

The basic reaction in algal photosynthesis is

$$(CO_2)_n + (H_2O)_n \xrightarrow[\text{Chlorophyll cat.}]{\text{light}} C_n(H_2O)_n + nO_2$$

Thus during photosynthesis the phytoplankton and other aquatic plants absorbs CO_2 and liberates oxygen. In oxygen method, clear (light) and darken (dark) bottles are filled up with water samples and suspended at regular depth intervals for an incubation period of 3-5 hours or the samples may be incubated under controlled conditions under artificial illumination in environmental growth chambers in the laboratory. The advantages of the oxygen method are that it provides estimates of gross and net productivity and community respiration and that analyses can be performed with inexpensive laboratory equipments and common reagents. The DO concentration is estimated at the beginning and end of the incubation period. Productivity is calculated on the assumption that one atom of carbon is assimilated for each molecule of oxygen released.

Experimental procedure

1) Estimate the solar radiation with a pyrheliometer or by Lux meter

2) Determine the depth of the euphotic zone (the region that gets 1% or more of surface illumination) with a submarine photometer. Select depth interval for bottle placement.

3) Introduce samples taken from each preselected depth into duplicate light bottle, dark bottle, and initial analysis bottle. Use water from the same grab sample to a set (i.e. one light, one dark and one initial bottle).

4) Determine the DO of the initial bottle by Winkler method with mangeanous sulphate, alkaline Iodide, sulphuric acid and standard sodium thiosulphate using starch indicator. DO may also be determined with an oxygen probe.

5) Suspend the light and dark bottles at the depth from which the samples were and incubate for 3-5 hours.

6) At the end of the exposure period, estimate the DO of both Light and Dark bottles by Winler method or by an oxygen probe.

Calculation

$$\text{Gross production} = \frac{\text{Light bottle DO - dark bottle DO}}{\text{Time (in hours)}} \times \frac{12}{32} \times \frac{1000}{1.2}$$

$$= \frac{\text{LB-DJB}}{\text{T}} \times 312.5 \text{ mgC/m3/hr}$$

$$\text{Net production} = \frac{\text{LB-IB}}{\text{T}} \times 312.5 \text{ mgC/m3/hr}$$

$$\text{Respiration} = \frac{\text{IB-DB}}{\text{T}} \times 375 \text{ mgC/m3/hr}$$

Where LB = Light bottle DO
DB = Dark bottle DO
IB = Initial DO
T = Time in hours

Primary production is generally reported in grams carbon fixed per square meter per day. Estimate the productivity of a vertical column of water 1 meter square by plotting productivity for each exposure depth and graphically integrating the area under the curve. Using the solar radiation profile and photosynthetic rate during incubation adjust the data to represent phytoplankton productivity during the entire photoperiod.

Primary productivity estimation from dial change of DO

The dissolved oxygen content in a water body continuously change over a 24 hours period because of the effects of respiration and photosynthesis and due to slow rates of diffusion. In general the DO content is minimum during early morning, increases during day time to a peak during noon or after noon and decline again during night time. The highest content of DO is found in the water body with the greatest abundance of phytoplankton, algae or submerged macrophyte. However, water of these water bodies also have high rates of respiration, so that they have the minimum DO content in the early morning.

Role of primary production in fish production

Primary productivity study is widely used to evaluate the fish production capacity of open waters such as oxbow lakes, reservoirs, rivers, estuaries, sea etc. The primary production is actually a measure of food produced by a system. If more food is available, there will be more animals who will come to the system to consume the food. Naturally the system will be termed as highly productive, moderately productive or unproductive depending on availability of rich food, moderate food or very low quantity of food.

From primary production studies the fish production capacity of an open water system may be evaluated. The fish production potential = 1.2% of the primary production in the open water system (Odum, 1960). Poor conversion was generally noted in ecosystem where carnivorous species dominate, whereas the fish production may be higher where the fast growing herbivorous species (eg. carps) dominate in the system.

Primary production of different ecosystem

Fish ponds: The primary production of 20 fish ponds located in 4 district of West Bengal was studied (Nath and Tripathi, 1997). High primary productions were recorded during Novemebr-December and during March-May. Maximum production was found just below the surface. The compensation depth in different centres ranged between 66.5 and 128.5 cm. Gross primary production of the ponds ranged between 2.4 and 9.14 $gC/M^3/day$.

Oxbow lakes: The flood plain lakes of Ganga and Brahmaputra basins had moderately rich primary production which was contributed both by phytoplankton and macrophyte, the contribution of the former being comparatively higher than that of the later. In macrophyte dominated beels, the primary production was 6.138 $gC/M^3/day$ (Pathak et. al., 1989).

Reservoirs: Indian reservoirs vary widely in productivity depending on physicochemical characteristics and other factors. Thus, poorly productive Bhatghar reservoir (Maharashtra) had low primary production (Gross 20.8-145.8 $mgC/M^3/day$, net 10.4-83.3 $mgC/M^3/day$.

However, Ganapati (1972) and Sreenivasan (1972) have reported some reservoirs, having higher productivity where GPP ranged from 1.6 to 3.228 $gC/M^2/day$ and NPP ranged from 1.36 to 1.64 $gC/M^2/day$. Similarly Khan et. al. (1996) studied a small productive reservoir, Baghla reservoir in U. P. which have gross and net primary production ranging from 37 to 325 and 25 to 300 $mgC/M^3/hr$.

Estuary: Primary production of Hooghly Matlah estuary which is one of the most productive estuaries of the world was studied during 1982-93 (Nath et. al. 1996). Maximum primary production was recorded at Canning in Matlah estuary, which was free from water pollution. In Hooghly estuary maximum primary production was recorded at Frazerganj in marine zone. Among freshwater centres Nabadwip had higher gross production but Medgachi had higher net primary production.

Minimum primary production was noted at Nawabganj, presumably due to industrial and municipal pollution. The gross primary production ranged from 0.44 to 0.794 gC/M^3/day and the net primary production ranged from 0.241 to 0.523 gC/M^3/day in the Hooghly Matlah estuary.

References

APHA, AWWA, WPC F. 1980. Standard methods for the examination of water and . APHA. Washington. 1134 p.

Khan, M. A., Singh, H. P., Singh R. K. and Tyagi, R. K., 1996. Ecology and fish yield from Baghla reservoir - a small impoundment in Ganga basin. *J. Inland Fish. Soc.* 28(2): 91-100.

Ganapati, S. V. 1972. Organic production in seven types of aquatic ecosystems in India. In Golley P. M. and Golley F. B. (eds). Tropical ecology with emphasis on organic production. *Univ. of Georgia. Athens*: 312-350.

Odum, H. T. 1960. The role of tidal marshes in estuarine production. 60: 1-4.

Nath D. and Tripathi, S. D. 1997. Primary production of some semi intensive fish ponds of West Bengal, India. *J. Inland Fish Soc. India* 29(1): 59-63.

Nath D., M. M. Bagchi and R. K. Banerjee, 1996. Changing trends in primary production and water quality and their bearing on fish yield in Hooghly Matla estuary. Paper presented at XIth Annual International Conference on sustainable development and environment organised by National Environmental Science Academy on march 15-17, 1996.

Pathak V., M. J. Bhagat and K. Mitra, 1989. Fisheries potential and management of oxbow lakes of Ganga and Brahmaputra basins. In conservation and management of inland capture fisheries resources of India. Ed. A. G. Jhingran & V. V. Sugunan. *Inland Fisheries Society of India:* 143-147.

Sreenivasan, A. 1972. Energy transformation through primary productivity and fish production in some tropical freshwater impoundments. In Kajak, J. and Hillbright I. A. (eds.). Productivity problem in freshwater. PWN. *Warsaw:* 505-574.

****

ROLE OF ABIOTIC PARAMETERS IN DETERMINATION OF PRODUCTIVITY OF OPEN WATERS

D. Nath
Central Inland Capture Fisheries Research Institute
Barrackpore-743101: West Bengal

Introduction

Physico chemical characteristics of water and soil vary significantly in open water systems such as beels, reservoirs, rivers and estuaries, which in general controls the productivity of the water bodies. Bottom soil plays an important role in the fertility of the water body. It provides shelter and food to the bottom microbiota which helps in the mineralisation of organic bottom deposits and governs the storage and release of nutrients in the water phase. The basic soil on which the reservoirs, beel or pond is built exert its influence upon the productivity of the water body only for a few years. With the advancement of time, production and decomposition of minute plant and animal organisms in the water body and their precipitation on pond bottom modify its properties to a great extent. In general, therefore, the physical and chemical properties of water in a water body are more or less a reflection of the properties of its bottom soil. Usually, water is acidic in character in a water body on an acid soil and alkaline when the bottom soil is calcareous in nature.

Productivity of any water body is directly dependent on the availability of major nutrients such as nitrogen, phosphorus, organic carbon, calcium, magnesium and potassium. Some micro nutrient or trace element may also contribute to its productivity. The availability of the macro and micro nutrients is generally dependent on soil reaction.

pH

A measure of the soil reaction, pH denotes its acid or alkaline character. It is one of the most important factors affecting productivity of an aquatic ecosystem. Soil pH is dependent on various factors such as calcium carbonate and bicarbonates, carbon dioxide and organic matter. Water bodies situated at high altitude (North Bengal, Assam etc.) may have acidic soil and water reaction. Industrial effluents having acidic nature may seriously affect a river or an estuary at its outfall region. Acid mine wastes when discharged to a natural water body, badly affect the system. In fish ponds near neutral soil reaction (pH 6.5-7.5) was considered was most conducive for high fish production. The Ganga and Narmada rivers had slightly alkaline soil reaction which is congenial for their aquatic productivity. Hardwater lakes (pH around 8) generally had high productivity. Highly acidic soil (below pH 4.5) and highly alkaline soil (pH above 9.0) are generally unproductive and in these soils available phosphorus contents are very poor. An acidic reaction favours the precipitation of soluble phosphate into insoluble forms rendering it unavailable to phytoplankton.

Nitrogen

Although nitrogen is available in plenty in the atmosphere but aquatic animals can not utilise this free nitrogen. However, nitrogen comes to open water system from the catchment areas in the form of fertilizers, industrial and municipal effluents etc. Some nitrogen is fixed in open water system by some bacteria and blue green algae. In soils it is present mostly in organic form but all of it is not available for utilization. It is only the fraction which is easily and directly utilized by plants which is termed as available nitrogen. In fish ponds, fish production is poor when available nitrogen is below 25 mg, average when 25-50 mg and relatively more favourable when 50-75 mg/100 gm of soil.

Phosphorus

In agriculture, phosphorus is important for root development, flowing and fruiting, crop maturation disease resistance, crop quality etc. It is considered as the most critical single element in pond productivity. The availability of phosphorus from soil depends on soil pH. In acidic soil phosphorus remains fixed as Iron, Manganese or Aluminium phosphate and this phosphate deficiency is reflected in the pond water. In alkaline soil, phosphorus gets fixed as calcium or magnesium phosphate. Phosphate fixation is at its minimum in near neutral pH (pH-7). If available phosphorus is less than 3 mg/100 g of soil, the water body is unproductive, average when 3-6 mg and productive between 6-12 mg/100 gm of soil.

Organic carbon and C: N ratio

Organic compounds are very useful due to their high carbohydrate content so necessary for bacterial activity. The oxbow lakes are generally very rich in organic carbon, available nitrogen and available phosphate. In soil the bacterial activity depends not only on the carbon content but also on the C:N ratio. Bacterial activity is low when C: N ratio falls below 10:1 and high when the ratio is 20:1.

In the open water systems and in fish ponds, fish production is low if the organic carbon is less than 0.5%, average when it is 0.5-1.5% and high when organic carbon is 1.5-2.5%. Similarly C:N ratio below 5 is indicative of poor production presumably due to industrial or municipal pollution, 5-10 of average production and 10-15 of high production due to conducive environment.

Calcium and magnesium

These two elements play a great role both in agriculture and pisciculture. Calcium is present in the soil as calcium carbonate and bicarbonate. Presence of Calcium carbonate (lime) in soil is responsible for its alkaline reaction and reduced solubility of iron, manganese and aluminium. These ions are very toxic to aquatic organisms under acidic conditions. The availability of phosphate, molybdate, exchangeable calcium and magnesium are greater in near neutral to slightly alkaline soils. Presence of lime also stimulates the general purpose heterotrophic soil organisms thereby increasing the activity of organic matter and nitrogen in the pond soil. A minisation, ammonification and sulpher oxidation are markly high under slightly alkaline environment. The nonsymbiotic bacteria and the nodule bacteria that fix nitrogen from the atmosphere are also stimulated in the presence of lime. However, exchangeable calcium in soil does not seem to show any significant correlation with fish production in open water system.

Micronutrients or trace elements

Trace elements like manganese, copper, iron, molybdenum Zinc, cobalt, and boron also play some important role in aquatic productivity. Except for iron and manganese, trace elements are found sparingly in most soils and their availability to the aquatic organisms is generally very low. In sandy, organic and very alkaline soils, micro nutrient availability may be a problem. Since the trace elements are required in very low amounts, a slight excess may be toxic. In general, the availability of micronutrients is dependent on soil pH, the optimum pH range being 6.5 to 7.5.

Potassium

Potassium is a major nutrient in agriculture. It helps in protein and carbohydrate metabolism, increases drought resistance, prevents lodging, increases disease resistance and is useful for tuber crops like potato. It is an activator of many enzymes. However, in fish culture its importance is rather low due to its easy availability in most open water systems. But water bodies with sandy, non-adsorptive soils may be potassium deficient which may respond to potassic fertilisation.

Physico chemical characteristics of water in relation to aquatic productivity

The more important physical and chemical qualities of water influencing aquatic productivity are temperature, transparency, pH, dissolved oxygen, free CO_2, total alkalinity and dissolved nutrients like nitrogen, phosphorus, potassium, calcium, magnesium and silicate.

Temperature

Fish production in a water body depends greatly on the temperature regime of the growing season which may vary from year to year. Fish is a cold blooded animal and body temperature of fish is the temperature of the water. Metabolic activity is nearly doubled for every 10 °C rise in temperature and hence fish growth is greatly dependant on water temperature. With the increase in temperature microbial activity is also increased and hence the release of nutrients by the decomposition of organic matter is more with consequent increase in nutrient status of the water body. In general, the temperature ranging between 23-30 °C may be considered conducive for growth of carps.

Transparency

Transparency is a measure of light penetration in the water body. This is inversely proportional to the quantity of the dispersed suspended particles in the water body. Neither very highly transparent nor very highly turbid water is conducive for the growth of fish, for both the conditions are an index of poor availability of fish food organisms. Productive pondsor oxbow lakes generally have a transparency of 20 to 60 cm. In rivers and reservoirs the transparency is minimum during monsoon and maximum during winter or summer. Transparency is generally lower in estuaries due to tidal effect.

pH

Slightly alkaline water reaction (pH 7.2 to 8.2) is most conducive for aquatic productivity. Strongly acidic (pH 3.8-4.5) and strongly alkaline (pH 10.5-14) waters are not suitable for fish culture. Fish growth will be poor if the water is moderately acid (pH 5.5-6.5) or moderately alkaline (pH 8.5-10.5). Fish growth in fish ponds and beels of Assam and North Bengal is generally poor due to acidic water and soil reactions.

Alkalinity

Total alkalinity which is a measure of bicarbonate and carbonate concentrations is a very important factor in the ecology of an open water system. Alkalinity is mostly due to carbonates and bicarbonates of calcium and magnesium. The bicarbonate, carbonate and CO_2 in water act as buffer which helps to keep the pH of water nearly constant. When there is an excess of CO_2 in water, some carbonate gets converted to bicarbonate and the pH is maintained at a constant level. When, however, due to phytoplankton photosynthesis CO_2 is exhausted, the photosynthetic work is continued by the decomposition of bicarbonate releasing the required CO_2 for photosynthesis. Generally, a water body having total alkalinity of 80-150 ppm is most productive, while the water body with low (below 20 ppm) alkalinity is poorly productive. But if the total alkalinity is very high (above 250 ppm), the water body may be medium or low productive due to fixation of phosphates and micronutrients.

Dissolved oxygen

Dissolved oxygen in water is absolutely essential for the respiration of aquatic animals and micro organisms. A water body gets its oxygen from air by diffusion, mechanical agitation, wave action and from photosynthesis by phytoplankton, algae and submerged macrophytes present in water. Oxygen acts as a regulator of metabolic processes of plant and animal community and also as an indicator of water conditions. Dissolved oxygen has an important role in maintaining the oxidative decay of the bottom organic matter. Soil bacteria and soil organisms take sufficient oxygen to mineralise the organic matter on the bottom soil. If oxygen supply is plenty and pH favourable, mineralisation of organic matter makes the water body nutrient rich and productive. When the oxygen supply is inadequate, anaerobic decomposition products are formed which have ill effects on the fish population and substantial fish kill may be possible. Dissolved oxygen content above 5 ppm is congenial for fish heatlh.

Free CO_2

CO_2 in water is required by phytoplankton and submerged macrophytes for their photosynthesis.

$$n(CO_2) + (H_2O), \quad \xrightarrow[\text{Chlorophyll Catalyst}]{\text{Sunlight}} \quad Cn(H_2O)n + nO_2$$

In photosynthesis, CO_2 is converted to carbohydrate and oxygen is evolved. However, if the free CO_2 content exceeds 30 ppm, this may lead to oxygen depletion and fish mortality may take place. The optimum content of free CO_2 in a water body is 5-10 ppm.

Dissolved nitrogen

As a constituent of protein, nitrogen occupies a highly important place in aquatic productivity. Soluble nitrogen compounds occur in a water body in different forms. Organic nitrogen compounds may be converted to inorganic forms as nitrate, nitrite, NH_3 and ammonium salts. The ammonium and nitrate form of nitrogen is easily absorbed by plants but green algae can use nitrogen in all the forms. Nitrogen and phosphorus in natural water bodies are generally far below the concentration for the optimal growth of plankton. Inorganic nitrogen content ranging between 1.0-2.5 ppm may be considered optimum for high fish production.

Dissolved phosphorus

In natural water bodies such as beels, rivers, lakes etc. phosphorus concentration is usually very low. Phosphorus occurs in two forms-inorganic and organic, but the soluble inorganic form is more important due to its active nature. Dissolved phosphorus below 0.05 ppm is indicative of poor production, 0.05-0.2 ppm of medium production, while water bodies having phosphorus content above 0.2 ppm may be considered optimum for high fish production. However, very high phosphorus (1.0 ppm and above) and nitrogen (2.5 ppm and above) contents may lead to eutrophication, which is not desirable for a open water system. Eutrophication brings excess growth of phytoplankton or algal bloom or weed in festation in the water body resulting in DO depletion and other adverse conditions.

****

ROLE OF BIOTIC COMMUNITIES IN PRODUCTION PROCESS IN OPEN WATER SYSTEM WITH SPECIAL REFERENCE TO PLANKTON AND MACROBENTHOS

M. K. Bandyopadhyay
Central Inland Capture Fisheries Research Institute
Barrackpore-743101: West Bengal

India is enriched with open inland water resources in the form of rivers, canals, reservoirs, lakes, estuaries and floodplain wetlands. The river system comprises of total surface runoff 167.23 million ha. metres, small reservoirs 14,85,557 ha., medium reservoirs 5,27,541 ha and large reservoirs 11,40,268 ha. Floodplain wetlands commonly known as mauns, beels, jheels spreaded over eastern U. P., nothern Bihar, West Bengal and Meghalaya with a total water area of more than 2,00,000 ha. The estuarine water network is 2.6 million ha. All these open inland water resources offer an immense scope for fisheries development in the country.

Plankton

The plankton community represent a heterogenous group of tiny plants and animals remain in suspension in sea and freshwater, which moves at the mercy of wind or waves. Plankton are generally divided into two groups namely phytoplankton and zooplankton. Depending on size, the plankton can also be classified into megaloplankton (more than 8cm), macroplankton (1 mm-1 cm), mesoplankton (0.5-1 mm), microplankton (0.06-0.5 mm), nanoplankton (0.005-0.006 mm) and ultraseston (0.0005-0.005 mm).

The phytoplankters are mainly represented by Euglenophyceae (euglenoids), chlorophyceae (grass green algae), charophyceae (stonewarts), Xanthophyceae (yellow-green algae), chrysophyceae (golden/yellow-brown algae), Bacillariophyceae (diatoms), Phaeophyceae (brown algae), Dinophyceae (dinoflagellates), Rhodophyceae (red algae) and Myxophyceae (Blue-green algae). Zooplantkers are comprised of Protozoans, Rotifers, Cladocerans, Ostracoda and Copepods.

Benthos

This group of organisms which live in or on the bottom of a water body is called benthos. Such organisms may be sessile (mussels, oyster, corals, diatoms, weeds, sponges), Creepers (prawns, crabs, crustaceans, copepods, molluscs and fishes) or burrowing (worms, crustacea, clams) in nature. Like plankton benthic organisms are also broadly divided into two groups- phytobenthos and zoobenthos.

Based on sizes, benthos are classified into three division namely, macrobenthos (larger than 0.5 mm), meiobenthos (larger than .044 nm) and microbenthos (smaller than .044 mm).

Food chain, Trophic Structure and Ecological Pyramids

The transfer of food energy from the producer level through a series of consumer level is called the food chain. At each level of transfer, near about 80% to 90% potential energy is lost as heat. Food chains are of two types: the grazing food chain, start from a green plant, goes to grazing herbivores (i.e. organisms eating living plant cells or tissue) and to carnivores (i.e. animal eaters); and the detritus food chain, which goes from non-living organic matter into micro-organisms and then to detritus feeding organisms (detritivores) and their predators. The interconnected pattern of food chains are often spoken as food-web.

The interaction of food chain phenomenon (energy loss at each transfer) and the size metabolism relationship in communities having a definite structure, known as trophic structure. This trophic structure varies from one ecosystem to another. Trophic structure may be measured and described either in terms of standing crop per unit area per unit time at successive trophic levels. Trophic structure and trophic function when shown graphically, it forms an ecological pyramid.

In the open water ecosystem, phytoplankton acts as the chief producers and occupies the lowest level in the food chain. Zooplankton are the primary consumers. Amongst the benthic organisms, phytobenthos acts as primary producer and the benthic heterotrophs help in the regeneration of nutrients. The macro-zoobenthos and other aquatic animals including fish are consumer; they are directly or indirectly dependent on primary producer in the ecosystem.

Role of plankton in production process

Plankton are of immense value as food. The phytoplankton produce complex food item from carbondioxide and dissolved nutrients (specially phosphates and nitrates) with the help of solar radient energy and chlorophyll. The herbivores, the primary consumers, graze on these primary producers. Small carnivores eat primary consumers and the higher carnivores eat the small carnivores. Some of the large animals like blue whales, fin whales and basking Sharks feed directly on plankton. Benthic and fixed forms, such as clams, barnacles and tunicates utilize plankton as food through filter feeding mechanism. Dead plankton serve as a regular source of food for the sedimentation feeders.

The importance of plankton in fisheries have been established by many eminent hydrobiologists and ichthyologists. It is well known that the zooplankton constitute the only food of the fry and many adult fishes also eat them. Apart from fishes, plankton also form the main food of some economically important aquatic species like pearl oyster. In the open water fishery, the availability of plankton directly control larval rearing of fishes as well as location specific fisheries development.

Plankton also helps in the natural purification of polluted water. Some of the micro-organisms like bacteria and protozoa are responsible for the precipitation of polluted water by flucculation. Ciliates also ingest the pathogenic bacteria along with saprophytes and contribute to effluent safety. Owing to their role in purification, the cladocerans have been called the living "bacterium and detritus filter".

Role of benthos in the production process

Benthic organisms play several physiological roles in an aquatic environment. The benthic algae and flowering plants are most significant for their production of food for all kinds of living aquatic organism. They also form extensive strands in the euphotic water, accumulating a great mass of fertilizer element and produce organic matter, which enables higher standing crop of fishes and other secondary producers.

The benthic secondary producers convert primary production to secondary production and thereby reducing or regulating the population of primary producers. The secondary producers play physical role in the environment, such as deposition ylime and other organic matters, reconsolidation or transportation. Benthic heterotrophs help in the mineralization of complex organic matter to its simplest form, thus enriching the aquatic environment for further utilization towards food production.

The macro-zoobenthos consume phyto and zooplankton and shifts gained energy to upper level consumers including fishes and plays a vital role in the production process.

****

Fig.1 Trophic status of Producer, consumer and mineralizer in an aquatic ecosystem

1 : Water phase ; 2 : Soil phase ; 3 : Autotrophic stratum ; 4 : Heterotrophic stratum ;
5 : Phytoplankton (autotrophs) ; 6 : Zooplankton (herbivores); 7 : Fish (carnivores);
8 : Bottom invertebrates (detritivores); 9 : Bacteria and Fungi (saprovores).

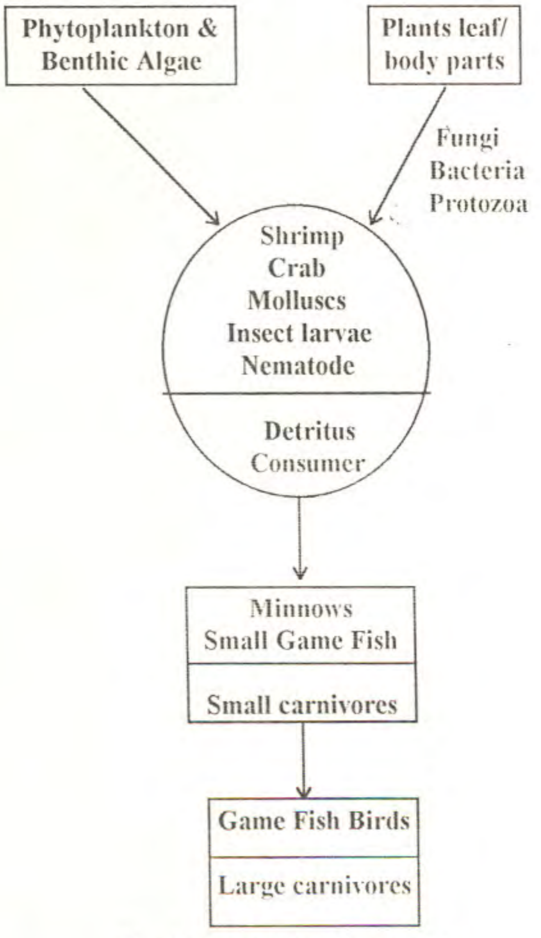

Fig 2 : Detritus food chain

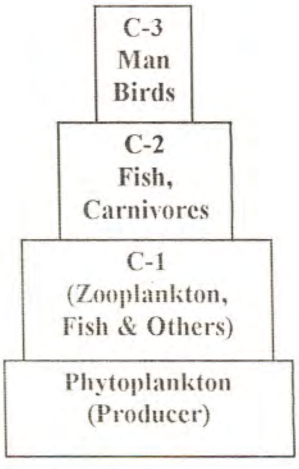

Fig 3 : Grazing food chain
C : Consumer

Importance of Preimpoundment Studies for future Management of a newly constructed Reservoir

Dhirendra Kumar
Central Inland Capture Fisheries Research Institute
Barrackpore West Bengal

Introduction

Large number of artificially constructed freshwater impoundments as a result of multipurpose river-valley projects have been added considerably to the already existing rich water potential for the development of the country's fishery resources. But preimpoundment studies have only been carried out for few reservoirs like Damodar Valley Corporation reservoirs and Hirakund Dam. Average fish yield from Indian reservoirs was frustatingly low *i.e.* less than 10 kg/ha/yr. Comprehensive research has been done by CIFRI under the All India Coordinated Research Project on Ecology and Fisheries of Freshwater Reservoirs and basic hypothesis regarding productive capacities of some large reservoirs have emerged. These studies have led to some increase in fish production from certain reservoirs.

Pre-impoundment study is a pre-requisite for adjudging future fisheries management strategies of a newly constructed reservoir. For want of such basic information on an elaborate scale, no standard techniques have so far been developed to manage the fisheries of these with the result the development measures in them are taken up long after impoundment. Consequently, the advantage of early enhanced productivity of the water in such man-made lakes is lost forever.

Advantage of Pre-impoundment Surveys

Pre-impoundment studies provide the framework for future development policies aimed at collecting information on (i) species of fish present in the river stretch above the dam site and future stocking policies, (ii) breeding of fish within the area of submergence and upstream to evaluate auto-stocking, (iii) changes in hydrobiological conditions of water in the area impounded and below, (iv) setting up of a hatchery for producing stocking material and (v) cleaning the proposed area of submergence of forest trees and other obstructions.

Pre-impoundment faunastic and Fisheries Survey of River basin

Through this possible effects of impoundment on the fisheries may be anticipated. Recommendations regarding the provision of fish-ways. Stocking and conservation could be made and can be followed with varying degree of success of different reservoirs. A complete survey of the fish and fisheries of the reservoirs together with an inventory of fishing villages, fisher's population, fishing crafts is essential for planned development as it is lacking in most of the cases.

Clearance of submerged obstructions

To facilitate easy fishing and the use of modern and effective methods of exploitation, the reservoir bottom, at least in its light penetration sections should be free from obstructions. However, while impounding streams or rivers, no attention is generally paid by the project authorities to this important development aspect. Thus it may be born in mind that even after the reservoir is filled whether it is possible to clear the obstructions at least in the reservoir margin. But at that stage the work can be taken up only in the summer months when water level goes down and shore areas are exposed. The problem of clearance of submerged obstructions can be tackled in small reservoirs by cutting standing trees on reservoir bed and auctioning wood.

Presence of aquatic vegetation not only hampers fishing but also suppresses growth of benthic fauna as it occupies productive zones, can also be tackled amicably upto some extent.

Establishment of fish farms at Dam site

Though the reservoirs which are connected with Ganga river system have natural stock of major carps but in view of large volume of water impounded of these dams, the original stock is to be supplemented by stocking them regularly with major carps fingerlings. While the reservoirs across other river basins do not have a natural stock of major carps, hence major carp fingerlings are to be planted in them.

Effective stocking operations are possible only when the fingerlings are reared near the reservoir sites as their long distance transportation is an uneconomical venture. But for construction of nursery and rearing pond's infrastructure adjacent to reservoir sites, a suitable site needs to be searched and water retaintivity in available soil must be ascertained before hand. If suitable sites for construction of these infrastructure is not available then fish seed rearing may be done on bay sites through cage or pen culture techniques.

Stocking of Reservoir

It has been observed that certain species of fish are unable to withstand the changed hydrological conditions of the reservoir as, for example, the mahaseer present in the river Mahanadi, Tungbhadra and Cauvery could not come up as a fishery in the Hirakund (Orissa), Tungbhadra and Krishnarajasagar (Karnataka) reservoirs respectively, while *Tor tor* dominated in catches of Gobindgarh reservoir (Rewa, M.P.) and forms a high percentage of catches in the Jaisamand lake (Udaipur, Rajasthan).

A dense stock of commercially important species needs to be maintained in the reservoir to procure a maximum sustained yield on an economically sound basis. The reservoirs may, therefore, have to be stocked from outside sources. Effective control of catfishes and other predatory fishes is imperative for building up a population of commercially important fishes feeding on lower food chains.

Investigations on Tungbhadra dam have shown that stocking of major carps in the reservoir has not been successful mainly because it was done near the dam site which is the deepest portion of the reservoir and almost a biological 'desert'. Therefore, stocking should be taken up in areas which are not deficient in fish food. Also emphasis is now shifting for stocking fingerlings above 15 cm in length.

Survey of fish breeding grounds in the reservoir

In many instances, fish breeds either in the reservoir itself or in the tributaries or streams which drawn into the river or reservoir. The major carps breed only in the upper reaches of the reservoirs. Studies revealed that in Konar reservoir, high currents washed the carp eggs into the reservoir depths resulting in negligible natural recruitment. Moreover, breeding of Indian major carps is governed by time and magnitude of monsoon floods. Thus, the breeding grounds should be modified appropriately to enhance natural recruitment in newly constructed reservoir.

Rehabilitation of Fishers and organisation of Co-opeartive Society

To develop a commercial fishery in a reservoir, it is imperative that a sufficiently large fishers population is settled around the reservoir at places which are near good fishing grounds and are easily accessible, so that collection and disposal of catches do not pose problem. When reservoir catch and number of fishers increases or where such condition already exists, the middleman generally appears on the scene. To avoid undesirable element, the organisation of fishermen's coopeartive society is the best solution. The co-operative societies organised at Mattur and Gandhinagar showed exemplary performances.

Management strategies for a newly constructed reservoir

Based on preimpoundment studies the below mentioned management measures need to be adopted for augmenting fish productivity from newly constructed reservoir.

1. To ensure high productivity of fish right from the initial stage :

   (i) Transplantation of the spawners of valuable food fishes to strengthen spawning stock in the first year of filling.

   (ii) Constructing fish hatcheries at the reservoir site to artificially raise fingerlings of desirable fish to stock the reservoir.

   (iii) Acclimatising and transplanting choice organism of food fishes to enrich food reserves of the reservoir, especially to combat the unfavourable conditions in the period of **trophic depression** which may be lost from 6-30 years.

(iv) Protecting fish and regulating fishing effort through measures like completely banning fishing of valuable food fishes two years prior to water filling and with in the first year of reservoir formation to obtain huge stocks of fry of desirable fish.

(v) Preventing trash fish menace by capturing and destroying them through all possible means.

(vi) Constructing fish lifts and fish screens at dams to preserve and replenish stocks of anadromous and semi-anadromous food fishes.

2. To provide facilities for fish propagation and ensure effective exploitation, collaborative effects of fishery scientists and engineers by adopting following methods :

(i) Preparation and leveling of the reservoir bottom for commercial fishing by trawling which in some cases reservoir bed is to be cleared of tree trunks and boulders etc.

(ii) Preparation of hauling areas for operation of seines.

(iii) Development of artificial spawning areas.

(iv) Working out the optimum water regime which determines success of breeding and survival and formation of year class strength.

3. The annual catch limits of desirable food fishes are set in advance at maximum value biologically substantiated while catch limits of trash fish is unlimited.

4. Great attention is paid in the Russia to develop rich fish food reserves and their hydrobiological regimes are suitably altered. Great emphasis is laid on hydrological, primary production, plankton, benthos studies and qualitative and quantitative estimation of their standing crops.

5. The mass development of phytoplankton in the reservoir. A great role of phytoplankton lies in supplying fine detritus, on which develops a rich saprophytic microflora, which in turn forms the food supply for Cladocerans and Copepods, on which many species of fish feed. Bacteriological studies figures prominently in Russia for understanding the role of bacteria in food conversion from one form to another in food chain.

Also there are few primary measures which may be adopted to improve reservoir productivity :

(i) Manipulation of water level to favour certain species and suppress others.

(ii) Introduction of certain species and desirable organisms to utilise unoccupied ecological niches.

(iii) Control of overpopulated fishes and large fish to reduce competition for food and space.

(iv) An increase in the harvest of fish through hook-and-line round the year or during open season.

(v) Publicity to make the anglers know the place and time to catch the fish.

DEFINTION, CLASSIFICATION OF THE RESERVOIRS AND DIFFERENCE BETWEEN LARGE AND SMALL RESERVOIRS

M. A. Khan
Central Inland Capture Fisheries Research Institute
Barrackpore-743101: West Bengal

Introduction

When a river/stream is dammed, the resultant impoundment is known as reservoir or "artificial lake". The reservoirs can be classified on the basis of area as small (<1000 ha) medium (1000 to 5000 ha) and large reservoir (>5000 ha). In India, due to large scale developmental studies, the area under reservoir is constantly increasing year after year and at present the area under reservoir is more than 3.1 m. ha. Out of these, there are 19000 small (1,485557 ha), 180 medium (527541 ha) and 56 large (1,140268 ha) reservoirs. The reservoirs may be shallow or deep. The production from large reservoir is very low i.e. 20 kg/ha/yr while from small reservoir is comparatively a little higher i.e. 50 kg/ha/yr.

The reason for this frustatingly low production is unscientific management of the reservoirs. Moreover, productivity of a reservoir is governed by a host of factors: such as climatic, edaphic (pertaining to soil, and morphometric (physical characters). The geographic location affects the metabolism of a reservoir through nutrition supply, shape of the basin and the efficiency with which the climatic factors are able to act in the dynamic exchange. The small reservoir being small are biologically more productive per unit area while reverse is true for the large and medium reservoirs. The main differences in small and large reservoirs are summarised in Table 1.

Table 1. The distinguishing features of small and large reseroviirss may be summerised as under:

(After Jhingran, 1965)

Small reservoirs	Large reservoirs
Single-purpose reservoirs mostly for minor irrigation	Multipurpose reservoirs for flood-control, hydroelectric generation, large-scale irrigation, etc.
Dams neither elaborate nor very expensive. Built of earth, stone, masonary work on small seasonal streams.	Dams elaborate, built with precise engineering skill on perennial or long seasonal rivers. Built of cement, concrete or stone.
Shallower, biologically more productive per unit area. Water-weeds commonly observed in perennial reservoirs but absent or scanty in seasonal ones.	Deep, biologically less productive per unit area. Usually free of aquatic weeds. Subjected to heavy drawdowns.
May dry up completely in summer. Notable changes in the water regimes	Do not dry up completely. Changes in water regimen not so pronounced. Maintaining a conservation-pool level.
Sheltered areas absent.	Sheltered areas by way of embayments, coves, etc. present.
Shore line not very irregular. Littoral areas mostly gradually sloping.	Shore line more irregular. Littoral areas mostly steep.
Oxygen mostly derived from photosynthesis in these shallow, non-stratified reservoirs lacking significant wave action	Although photosynthesis is a source of D.O. the process is confined to a certain region delimited by vertical range of transmission of light (euphotic zone). O_2 also derived from significant wave action.
Provided with concrete or stone spillway, the type and size of its structure depending on the runoff water handled.	Provided with much more complex engineering devices.
Breeding of major carps invariably observed in the reservoir abaove the spill way.	Breeding mostly observed in the head waters or in other suitable areas of the reservoir.
Can be subjected to experimental manipulations for testing various ecosystem responses to environmental modifications	Cannot be subjected to experimental manipulations.
Trophic depression phase can be avoided through chemical treatment and draining and cycle of fish production can be repeated as often as the reservoir is drained.	Trophic depression phase sets in.
The annual flooding of such reservoirs during rainy season may be compared to overflowing flood-plains. Inundation of dry land results in a release of more nutrients into the reserovir when it fills up, resulting in high production of fish food through decomposition of organic matter, predominantly of plant origin leading to higher growth and survival.	Loss of nutrients occurs which get locked up in bottom sediment. Reduction in benthos also occurs due to rapid sedimentation.
Through complete fishing or overfishing in such seasonal reservoirs, no brood stock is left over to contribute to succeeding year's fishery through natural recruitment. The fish population has to be built up solely through regular stocking. There is thus established a direct relationship between stocking rate and catch per unit of effort.	In contrast, prominent annual fluctuations in recruitment occur and balancing of stock number against natural mortality requires excessive number of fingerlings in such large reservoirs. Their capture requires effective exploitation techniaques.

****

MANAGEMENT NORMS FOR ENHANCEMENT OF FISH YIELD FROM THE SMALL RESERVOIRS

M. A. Khan
Central Inland Capture Fisheries Research Institute
Barrackpore-743101: West Bengal

Introduction

Small reservoirs are formed due to damming of small rivulets. The main function of small reservoirs is either flood control or irrigation or both. The small reservoir involves very simple engineering design and less expenditure on their construction, due to this reason they have out numbered other types of reservoirs *ie* medium and large. According to an estimate there are about 19000 small reservoirs covering an area of about 14,85 557 ha. The average fish production from this resource is about 50kg/ha/year. The main reason for low production despite high productivity is unscientific management.

Central Inland Capture Fisheries Research Institute has developed a package of practices based on eco-friendly management over a period of three decades through which a fish production of about 150 to 200 kg/ha/year can be achieved.

Aqua-culture trechniques in small reservoirs

The aquaculture technique practiced in these reservoirs may be described as "extensive" where cultured fingerlings are raised in water bodies with few modifications of the habitat. This is contrast to the intensive culture practised in ponds and receways ertc., where abiotic and biotic components are under control. The capture and culture fishery principles grade into each other in small reservoir where the fishery depends on stocked fingerlings.

Aquaculture techniques in small reservoirs

The aquaculture, practiced in these impoundmnets, may be described as *'extensive'*, where cultured fingerlings are raised in water bodies with few or no modification of the habitat. This is in contrast to the intensive culture practised in ponds receways etc. where abiotic and biotic components are under control. The capture and culture fishery principles grade into each other in small reservoirs where the fishery depends on stocked fingerlings.

Past and present status of small reservoir fisheries

Fish culture in the small reservoirs, hitherto being practised by the state Governments consists of supplementing the natural stocks of economic fishes with stocking on arbitrary basis without any definite levels or ratios based on the biogenic capacity of the ecosystem. Stocking rates wherever prescribed do not appear to have been followed strictly. Despite the arbitrary stocking a few reservoirs, have been reported to show high fish production with repeated regular stocking. Keetham reservoir (250 ha) in U. P. for example, produced 530 kg/ha in 1959-60 although the yield declined drastically in the later years. This emphasises the need to focus attention towards fish culture in such ecosystems based on an understanding of the environmental and biological parameters, basic productivity levels and ecological relationships.

Stocking policy

Stocking of fish in small reservoirs has proved to be a useful tool for developing there fisheries potential. Stocking of economically important, fast growing fishes from outside is aimed at colonizing all the diverse niches of the biotope for harvesting maximum sustainable crop from them.

This widespread management practise has been proved to be highly remunerative in such small water bodies where almost complete annual harvesting is possible. This has amply been demonstrated in Gularya, Bachhra and Baghla reservoirs (U.P.) and Aliyar reservoir in Tamil Nadu (Table2). Stocking is not merely a simple matter of releasing of appropriate species into an ecosystem but needs evaluation of an array of factions *viz.*, biogenic capacity of the environment, the growth rate of the desired species and the population density as regulated by predatory and competitive pressure

During summer months, small reserovirs either dry up completely or else the water level in them gets so drastically reduced that through over fishing no brood stock is left over to contribute to the succeeding years fishery through natural recuritment. Consequently, the entire catch from these water bodies depend on the fishes stocked from outside to offset this loss. There is thus established a direct correlation between the stocking rate and catch per unit effort in such heavily fished waters. Stocking is therfore a useful tool for the management of small reservoirs where stocks can be maintained at levels higher than the natural carrying capacity of the environment through supplemental fertilization. The number of fish to be stocked per unit area was to be based on the natural productivity of the system, growth rate of fishes, natural mortality rate and escapement through the irrigation canal and spill-way.

Determination of stocking rate

Stocking in small reservoir is mainstay of fisheries management in small reservoirs and is therefore of utmost imortance. The stocking rate can be calculated based on the average growth rate of the individual fish and the expected production and using the following formula

$$\text{stocking rate of fingerlings/ha} = \frac{\text{Expected fish production (kg)}}{\text{Av. fish growth rate (kg)}} + \text{loss due to fingerlings mortality and escapement (\%)}$$

Welcomme (1976) has also given a formula for calculating stocking rate, the model assumes insignificant breeding by used stocked population and therefore is applicable to total cropping situation. This model has not been used in India. How it will fit in Indian condition is at present is only a guess work.

Case studies of some small reservoirs

To establish a baseline for evolving suitable management measures towards fishery development in small reservoirs, the Central Inland Fisheries Research Institute (CIFRI) initiated investigations on small reservoirs of M. P. *Viz.*, Loni, Kulgarhi, Govindsagarh and Naktara; Gulariya, Bachhra and Baghla in U. P., Aliyar Reservoir in Tamil Nadu and Kyrdemkulai in Meghalaya. Investigations on hydrology primary productivity, plankton, macrobenthos, macrovegetation, soil characteristics, experimental fishing and biology of commercial fishes have been conducted. Range of certain abiotic and biotic parameters in some small reservoirs of India are summerised in Table 1. A critical evaluation of these parameters indicates that they can support moderate to high fish production.

Biotic communities

The range of biotic parameters at certain small reservoir studied by CICFRI are summorised in Table 1 and brief description given below:

Plankton:- Plankton population ranged from 58 unit/l to a high of 40,000 unit/l in Baghla reservoir. The high population was observed due to *Melosira*. The low plankton population was observed in monsoon due to high inorganic turbidity and high in post monsoon followed by summer months. Dominance of Myxophyceae was observed in these reservoirs followed by Bacillariophyceae and Chlorophyceae. Myxophyceae was chiefly represented by *Microcystis aeruginosa;* bacillariphyceae by *Synedra ulna Fragilaria* spp., *Melosira granulota* and *Chlorophyceae* consisted of *Pediastrum duplex*, *Spirogyra* sp. *Oedogonium* sp., *Pandorina* sp. as dominant forms.

Copepods and rotifers were the main constitutents of zooplankton, mainly represented by *Diaptomus, Cyclops Brachionus, Keratella, Filinia* and *Polyarthra*. Maximum abundance was observed in summer and minimum in monsoon.

Macrobenthos communities:- Bottom fauna was generally rich which ranged from 95 unit/m^2 (Gulariya reservoir) to a high of 4620 (Bachhra reservoir). In these water bodies, insects dominated the others. The fauna was represented by chironomids, phylopotamus (insecta), *Pisidium, Corbicula, Lymnaea (Mollusca)* and *Brachiura* sowerbyii (Annelida).

Fish fauna:- Fish fauna was observed well diversified belonging mainly to carps, cat fishes, featherbacks, murrels and clupeids, only in Kyrdemkulai reservoir mahseers like *Tor putitora, Tor tor* and *Acrossocheilus hexagonolepis* were observed besides small hill-stream fishes. Recommendations for development of Kyrdemulai and Nongmahir reservoirs have been submitted to the Northeastern Council for implementation by the State of Meghalaya.

Planning criteria

A systematic and integrated approach towards scientific studies and planning criteria for undertaking fish culture in small reservoirs should have an understanding of the following factors.

1. The reservoir morphometry and water resident time
2. The physico-chemical characteristics of water and soil
3. The animal and plant inhabitants
4. The relation between the inhabitants and the physico-chemical aspects of the environment in terms of population and community dynamics.

In tune with the need for rapid assessment of the country's small reservoirs resources, the following planning criteria are suggested for the resource assessment.

i). Preparation of an inventory of such small ecosystems alongwith their estimated of potential yields. This can be further divided into:-

a) Reservoirs which are best developed as capture fisheries
b) Reservoirs mostly of local interest having significant potential for fish culture
c) Reservoirs intermediate in size and potential yield.

General consideration

ii) Since the breeding of the major carps has been repeatedly observed to take place above the spill way, resulting in heavy escapement of the brood, this poses a serious problem for building up stocks of desirable fishers in such reserovirs. The situation is further worsened by heavy escapement of fingerlings and adults through irrigation canals. Development of fisheries in such water bodies, therefore requires suitable screening of the spillway and the canal mouth. Such protective measures have already been installed in Loni, Bachhra, Baghla and Gulariya reservoirs and have paid rich dividends in enhancing the fish yield from these reserovirs (Table 4). In some of the reservoirs fishes have also been observed to move up the spillways into the reservoir whereas in others the spillways provide an insurmountable barrier to fish moving up the dam. To minimize losses by way of escapement of fish through spillway and canal, it would be an economic proposition to have an annual cropping policy so that the reserovir is stocked in August-September and harvested by June end next year.

iii) Vegetation should not be planted in the reservoir, since the wrong kinds can chocke up the reservoir and the canal.

iv) Methods for predator control and check of weed fishes are already available in literature.

v) Aquaculture in small reserovirs can also play an impaortant role in integrated rural development since it can be profitably combined with duckery and piggery.

Summing up, it may be stated that small reservoirs occupy a unique position in limnology analogous to field plots used in agriculture science *ie.* a means of assessing effects of environmental modifications on the ecosystem on a reduced scale.

Socio-economic consideration

It has become necessary to impart certain measures of stability to fish production in reservoirs since wide fluctuations in yield rates result in consequent rise or fall in income of thore who toil on water. The fishery potential of the reservoir is largely under utilized and it is well witness by prevalance of low productivity, low income low saving and almost complete absence of inventory building process. The exploitation policy ought to have twin objectives of development and conservation. Even a cursory look of the existing leasing systems indicate lack of development bias further, imperfections of marketing system have also contributed to shrinkage in fishermen's returns. Presently earning of fisher folk is lower than those unskilled form workers though risks and uncertanties in catch and incomes are much more in their case. Therefore, there is an urgent need to evolve a package approach comprising stocking monitoring programme equitable and just royalty arrangements, marketing intervention by cooperatives and corporations and quick distribution channels.

Table 1. Range of certain physico-chemical and biotic parameters of small reservoirs.

Parameters	Reservoirs					
	Gulariya	Bachhra	Baghla	Aliyar	Chapparwara	Kyrdemkulai
Transparency (cm)	11-80.0	17-145	9-204	108-182	-	2.20-2.84
D. O. mgl^{-1}	4.9-9.0	2.5-8.60	2.40-12.80	4.2-11.6	6.10-10.0	6.70-7.10
pH	7.2-8.4	6.96-8.30	7.32-8.84	6.6-6.8	8.0-8.40	6.8-7.0
Free CO2 mgl^{-1}	Nil-4.0	Nil-7.20	Nil-3.0	Nil-10.0	Nil	2.0-2.60
Alkalinity mgl^{-1}	38-80	95-190	42-106	16-72	76-100	22-32
Hardness mgl^{-1}	13-34	21-80	-	-	-	18.56-27.84
Nitrate mgl^{-1}	0.08-0.20	0.085-0.180	0.28-0.33	-	0.40-1.10	0.02-3.61
Phosphate mgl^{-1}	0.05-0.13	0.06-0.250	0.28-0.36	Trace-0.4	0.11-0.16	Trace-0.02
Silicate mgl^{-1}	5.0-14.0	6.80-14	2.4-4.9	Trace-0.2	1.92-8.0	1.0-10.0
Plankton u/l	245-4060	70-8432	58-40000	-	3100-20100	8420*
Macrobenthos u/m^2	95-4169	342-4620	976-2132	-	110-947	134*
Macrovegetation u/m^2	Absent	Absent	250-2200	Absent	470-1350	Absent

(* indicates average value) After khan, 1997

Table 2. High yields obtained in small reservoirs due to management based on stocking from (*modified after Sugunan, 1995*)

Reservoirs	State	Area ha.	Stocking rate mo ha^{-1}	Yield Kg ha^{-1}
Aliyar	Tamil Nadu	650	353	194
Meenkara	Kerala	259	1226	107
Chulliyar	Kerala	159	937	316
Gularya	Uttar Pradesh	300	517	150
Bachhra	Uttar Pradesh	140	763	140
Baghla	Uttar Pradesh	250	-	102
Bundhk Beratha	Rajasthan	-	164	94
Chapparwara	Rajasthan	200	300	79

RIVERINE RESOURCES OF INDIA, STATUS OF FISH PRODUCTION AND METHODS OF CONSERVATION OF FISH STOCK

M. A. Khan
Central Inland Capture Fisheries Research Institute
Barrackpore-743101: West Bengal

Riverine Resource of India

Nature has bestowed India vast expanse of open inland waters in the form of rivers, lakes, oxbow lakes and estuaries. These water bodies harbour the original germplasm of one of the richest and diversified fish fauna of the world, comprising 930 fish species belonging to 326 genera out of 25000 total fish species.

The total length of Indian rivers is about 45000 Km which includes 14 major rivers, each draining a catchment area of above 20,000 Km^2 . 44 medium rivers with catchment area between 2000-20,000 Km^2 and the innumerable small rivers and desert streams that have a drainage of less than 2000 Km^2. The major river systems of India on the basis of drainage, can be divided broadly into two; (i) Himalayan river system (Ganga, Indus and Brahamputra) and (ii) Peninsular river system(East coast and West coast river system). The details of the area and potential fish yield of the major rivers is furnished in Table 1 and brief description of fisheries resources is given below.

1. **Ganga river system** : It is one of the largest river systems of the world, having a combined length (including tributaries) of 12500 km. After originating from Himalaya, it drains into the Bay of Bengal, after traversing a distance of 2225 km. The Ganga river system harbours about 265 fish species, out of these 34 species are of commercial value including the prized Gangetic carps, large catfishes, feather backs and murrels.

In mountainous region, from source to Haradwar the fisheries is dominated by *Schizothorax* spp.; catfishes, *Mahseers* and *Labe*o spp. The commercial fisheries in this zone is non-existing due to sparse population, unaccessible terrain and poor communication between fishing grounds and landing centres. However, commercial fisheries assumes importance in 1005 km middle stretch of the river (Kanpur to Farakka).The important landing centres are Kanpur, Allahabad, Patna, Buxar and Bhagalpur. The mainstay of fishery are the species belonging to cyprindae (176 species) and siluridae (catfishes). The important species are: Gangetic major carps, catfishes, murrles, clupeids and featherbacks besides migratory hilsa. On an average fish yields has fluctuated in the stretch between a high of 230 t to a low of 12.74 t during 1958 to 1995 and yield of major carps on Kg ha^{-1} yr^{-1} basis from 83.5 to 2.55 during the above period. The main reasons for decline in fish yield may be attributed to (1) sandification of the river bed (upto Patna) which reduced the rivers productivity due to blanket effect (2) marked reduction in the water volume on account of increased sedimentation (3) increased water abstraction and (4) irrational fishing. These are the main reasons for decline in fish yield, e.g. the fish yield has come down at Allahabad and Patna landing centres from 950 Kg Km^{-1} yr^{-1} and 1811.2 Kg Km^{-1} yr^{-1} in 1960's to 311.6 Kg Km^{-1} yr^{-1} and 629.8 Kg Km^{-1} yr^{-1} in 1990's respectively. The estimated mean annual fish landings of the some important landing centres on river Ganga is depicted in Table 2.

Decline in Hilsa Fishery : The commissioning of Farakka barrage in 1975 caused an adverse effect on hilsa fishery, being migratory in nature. In pre-Farakka period (1958-72), the yield of hilsa at Allahabad varied from 7.87 to 40.16 t, at Buxar from 7.38 to 113.36 t and at Bhagalpur, 1.47 to 9.79 t. The scenario has adversely changed in post-Farakka period and hilsa yield has come down to 0.13 to 2.04 t, 0.07 to 2.60 t and 0.01 to 2.18 t respectively at the above centres. This is a classical example of adverse effect of construction of dams/barrages on the yield of migratory fishes. Similar problem is observed in migration of mahseers in upland rivers due to construction of barrages. This has resulted in dwindling of their population.

Potential fish yield: Actual fish production from the river at Allahabad was 21.33 during 1972-79, 28.69 Kg ha^{-1} during 1980-86 and 15.19 Kg ha^{-1} during 1989-93. But only 13.29-13.74% of the potential is being harvested. At Patna and Bhagalpur, 25.19% to 26.30% of the potential is harvested. The overall utilization of fish yield potential in the upper and middle Ganga comes to only 22.80%. In the lower Ganga, against a potential yield of 198.28 Kg ha^{-1} , only 30.03 Kg ha^{-1} is currently harvested (Table 3). Thus, in general the fish yield potential is unadequately utilized in all the sectors leaving scope for further improvement.

Brahamaputra River System : The Brahamputra river originates from a glacier (Kubiangiri) in Tibet and has a combined length of 4025 km including its tributaries. The geological nascent state of Himalayas from where this river originates has substantially contributed to the high silt in the main channel. On account of this, Brahamputra river bed has risen during 1937-97 by c 4.5 m due to deposition of silt. Like Ganga basin, the Brahamputra valley is also dotted with abandoned beds called beels which support rich fishery. The major portion of the river lies in Tibet and in Indian territory river flows about 700 Km only. It is joined by Ganga in Bangladesh, forming the largest delta in the world.

Fish stock composition: The upper sector of the river is not having commercial fishery of any significance. This segment harbours cold water fishes such as *Tor tor, T.*

putitora, T. mosal, T. progeneius, Acrossocheilus hexagonolepis and large cat fish *Bagarius bagarius*. A total of 126 fish species belonging to 26 families out of which 41 are of commercial importance have been reported. The fish fauna is a mixture of torrential fauna, specific to northern bank and that of southern bank is of a mixed type. The major constituents of potamic stretch fisheries are: Gangetic major carps, medium carps, minor carps, catfishes (*W. attu, M. seenghala, M. aor, M. vitattus, B. bagarius, S. silondia, C. garua, P. pangasius, Rita rita, H. fossilis, O. bimaculatus, A. coila*) and *Hilsa ilisha*. Miscellaneous fishes such as *S. phasa, G. chapra, M. armatus., M. aculeatus, G. giuris, Pama pama, Ambassis* spp. and feather-backs (*Notopterus notopterus, N. chitala*) also form substantial fisheries of the potamon region.

The average catch at four important landing centres was estimated at 847 t in 1970's . The fisheries in the upper, middle and lower stretches of the river is dominated by catfishes. In the upper middle stretch miscellaneous fishes dominate (54.14%), followed by cat fishes (28.40%) and major carps (17.46%), while in middle stretch catfishes (28%) have replaced the miscellaneous fishes followed by major carps (26%) and hilsa (18%)., while fisheries of lower mid-stretch is again dominated by miscellaneous group (34%) followed by catfishes (24%), minor carps (20%) major carps (11%) and hilsa (7%). Prawn contribution in the total landing of the mid-stretch is restricted to only 4 to 7%.

In another survey conducted by CIFRI, during 1973-79 at the landing centres of Guwahati revealed that the fish landing has decreased to about 6-folds from 233.44 t in 1973 to a low of 39.02 t in 1979. The major carps yield has drastically declined to the tune of 5.6-fold (47.61 to 8.5 t) of catfishes by 8-folds (58.7 t to 7.3 t), and of hilsa by 2.7-folds (21.63 t to 8.02 t). Similarly, the yield per Km. of river stretch has also declined from 2.3 to 0.4 t during the above period. The decline in major carps yield may be attributed to heavy exploitation of brooders (ujaimara activity) and as well as of juveniles.

Indus river system : The major portion of Indus river system lies within Pakistan but its five tributaries viz., the Jhelum, the Chainab, the Ravi, the Beas and the Sutlej originate from western Himalayas.

Fish stock composition: In head waters of these rivers commerical fisheries is absent. The common fish species inhabiting are: *Salmo trutta fario, S. gairdneri, Tor tor, T. putitora, Schizothorax* spp. *Labeo dero, Gara gotyla*; *Botia* spp. and *Nemacheilus* spp. The Beas and Sutlej rivers contain indigenous carps and catfishes akin to Ganga river. The commercial fishery operations only takes place in middle and lower reaches of these rivers, but catch data is not available. Heavy water abstraction from these rivers has been reported to be responsible for reducing fish stock. Further, faulty designed fish-ladders and fish passes in the dams, weirs and barrages for providing ascend to fishes are not functioning properly and rather act as fish traps instead of fish passes.

Jhelum in Jammu and Kashmir is reported to support commercial fisheries. The species caught are : *Shizothorax* spp., *Labeo dero, L. dyocheilus, Crossocheilus latius, Puntius conchonius, Cyprinus carpio (C. communis and C. specularis*) loaches and *Glyptothorax* spp.

Peninsular river system : This system may be broadly categorised into two (1) East coast river system and (2) West coast river system.

1. **East coast river system** : The combined length of the four rivers which constitutes this system *viz*., the Godavari, the Mahanadi, the Krishna and the Cauvery is about 6437 km with a total catchment area of 121 mha.

The Godavari : The headwater harbours a variety of game fishes but donot support commercial fishery. According to a survey conducted by CICFRI (1963-69) for a riverine stretch of 189 km (between Dowlaiswarum and Bumnagudum anicut), a fish yield between 218 and 330 t was estimated. The fish yield kg/ha ranged between 6.14 kg (1969) to 9.36 kg (1963), indicating a declining trend. It has been observed that at present (1990's) river is maintaining a fish production of 1 tonne/km/annum against a fish production of 1.392 $t/km^{-1}yr^{-1}$ in 1960's.

Fish Stock Composition :-The commercial fisheries consists of carps (*major carps* and *L.fimbriatus*), large cat fishes (*Mystus spp*., *Wallago attu*, *S.childreni* and *B.bagarius*) and fresh water prawn (*M.malcomsonii*). Hilsa formed a lucrative fisheries and its landing fluctuated widely between 15.5t to 46.3t during the 1963-69. The Indian major carps planted in the river in the beginning of 19th century are thriving well and contributing to the commercial fisheries. Among miscellaneous fishes, *Chela argentina*, *P. aurulius* and *P. conchonius* dominate the catch.

The Mahanandi River : The upper reaches harbour game fishes but commercial fishery is non existent due to unaccessible terrain. The ichthyofauna is similar to Ganga with addition of peninsular species. Hilsa is confined to lower reaches and together with major carps and catfishes forms lucrative fishery. Data on fish production and catch per unit effort is not available.

Krishna River : A number of dams have been constructed on this river which has altered the ecology of this river. In general, the physiography and fish fauna of the Krishna river resembles to Godavari river system. The headwaters support rich fishery when compared to mid-stretch, which is rocky and unaccessible. According to a report (1963) about 91 to 136 kg of fish was caught in the river Vijaywada. No information is available on its present fishery and catch statistics.

Cauvery River : The water resource of the river is extensively exploited, as numerous reservoirs, anicuts and barrages have been built on the river. The river exhibits substantial variation in its fauna. The game fishes like *Tor khudri* and *T. mussullah* are found all along the river's length except the deltaic stretch. Eighty species of fish belonging to 23 families have been reported. It's fish fauna differs signficiantly from Krishna and Godavari. The commercial fisheries comprised of carps (*Tor* spp., *P. carnaticus*, *P. dubius*, *Acrossocheilus hexagonolepis*, *Labeo kontius*) cat fishes (*Glyptothorax madraspatanus*, *Mystus* spp., *P. pangasius*, *W. attu*, and *S. childreni*. Data on catch statistics is not available.

West Coast River System : The main westward flowing rivers are Narmada and Tapti.

Composition of fish stock : Narmada river harbours eightyfour fish species belonging to 23 genera. The contribution of carps in commercial fishery is of the order of 57.47 to 62.40% (Mahseer, 23.7 to 27%, *Labeo fimbriatus*, 18.20 to 19.20%; *L. calbasu*, 52-6.40%) followed by catfishes, 34 to 38% (Rita spp. 12.0 to 14%, *M. seenghala*, 7.80 - 9.80%, *M. aor* 4.7 to 5.0%, *W. attu*, 7.40 to 8.20%, *M. cavasius* 0.5 to 0.8%) and miscellaneous fishes 4 to 5% (*Channa* spp., *Mastacembalus* spp., *N. notopterus* and minnows). According to an estimate from a 48 km stretch (Hoshangabad to Shahganj) of the river, a monthly yield of 32.8 to 52.7 tonnes was reported in 1967. Since then, no perceptible change either in fish catch or in fish composition has been observed. However, now the river ecology might undergo a sea change with the proposed irrigation projects which will transform the river into a chain of reservoirs (major 450, medium and minor 350) obliterating the riverine habitat.

Tapti river : Not much informaion on fish stock composition and fish yield is available. About 2.60 tonnes of fish/day is captured from the river. The commercial fishery is mainly consists of
Tor tor, *Labeo fimbriatus*, *L. boggut and L. calbasu* among carps followed by cafishes such as *Mystus* spp. and *W. attu.*

Management measures

Biological and ecological studies have revealed that the fish communities are very sensitive to flood regime because of their dependence on the seasonal floods to inundate the ground needed for feeding and breeding. Any change in the pattern and form of flood curves result in the alternation of fish community structure. A characteristics feature of a river system is the nature of the input governing the productivity pattern. In the upper stretch of the rivers, such inputs are mainly allochthonous but in the potomon region encompassing the flood plains, the major inputs are silt and dissolved nutrients. There is a gap of knowledge on the relationship between these inputs and energy flow and productivity trends in these systems.

The intensity of fishing, nature of exploitation and species orientation are the characteristic of the artisinal riverine fisheries and are governed by :(1) seasonality of riverine fishing activity; (ii) unstable catch composition; (iii) conflicting multiple use of river water, (iv) cultural stresses leading to nutrients loading and pollution; (v) lack of understanding of the fluvial system and infirm data base; (vi) fragmentary and out moded conversation measures lacking enforcement of machinery; (vii) inadequacy of infrastructure and supporting services (viii) affordability and palatability and (ix) socio economic and socio-cultural determinant. An intelligent management strategy has to take cognisance of key parameters such as hydrology, fish stocks and dynamics of their population together with regularity measures for fishing. Observance of closed seasons and setting up of fish sanctuaries have proved their efficacy in fostering recovery of impaired fisheries. Experience has indicated that gear control measures are liable to fail in yielding results until the artisanal level of fisheries exploitation is significantly changed.

Future approach:

There is an urgent need of integrated riverine management which envisages:

i) basin-wise approach, taking into account, the multiple use of river water and the impact of developmental activities on the biotic wealth;

ii) comprehensive computer model for environmental impact assessment;

iii) a judicious water allocation policy for various sectors taking into consideration the biological threshold levels; and

iv) keeping fisheries at par with other developmental and conservation activities in the river basin.

If these measures are religiously followed, the fish yield from Indian rivers is bound to enhance which will provide not only high quality of protein but will uplift the status of fishers in this country as well as help in conservation of original germplasm.

Conclusion

Finally it may be concluded that the decision taken by legislators and politicians will have a greater impact on the future of the riverine ecosystems than any amount of limnological work. The biological solutions to many environmental problems are within reach, given the *political will and suitable legislation*. However, ecological viable management strategies will fail if do not address socio-economic and cultural contexts, or are considered in isolation from the aspirations of the local populace. The implications are clear: we must continue to contribute to the academic development of limnology, but make greater effects to disseminate our knowledge of river ecosystems and communicate with those planning large scale development as well as those whose activities have a direct effect on the ecosystems at issue. Otherwise species loss and further degradation of rivers will result from a failure to engage in wide-ranging discourse. Time has come that we should weigh our priorities, should we increase out put of scientific papers, while ignoring the *realpolitik* of conservation and management or should we devote more effort to communicating the revealance and importance of our science. Further most of the rivers are interstate and each state has its own priorities. A common property approach prevails for much of the system and management is restricted to the auction of fishing rights for river stretches, without restriction on size of catch, size of fish or fishing season. Large scale capture of brood stocks while migrating during monsoon, large scale poaching, destruction of fish in their summer refugia and enormous destruction of juveniles are more a rule than an exception. Moreover no states want to spend money on developmental auspects and their attitude is that of a spendthrift. Under these circumstances, for sustainable exploitation and development of riverine resources, there is an urgent need for establishing, a central organisation which should be responsible for holistic development of the riverine resources of the nation.

Table 1. Showing the potential fish yield from Indian rivers based on their length and basin area

River	Length (km)	Basin area (million km^2)	Catch Area based tonnes	Stream length based tonnes
Himalayan river				
Ganga	2525	0.88	17443	17142
Yamuna	1376	0.37	5243	8588
Brahamaputra	800	0.19	1782	3958
East Coast rivers				
Krishna	1401	0.26	5434	5365
Cauvery	800	0.09	1791	1917
Mahanadi	880	0.14	2088	2943
West coast rivers				
Narmada	1312	0.10	4844	2124
Tapti	720	0.06	1454	1294
Mahi	533	0.02	802	446

(After Khan and Tyagi, 1996)

Table 2. Estimated mean annual landing (metric tonnes) at different centres in Ganga

Centres	1959-66	1973-81	1981-89	1989-97
Allahabad	207.17	129.63	128.46	67.55
Buxar	65.85	13.59	25.65	N.A.
Patna	81.93	85.5	70.84	N.A.
Bhagalpur	108.86	N.A.	62.45	37.79

Table 3. Energy transformation fish production potential and extent of utilisation of potential fish yield in river Ganga at different centres

Centre	Year	Av.Carbon production $mgCm^{-2}day^{-1}$	Av. Rate of energy transform-ation $calm^{-2}day^{-1}$	Photosynethetic efficiency %	Fish production potential kg ha-1yr-1	Actual harvest $kgha^{-1}yr^{-1}$	Extent of utilisation %
Kanpur	1987-88	234.5	1419	0.077	50.10	-	-
Allahabad	1974	-	4501	0.241	160.44	21.33	13.29
Varanasi	1987-88	589.1	3243	0.173	112.20	-	-
Patna	1987-88	293.0	3534	0.190	122.40	30.84	25.19
Bhagalpur	1972	-	3586	0.186	120.68	31.64	26.30
	1987-88	420.0	4124	0.220	142.80	36.75	25.73

Table 4. Estimated yield of Indian major carps in the river Ganga (kg/ha/yr)

Centres/year	1958-61	1961-69	1980-86	1989-95
Kanpur	83.5	24.3	-	-
Allahabad	15.6	21.5	9.29	7.2
Buxar	17.1	3.8	7.0	-
Patna	13.3	13.3	5.08	3.04
Bhagalpur	3.6	7.5	2.9	2.9
Mean	26.62	14.08	6.07	3.30

Possibilities of Cage Culture in the Beels

G. K. Vinci,
C.I.C.F.R.I.
Barrackpore

Introduction

India has extensive riverine wetlands in the form of floodplain lakes especially in the states of Assam (1,00,000 ha), Bihar (40,000 ha), West Bengal (42,000 ha), Manipur (16,500 ha), Arunachal Pradesh (2,500 ha), Tripura (500 ha) and Meghalaya (213 ha). At present there is very low level of fish production i.e. 100-200 kg/ha/yr. There is a potential of 1,000-2,000 kg/ha/yr. As a management measure specially in the weed choked beels cage culture of fishes and prawns is recommended.

Cage culture

Cages enclosed totally on all sides or enclosed totally except the top side. Materials used could vary from natural indigenous products to synthetic and metallic ones.

Types of cages

There are basically three types of cages and these are described below :

1. *Surface cages resting on the bottom*

   These are generally utilized in running water as practiced in Indonesia. The cages are rectangular in shape with dimension ranging from 1.5 to 3 m long, 90-150 cm wide and 60 to 70 cm high. Materials used are bamboo slats, each measuring about 2-3 cm wide with interstices between bamboo slats of 1/2 to 1-1/2 cm. At normal water level, the cages may be exposed to a height of about15-20 cm above the water but they are completely submerged during floods. The structures are held in position by strong wooden or iron bars driven intothe river bed. The cages are susceptible to damage by stone or branches rolling down the streams in fast flood but can be expected to last for about 2 years.

2. *Cages floating at the water surface*

   This is the type widely used for cage farming in protected bays, lagoons, sheltered coves and inland seas. The use of floating cages dates back as early as the turn of the 20th century in Cambodia and from there it has spread to most countries in Southeast Asia and to many countries in the world either on experimental or commercial scale.

3. *Cage submerged either floating in midwater or resting on the bottom*

   This type of cage which is essentially marine is not widely used. Nevertheless, certain countries like Scotland is using this in the production of lobsters. Maintenance of this kind of cages can be very expensive requiring regular scubadiving for maintenance and feeding.

Type of Environment Suitable for Cage Farming

Like in pen and pond culture, site for cage farming must also be favourable not only for the physico-chemical and biological requirements of the cultured fish but also to the structures themselves (i.e., cages).

The following factors are considered important in the selection of site for cage cultivation.

A. **Physical factors**

1. *Shelter* - It is advantageous that the site is protected from strong wind so that damage to the structures and even loss of stock may be avoided.

2. *Land base* -This is essential in providing a base for operation, accommodation by the work staff and storage of equipment and gears.

3. *Topography* -Sites with shallow sills and deep pits are unsuitable because oflack of exchange between the sea and the sill. In general, a steep slope to shore leading to a flat bottom in 3-4 m at the lowest tide is suitable for cage farming.

4 *Bottom condition* - It is virtually possible to set up cages on almost any type of bottom. However, extremely rocky bottom may not allow installation of anchorages while a very soft bottom although permits installation generally indicate low water exchange rate making it unsuitable location for high density culture. Areas with firm substrate of fine gravel, sand, mud or any combination of these are suitable for cage culture.

B. **Hydrographical Factors**

1. *Water quality* - It is universal that growth and survival of aquatic organisms are largely dependent on water quality. As such, optimal conditions for growth of the cultured stock must be made available. The requirements of various species of fish ofcourse differ.

2. *River/stream run off* - Sites must be situated away from points of freshwaterrun-off because the influx can increase the danger of the cultured fish from exposure to heavy metals which might be laced from the catchment areas.

C. **Biological Factors**

1. *Diseases* - Areas of heavy natural disease occurrences on the species to be farmed must be avoided because cultured stock may be contaminated orinfected.

2. *Predators.* - Presence of predators in the area of farming may pose a serious threat to the fish stock especially if their number is excessive. Predators may be aerial (e.g. birds), terrestrial (e.g. snakes, dogs, rats) or aquatic (e.g. snakes, carnivorous fishes.

Species of Fish Suitable for Cage Cultivation

1. Fast growth
2. Good consumer acceptance
3. Tolerant to a wide range of environmental conditions
4. Resistant to diseases
5. Easy to culture
6. Spawn naturally or artificially
7. Produce large number of offspring
8. Eggs and larvae can be hatched and reared under controlled conditions
9. Little or no competition for food with man
10. Ability to remain live out of the water for considerable period (This is important in places where consumers prefer to buy live fish)

Life span of various materials used in temperate and tropical cage construction

Materials	Life expectancy in fresh waters
Bamboo and logs	1-2 years
Metal drums	0.5-3 years
Rubber types *	5+ years
Used plastic drums	1.2+ years
Styrofoam- covered	5+ years
- not covered	2+ years
Ferrocement	10+ years
PVC pipes	5+ years
Spherical buoys - aluminium	10+ years
- plastic	5+ years
Aluminium cylinders	10+ years

*Polystyrene filled

Details of cage culture experiment

Cages	3 m x 6 m (6 units)	=	108 m^2
	3 m x 6 m (2 units)	=	72 m^2
Total area		=	180 m^2
Species		=	***Tilapia nilotica***
Total stock		=	26,4000 fish seeds
Average stock density		=	$147/m^2$
Dates stocked		=	Mar 1979/Sept 1979
Dates harvested		=	Jul 1979/Dec 1979
No. of rearing days		=	140
Production :			
kg/harvested		=	1,645
kg/m^2		=	9.13
Average wt./fish/kg		=	62.3
Total kg/sold			1,645

Table .I -Extensive cage tilapia production figures from the Philippines

Lake	Cage size (m)	Stocking Density (no/m^{-3})	Culture Period (months)	Size at Harvest (g)	Production ($kg\ m^{-3}$ $months^{-1}$)
Bunot	20 x 25 x 5	4	4	250	0.24
Laguna de Bay	5 x 10 x 3- 10 x 20 x 5	4-8	4-5	100	0.07-0.18
Samplaoc	10 x 10 x 9- 25 x 20 x 9	1.6-2.0	6-9	225-300	0.05-0.08
Taal	10 x 5 x 3	50	4	100	1.25
Bato	-	50	4	160	1.90
Buluan	5 x 10 x 5	10	5	200	0.40

STATUS OF FISH PRODUCTIVITY OF FLOODPLAIN LAKES IN INDIA WITH PARTICULAR REFERENCE TO NORTH-EAST

B. C. Jha
Central Inland Capture FISHERIES Research Institute,
Barrackpore-743101, W.B.

INTRODUCTION

Floodplain lakes are one of the prime resources of fish protein in Ganga & Brahamputra basins. It is a paradox, however, that inspite of this fact the lakes have been neglected for such a considerable period and as a result these are passing through a critical phase of ecological succession.

Studies conducted in such lakes have indicated poor health of the ecosystem owing to the existence of high degree of eutrophication as reflectd by the massive infestation of aquatic weeds, besides other aberratins. Most of the lakes are choked with weeds to the tune of 50 to 100 % of surface coverage and are heading towards swampification.The prized economic fishes likeIndian major carps have either completely been eliminated or their population has dwindled to an alarming proportion. Fishes of less economing value have occupied the niche with vengence. So is the case with the predators. The catch of prized fishes is on the decline year after year. The changed morphometric features of the lakes in the face of changed land use patterns has affected the breeding of carps in these lakes and thus the natural recruitment which was the main stay for lucrative fishery has been lost. Morever, the natural recruitment what so ever may be there is not allowed to build the desired population due to the mass scale operation of small mesh nets (1-2 mm) which haul them up at fingerling or juvenile stages. The fishermen operate such small bar nets owing to very poor availability of bigger fish population. In the process of fishing the minor carps and smaller fishes, the newly recruited major carps, specially during monsoon, are also fished out.

Inspite of the fact that these lakes have exhibited the presence of relatively high diversity of fish fauna, the medium sized fishes like *Notopterus notopterus*, *Mystus cavasius*, *Clarias batrachus*, *Chana gachua*, *Mastacembelus armatus*, *Mastacemblus pancalus* and big fishes like *Wallago attu*, *Channa marulius* and *Channa striatus used to* dominate the fishery even to the tune of more than 35%. The prized fishes like *Catla catla*, *Labeo rohita*. *Cirrihinus mrigala* and *Labeo calbasu*, though contribute to the fishery of these lakes but their contribution is generally low 3-22% only, The miscellaneous fishes have been observed to be the main stay for marketing and among them *Nandus nandus*, *Oxygester spp*, *Puntis spp*, *Mystus vittatus, Chela spp., Satipina phasa etc.* are important. In fact these small fishes account for 50% or more of the daily catch.

Shrimp fishery has been found to be very common in these lakes as indicated by the extensive use of a large number of traps specially during the summer months.

The period between March to June was found to be the best for shrimp fishery, which at times contribute up to 30% of the total catch specially from shallow tectonic lakes.

FISH PRODUCTIVITY POTENTIAL

Studies conducted by CIFRI in selected lakes from Assam, Bihar, Uttar Pradesh and West Bengal reveal that these lakes are highly productive in nature. The productivity potential estimated ranged between 1000 - 1800 kg / ha/yr. The lakes in North-Eastern states with acidic pH have indicated relatively less productivity potential Which may be attributed to low primary production owing to low hour of sunshine and the precipitation of all important phosphate, necessary for the growth of phytoplankton.

STATUS OF FISH YIELD

Presently the estimated fish yield from these lakes ranges between 30 - 250 kg/ha/yr which is very low in the light of high to very high productivity potential. Certain lakes which are partially or thoroughly managed have shown considerable improvement in their yield rate. It is evident, therefore, that better fish yield can be harnessed from this resource provided managed on scientific lines.

TREND OF FISH CATCH

Indian major carps (IMC0 ---------- 1.0 - 30.0 %

Medium carps-------------------------- 08.0 - 25.0%

Large Cat fishes --------------------- 25.0 - 35.0%

Feather Backs ----------------------- 06 - 15.0 %

Micellaneous fishes------------------- 40 - 65.0%

The general sequence of abundance of various groups thus can be traced as:

WILD FISH > LARGE CAT FISH > MEDIUM CARPS> FEATHER BACKS > INDIAN MAJOR CARPS

****

ORIGIN AND CLASSIFICATION OF FLOODPLAIN LAKES

B. C. Jha
Central Inland Fisheries Research Institute,
Barrackpore-743101, W. B.

INTRODUCTION

Floodplain wetlands or Floodplain lakes are on of the prime fishery resources in the Ganga and Brhamputra basins. These lakes are characteristically shallow in nature but very sensitive biologically as support huge biodiversity both plants and animals. An estimated two lakh ha of water area available under this resource and such lakes have indicated very high productivity potential in the range of 1000 - 1500 kg/ha.

ORIGIN OF FLOODPLAIN LAKES

The origin of ox-bow lake is a complex phenomenon as in its formation many natural and human forces are involved. Each group of lake is formed due to some specific reason and thus has specific characteristics and separate identity. These diverse characterstics of lake groups or lake districts had always fascinated the limnologist and the fishery biologists. The genesis of the formation of lake basins has been identified as *constructive*, *destructive* or *obstructive* by geomarphologists and they have attributed seven main reasons for their origin, such as, (i) tectonic activities (ii) land slides (iii) glacial activity (iv) drifting activity (v) volcanic activity (vi) solution activity and (vii) fluviatile activity.

The clustur of natural lakes in the Ganga and Brahaputra River Systems in Assam, Bihar, Bengal, Uttarpradesh, Manipur etc. is an excellent example of fluviatile activity of the rivers. Sinuosity, produced by the accidental variations in the topography, exerts greater pressure on the concave side of the river and thus erosion sets in. The concavity is further been accentuated with the passage of time. The continuous deposition of silt, starts mounting pressure on the slower convex side of the river. A further increase in concavity and soil erosion causes the formation of meanders which ultimately cut-off and become isolated from the original source and as a result loop like impoundments are formed. The phenomenon is more pronounced in easily eroded flood plains. The abandoned loop like channels, thus formed, are of varied depth, depending upon the depth of the parent river and the amount of silt load at the time of cutting of an impoundment. In addition to oxbows tectonic lakes are also available under these basins and this case the origin of a lake takes place due to geomorhological change on the earth crust and the depression thus created are being converted into lakes subsequently with the accumulation of flood waters. Such lakes may be perennial or seasonal depending upon the depth of the depression and the amount of water mass accumulated therein.

The nomenclature of these lakes is a moot point of discussion, however, they are generaly known as *ox-bow lakes* or *tectonic lakes*. The lakes are known by different names in defferent parts of India and abroad. In north Bihar they are known as *Maun,* in West Bengal and Assam *beels*, in Uttar Pradesh as *tal* or *Jheels*; in Manipur as pat, in Australia they are known as *Bellabongs*, in France as *Lones* and in Germany as *Altwasser*.

CLASSIFICTION OF FLOODPLAIN LAKES

The Ganga and Brahamputra basins comprise a number of 'u' or 'saucer' shaped natural impoundments, originated due to the fluviatile activity rivers and their tributaries or due to dectonic activities on the earth crust.

Physically the **ox - bow lakes** of the basins can be classified as under :

(1) Well established lakes with connecting channels ;
(2) well established lakes without connecting channels ;
(3) well established lakes falling in between the embankment and the river which are flooded during the monsoon and
(4) half-formed lakes between the embankment and the river which are engulfed by the river during monsoon.

An artificial classifiction of these lakes can also be made as:

(1) The 'Live' or 'open' lakes,
(2) the 'dead' or 'closed' lakes, and
(3) the partially fluviatile incomplete lakes.

Characteristically the 'live' lakes have shown greater potentialities for fisheries development due to the following apparent reasons .

(a) The influx of flood water during monsoon helps in uprooting the choked aquatic vegetation to a greater extent which makes the lake water more conducive for the better proliferation of biotic communities.

(b) The influx of allochthonous energy input through the flood water, helps in increasing the energy budget, which in turn provides better opportunities for the growth of primary producers, the basic for aquatic productivity.

(c) The influx of river water helps in natural recruitment of prized fishes, major carp in particular, thereby making the lakes more viable economically.

The 'live' lakes have disadvantages in their own way as they are silted relatively faster with the influx of silt load along with the flood waters and thereby becoming shallow to shallower every year. The benthic enviroment is worst affected in this process as the niche is drastically altered due to the sudden deposition of silt load a sort of desertification takes place. It affects the benthic environment in two conspicuous ways as under:

> (1) *The existing flora and fauna are either killed or displaced from their native habitat.*
>
> (2) *The "oxidative micro - zones" are covered under the silt, which in turn inhibit the release of nutrients in the media and thus the entire productivity equillibrium is disturbed.*

Whatever, the eco-limnological adverse impect may be ,the 'live-lakes' have definite edge over the 'dead-lakes', especially in relation to the following apparent reasons:

(a) The absence of any connecting channel in dead lakes leads to vigrous growth of aquatic-weeds indirectly, as the influx of water is restricted to monsoon rain only, which is unable to exert any kind of pressure to uproot the vegetations.

(b) Greater proliferation of aquatic plants contributes very high semi-decomposed vegetative matter at the bottom and as a result the bulk of the oxygen budget is consumed to oxidize the same at that strata. In such lakes occassionally the BOD value increases remarkably at the cost of dissolved oxygen. The phenomenon exerts great stress and strain to the biota thriving there in. The foul odour emitted from such lakes is a pointer towards this process.

(c) No natural recruitment of prized fishes takes place in such lakes and thus the water is gradually dominated by species of less economic value and market acceptability.

(d) Luxuriant growth of unwanted weeds makes the fishing activities all the more difficult, resulting in poor yield.

(e) The renewal of allochthonous energy budget is dependent on the monsoon run-off from catchment area only, which is generally, not sufficient to support luxuriant growth of primary producers and as a result the abundance of phytoplankton is invariably poor.

The third category of lakes "the partially fluviatile" types are strategically unsuitable for taking up any management approach as they fall in between the artificially raised earthen embankment and the rivers and thus get lost during the monsoon months, when the river water spreads. Practically, they become a part of the swollen river course, leaving no approach to the lake site. However, they are quite significant from capture fisheries point of view after the river water recedes to its original courses during the post monsoon months. Incidence of natural recruitment is significantly high in these lakes as they act as a collection sink of river stock and are ideally suited for capture fisheries practices atleast for six months. This category of lakes are almost akin biologically to the "live-lakes" to some extent but are getting silted at a faster pace. In the face of such odds, the very existence of such lakes becomes doubtful.

CLASSIFICATION OF TECTONIC LAKES

The tectonic lakes as stated above take their origin from tectonic activities on the earth crust and as such can be classified as under:

a) Perennial lakes:

The lakes which retain reasonable water depth round the year

b) Seasonal or temprory lakes:

Such lakes are generally found during the monsoon or immediately after it but remain dry during the longer part of the year.

Ecologically such lakes are more akin to closed oxbow lake but highly significant from biodiversity point of view.

****

Common weeds and their management

G.K. Vinci
Central Inland Capture Fisheries Research Institute
Barrackpore - 743101, West Bengal

Introduction

Plants are considered to be originated in water, later, during their evolution process they developed vascular organisation adapted to terrestrial habitat (Gupta, 1979). There are 400,000 known species of plants in the world. Among them only 400 species are coming under weed category. A weed can be defined as *"an aquatic plant which, when growing in abundance, is not desired by the manager of its place of occurrence"*. The seeds of many species of weeds live longer, some germinate after a rest of 50 years or more. The number of seeds of weed plants are many times more than crop plants. Many of the weeds have short lives. Aquatic weeds are broadly grouped into four categories according to their growth habit *: free floating, sumberged, rooted floating leaved and emergent weeds.* The common aquatic weeds are listed in Table 1.

Free floating

The most wide spread of all weeds in Asia are two free floating weeds of south American origin. They are water hyacinth *(Eichhornia crassipes)* and *Salvinia* spp. *Salvania* represented by 3 species.

a) *S.molesta* - introduced in the early 1930s in tropical Asia through botanical gardens in Colombo, Calcutta, and Bogor (Indonesia). It spread from Sri Lanka to Kerala and otehr southern parts and Calcutta to the northern parts of India.

b) *S.cucullata* - a native of tropical Asia (eastern India or Burma) has spread to the whole of south-east Asia.

c) *S.natans* - occurs in Kashmir lakes and Indonesia.

Among other free-floating weeds, water lettuce *(Pistia stratiotes)* is the most important one. Several lemnids particularly *Spirodela polyrrhiza* and species of *Lemna* are very important as they may form a thick, cover to the surface of a water body.

Submerged weeds

Most common submerged weeds are *Hydrilla verticillata, Vallisneria spiralis, Potamogeton pectinatus, Ottelia alismoides, Ceratophyllum demersum* and *C.muricatum.*

Rooted floating-leaved weeds

Several members of Nymphaeaceae such as *Nelumbo nucifera, Nymphaea nouchali* and *Nymphoides cristata* are considered as weeds as their leaves can cover the water surface completely. Many other species creep over the water surface while rooted in shallow water on the shores. ***Eg.*** Ipomoea *(I.aquatica, I.crassicaulis*) and *Jussiaea repens.*

Emergent weeds

The rooted emergent weeds dominate shallow lakes, fish ponds, margins of reservoirs and irrigation canals. Dominant among them are : Typha, Monochoria, Alternanthera

Positive role of aquatic weeds

Excessive growth of aquatic plants can create a wide range of problems. But in a limited growth they have important functions in the aquatic ecosystem. The submerged plants oxygenate the water, serve as food for many animals and provide suitable sites for shelter and spawning of aquatic animals. They can reduce nutrient loads thereby minimise the development of algal blooms and eutrophication.

Negative role of aquatic plants

Excessive growth of aquatic macrophytes can lead to accumulation of organic matter which in turn deplete the oxygen content of the water causing distress or death of aquatic animals. Anaerobic conditions make the water undrinkable and may cause the production of hydrogen sulphide. This can seriously affect even the equipments at the hydroelectric power installations. Vectors of many waterborne diseases are supported by the vegetations. Excessive weed growth can also cause reduction in water flow rate which may lead to flooding and erosion of the shores of the water body. Another problem of luxuriant growth of emergents on the shores and of submerged or floating vegetation in the open water may hinder recreation. Masses of dead plants reduce the aesthetic value of the water body.

Management of aquatic weeds

With the increasing degree of weed problem normal removal of weeds and destruction was the only option left in the early years. Machines are rarely used in India because of the technological and operational problems. Most of the imported machines often do not suit the field conditions. Chemical and biological control have their own limitations. In India it is concluded that a sustained effort of normal removal and strict vigilance has no other alternative.

i) Water level management

Aquatic plants especially submerged species are affected by the water level fluctuations. A sudden drop in water level can kill the plants or atleast can reduce the growth. Submerged weeds are effectively controlled in irrigation channels (Chambal irrigation system, Bhakra canals etc.) by periodically stopping the water flow and allowing the bed to dry for a few weeks.

Water level fluctuation has a risk factor also, as it may encourages the growth of emergents which are favoured by shallower water.

Chemical control

In the early days arsenites, copper sulphate and similar inorganic chemicals were tried. Ammonia is a good weedicide. A variety of herbicides like 2,4-D, methoxone, diquat, paraquat, aminotriazole etc. either alone or in combinations have proved effective against submerged, free-floating and emergent weeds.

Herbicides can control aquatic weeds but they pose some problems also; (1) the chemicals must be used at regular intervals (2) the herbicides have restricted use as in most cases the water bodies are used for multiple purposes. The common herbicides used in India are listed in Table 2.

Biological control

There are a lot of organisms which attack aquatic plants. However, most of these organisms are either not much efficient or they are host specific. In many cases these insects not only attack weeds but also other economically important plants and animals. The biocontrol agents of the weeds are listed in Table 3. The insects which are used as biological control are just one of the components in a control strategy. The pathogens easily attack a damaged plant and kill it. Many trials have been carried out on grass carp (Ctenopharyngodon idella) for controlling submerged weeds and water hyacinth.

Only limited success has been achieved in controlling the growth of submerged weeds with grass carp. Selective feeding behaviour of the carp and its preference for tender-leaved plants. It feeds very little on water hyacinth, salvinia and emergent weeds. Another problem is the breeding of grass carp in field conditions outside their native range *i.e.,* North China and Siberia.

Utilization of aquatic plants

The aquatic plants provide food for man. Lotus is sacred in India; its flowers are offered in temples, seeds are eaten and the spongy petioles serve as vegetable. *Cyperus esculentus* is cultivated for tubers. *Trapas bispinosa* are used for fruits and wild rice grains. *Ipomoea aquatica* is used as vegetable. The leaves of *Typha* spp. are widely used for mats, ropes and thathing. Several aquatic plants are used as animal fodder and medicines

The utilization of weeds as their management measure is more appealing than complete destruction. In Asian countries, the native weeds were in use from time immemorial. The exotic weeds like water hyacinth are also put to use as cattle feed, pig feed, compost and energy from water hyacinth.

Conclusion :

Latest interest of putting the weeds to use than removing the weeds could only aggravate the problem. However, the benefits attain from using the weeds are far lesser when they are seen on the angle of economic viability. These benefits are not enough to compensate the losses to fisheries, hydroelectric power generation and water for irrigation.

Table I. Noxious aquatic weeds

Species
Eichhornia crassipes
Salvinia spp.[a]
Salvinia cucullata
Pistia stratiotes
Lemnaceae
Hydrilla verticillata
Najas indica
Ceratophyllum demersum
Vallisneria spp.
Potamogeton spp.
Potamogeton malaianus
Nymphaea stellata
Nelumbo nucifera
Typha spp.[b]
Scirpus grossus
Panicum repens
Monochoria vaginalis
Mimosa pigra

Table II.

The common herbicides, the weeds on which they have been found effective, the doses and the methods of application are shown in the table below :

Weed	Herbicide	Usual Dose	Method of application	Remarks
Water hyacinth,	2, 4—D	8—10 kg/ha	Foliar spraying.	
Ipomea spp.	,,	2—4 kg/ha	,, ,,	
Sedges and *rushes*,	,,	5—10 kg/ha	foliar spraying/ root-zone treatment.	
Lotuses & lilies	,,	5—10 kg/ha	Root-zone treatment	Only the exposed parts of the infestation will be affected.
Ottelia, Vallisneria	,,	10—20 kg/ha	do	
Aquatic grasses in young stages.	Dalapon	5—10 kg/ha	Foliar spraying	
Aquatic grasses	Paraquat	2 kg/ha	do	Quick death of the foliage only
Aquatic grasses	Diuron	4 kg/ha	Root-zone treatment	Effect is slow but long lasting
Microcystis, and other noxious planktonic and filamentous algae.	,,	0·1—0·3 ppm	dispersal in water column	The chemical has long-lasting action and can be applied in split doses.
All Submerged weeds.	Ammonia	10—15 ppm.	,,	
Pistia	,,	1% aqueous with 0·25/ wetting agent,	Folier spraying	
,,	Paraquat	0·2 kg/ha	do	
Salvinia	Ammonia	2% aqueous solution with 0·25% wetting agent.	do	
,,	Paraquat	0·4 kg/ha	do	

Table III.

Native and introduced biological control agents of important aquatic weeds used in trials in Asian countries

Weed species	Biocontrol agent	Country	Reference
Water hyacinth	*Neochetina eichhorniae*	Thailand (1979)[a]	Napompeth 1984
		Indonesia (1979)	Kasno, Aziz, and Soerjani 1979
		Sri Lanka[b]	Napompeth 1984
		Burma[b]	Napompeth 1984
		India (1983)	Jayanth 1987
	Neochetina bruchi	Indonesia (1979)	Kasno and Soerjani 1979
		India (1983)	Jayanth 1987
	Gesonula punctifrons	India	Sankaran, Srinath, and Krishna 1966
	Orthogalumna terebrantis	India (1986)	Jayanth 1987
	Sameodes albiguttalis	India	Jayanth 1987
	Acigona infusella	India	Jayanth 1987
	Ctenopharyngodon idella	Most countries	
Salvinia molesta	*Nymphula responsalis*	Indonesia	Subagyo 1975
Hydrilla verticillata	*Parapoynx diminutalis*	Indonesia	Balciunas 1983
	Hydrellia pakistanae	Pakistan	Baloch and Sana-Ullah 1973
	Bagous sp. nr *limosus*, *Bagous* sp. nr *lutulasus*	Pakistan	Baloch, Sana-Ullah, and Ghani 1980
Pistia stratiotes	*Proxenus hennia*	Indonesia, Malaysia	Mangoendihardjo and Nasroh 1976
	Episammia pectinicornis	Thailand	Napompeth 1982
Myriophyllum spicatum	*Bagous geniculatus*, *Bagous vicinus*, *Phytobius* spp.	Pakistan	Habib-ur-Rahman *et al.* 1969

[a] The year in parentheses refers to the year of field release.
[b] Introduced from Thailand, field release not confirmed.

GUIDELINES FOR THE DEVELOPMENT OF FISHERIES OF LARGE RESERVOIRS IN INDIA

V. V. Sugunan
Central Inland Capture Fisheries Research Institute
Rajgarh Road
Guwahati

INTRODUCTION

A number of river valley projects have been taken up in India during the last five decades with the primary objective of storing river water for irrigation, power generation and a host of other activities. One of the direct results of these projects is the creation of a chain of man-made lakes, dotting the Indian landscape from Kashmir to Kerala and Gujarat to the Northeast. That the reservoirs hold tremendous potential for inland fisheries development in India has long been recognised. However, this vital resource is not contributing to the inland fish production of the country to the extent it should.

Resource size and classification and yield trends

Despite the overwhelming importance of reservoirs in the inland fisheries of India, a reliable estimate of the area under this resource is still elusive, causing serious constraints to the R & D activities. A study made recently by the Food and Agriculture Organization (Sugunan, 1995) has estimated the surface area of reservoirs in the country at 3 million ha. All man-made impoundments created by obstructing the surface flow, by erecting a dam of any description, on a river, stream or any water course, have been reckoned as reservoirs. Reservoirs are classified as small (<1,000 ha), medium (1,000 to 5,000 ha) and large (> 5000 ha), especially based on the norms of the Government of India. However, water bodies less than 10 ha in area, being too small to be considered as lakes, are excluded.

Determinants of productivity

Reservoir is a man-made ecosystem without a parallel in nature. Though essentially a combination of fluviatile and lacustrine system, a close examination of the biotope reveals that it has certain characteristic features of its own. The riverine and lacustrine characters coexists in reservoirs, depending on the temporal and spatial variations of certain habitat variables. For example, the lotic sector of the reservoir sustains a fluviatile biocoenos, whereas the lentic zone and the bays harbour lentic communities. During the months of heavy inflow and outflow, the whole reservoir mimics a lotic environment whereas in summer, when the inflow into and outflow from the reservoir dwindle, a more or less lentic condition makes them distinctly different from their natural counterparts is the water renewal pattern marked by swift changes in levels, inflow and outflow.

In India, most of the precipitation takes place during the monsoon months which contribute substantially to the surface flow. During this period, due to a heavy inflow of water into the system, all outlets of the dam are usually opened, resulting in total flushing. This process dislodges a considerable part of the standing crop of biotic communities at the lower trophic level and disturbs the natural primary community succession. The sudden level fluctuations also affect the benthos by exposing or submerging the substrata.

Factors determining the water and soil quality in reservoirs are different from those of natural lakes. In the latter, the basin soil plays a predominant role in determining the chemical water quality through soil water interphase. In the reservoirs, on the other hand, the nutrient input from the allochthonous source often determines the water quality, nutrient regime and the basic production potential. This is because of the fact that the catchment of parent rivers is very often situated far away from the reservoir, under totally different geoclimatic conditions. Deep draw down, wind-mediated turbulence, locking up of nutrients in the deep basins, etc., are but some of the factors that impart the uniqueness to the reservoir ecosystem. Besides, the varying purpose and design of the dams make the reservoirs different in their hydrographic and morpho-edaphic characteristics, with implications on the production potential.

The Indian reservoirs are exposed to a wide range of climates from the temperate Himalayas in the north to the extreme tropical in the southern peninsula. From Gobindsagar in Himachal Pradesh to Chittar in Tamil Nadu, they spread over the southern slopes of Himalayas, the Indo-Gangetic plain, the Vindhyas, the Satpuras, the Western and Eastern Ghats and the Deccan plateau. Prevailing climatic factors including air temperature, wind velocity, rainfall, etc. play an important role in the biological productivity of a water body. The wide seasonal variations in air temperature is the predisposing factor in the thermal features of the north Indian and peninsular reservoirs. In contrast to the reservoirs of the north, their southern counterparts are characterised by the narrow range of fluctuations in water and air temperature during different seasons, a phenomenon which prevents the formation of thermal stratification.

The amount of rainfall determines the rate of inflow into the reservoir, and hence plays a crucial role in bringing in the water replenishment and nutrient enrichment. More often, rainfall in the catchment of the river situated hundreds of km away from the reservoir affects the inflow rate. Another important climatic factor with implications on thermal and chemical regimes of the reservoir is the wind. It helps distribution of heat and equalisation of temperature in the water column. Wind velocity is very high in monsoon and premonsoon months in most reservoirs in India. Wind-induced turbulence is important in churning of the reservoirs and thereby facilitating the availability of nutrients at the trophogenic zone.

Morphometric factors

Reservoir morphometry is a function of the height of the dam and the topography of the impounded areas. Apart from the nature of the basin and the characteristics of the terrain, it is the design of the dam and the water use pattern that decide the influence of morphometric and hydrographic features on the aquatic productivity. Most of the hydel reservoirs on the mountain slopes of Western Ghats, Himalayas and the other highlands are deep, with steeper basin walls than the irrigation impoundments.

One of the most important morphometric considerations is the mean depth, that is believed to determine the productivity of reservoirs. This is based on the well known dictum that the shallower lakes have greater part of their water in the euphotic zone, facilitating greater mixing and circulation of heat and nutrients and hence higher productivity. A large portion of water in deep lakes serves as a nutrient sink at the bottom, where organic matter accumulates and thus the nutrients become unavailable at the photosynthetic zone.

Shoreline and volume development indices

A highly crinkled shoreline, as indicated by the high values of shoreline development index, is believed to be indicative of productive nature of the water body. An irregular shoreline encompasses more littoral formations and areas of land and water interface. High shoreline indices of Hirakud (13.5), Gobindsagar (12.26), Tilaiya (9.12), Konar (8.78), Nagarjunasagar (7.89) and Rihand (7.04) are accompanied by a moderate to rich plankton community.

Hydro-edaphic factors

Water and the bottom soil being the media in which various biotic communities exist, the assessment of parameters determining their quality assumes importance. It is well known that the productivity of a reservoir is dependent on its biogenic capacity to transform the solar energy into chemical energy. This energy fixation at primary producer level. however is subject to a variety of factors, chiefly the availability of sunlight, conducive thermal regime, availability of carbon dioxide and the essential catalysing agents like nutrients. A high productivity regime throughout the year and the plentiful sunlight by virtue of geographical advantage provide the ideal perequisite for photosynthetic abundance in Indian reservoirs.

Nutrient budget

Most of the Indian reservoirs are characterised by low levels of phosphate and nitrate. Phosphate very seldom exceeds 0. 1 mg I^{-1} in reservoirs free from pollution. However, the reservoirs of Rajasthan have particularly high levels of phosphate, ranging from traces to 0. 929 mg I^{-1}. They receive phosphate from the rain washings derived from soil types like brown hills, grey brown hills, red and yellow and desert soils. In the highly eutrophic reservoir of Mansarovar in Madhya Pradesh phosphate levels of 4 to 13 mgl^{-1} were recorded.

Nitrate nitrogen in water in Indian reservoirs is mostly in traces and seldom exceeds 0.5 mg 1^{-1}. Lack of nutrients in water, especially the nitrate nitrogen and phosphate, does not seem to be indicative of low productivity. In many cases, despite their virtual absence, the production processes are not hampered. In Amaravathy, Bhavanisagar, Gandhisagar, Ravishankarsagar and many other reservoirs, moderate to very high primary productivity is reported, although the phosphate in water is either absent or present in a very low concentration. In the tropical reservoirs, phosphate level in water has limited scope as an indicator of productive traits. This phenomenon is attributed to rapid turnover of nutrients and their quick recycling, as seen from the high metabolic rates.

Unlike the nutrients like phosphate and nitrate, the measure of total dissolved solids in the form of total alkalinity and the specific conductivity reflects the production propensities of reservoir satisfactorily, with the exception of Amaravathy which, despite very low levels of specific conductivity (38 to 63 @ µmhos), total alkalinity (7 to 84 mg I^{-1}) and total hardness (18 to 50 mg I^{-1}), supports a very rich plankton community and a good stock of fish.

A close examination of physico-chemical data pertaining to more than 100 reservoirs in the country leads to the conclusion that none of the morphometric, edaphic, and water quality parameters can be used as a dependable yardstick to predict the organic productivity to any degree of accuracy, production propensities of each reservoir being determined by a variety of factors. The vertical gradient of some of the chemical parameters, especially the dissolved oxygen, however, conveys the status with a higher level of accuracy. The main parameters to determine the factors mentioned above are tabulated in Table 1.

Productivity

Phytoplankton forms the base of food pyramid in a reservoir ecosystem and their population determine its basic productivity. On of the major criteria for determining the fish yield potential of a reservoir is to estimate the rate at which the solar energy is tranformed into chemical energy by the photosynthetic organisms. Rate of primary productivity in reserviors is very high due to the warm tropical conditions available in most part of the country. Many workers consider 1% of the total carbon produced at the phytoplankton phase as the potential fish production from a water body, although almost all reservoirs produce much less fish than their potential.

Table 1. Physico-chemical features of Indian reservoirs (rangeof values)

Parameters	Overall range	Productivity		
		Low	*Medium*	*High*
A. Water				
pH	6.5-9.2	<6.0	6.0-8.5	>8.5
Alkalinity (mgl^{-1})	40-240	<40.0	40-90	>90.0
Nitrates (mgl^{-1})	Tr.-0.93	Negligible	Upto 0.2	0.2-0.5
Phosphates(mgl^{-1})	Tr. 0.36	Negligible	Upto 0.1	0.1-0.2
Sp. Conductivity (µmhos)	76-474		Upto 200	>200
Temperature (^{O}C)	12.0-31.0	18	18-22	>22
			(with minimal stratification: *i.e.*, >5^{O}C)	
B. Soil				
pH	6.0-8.8	<6.5	6.5-7.5	>7.5
Available P (mg/100 g)	0.47-6.2	<3.0	3.0-6.0	>6.0
Available N (mg/100 g)	13.0-65.0	< 25.0	25-60	> 60.0
Organic carbon (%)	0.6-3.2	< 0.5	0.5-1.5	1.5-2.5

Biotic communities

The highly seasonal rainfall and heavy discharge of water during the monsoons result in high flushing rate in most of the reservoirs which does not favour colonisation by macrophytic communities. Similarly, inadequate availability of suitable substrata retards the growth of periphyton. Plankton, by virtue of drifting habit and short turnover period, constitutes the major link in the trophic structure and events in the reservoir ecosystem. A rich plankton community with well-marked seral succession is the hallmark of Indian reservoirs.

RESERVOIR FISHERIES MANAGEMENT

Since fish production from medium and large reservoirs is essentially extractive in nature, the essence of management strategy lies in judicious exploitation of fish stocks which are self-sustaining to a large extent. Nevertheless, the ecosystem management provides different degrees of freedom for stock augmentation, depending on the size and class of the water body. Productivity of a lake is dependent on its capacity to transform the solar energy into chemical energy. Energy fixed at the primary producer level passes through a trophic chain before a portion of it reaches the level of fish flesh. Since energy is dissipated at every level in the trophic chain, a fishery based on short food chain is preferred.

Reservoir management is a mix of capture and enhancement norms the relative contribution of which vary according to the size, water renewal pattern and the fish stock structure of the reservoirs. Small reservoirs are managed as culture-based fisheries where the catch depends mostly on the stocked fishes. Thus, effective stocking and recapture hold the key to success in such system. Conversely, medium and large reservoirs are predominantly capture fisheries systems and the management norms are based on the principle of stock manipulation, adjustment in fishing effort, observance of conservation measures and gear selectivity. Selective stocking is resorted to for correcting imbalances in species spectrum and to fill the vacant ecological niches.

Various management processes involved in fisheries management of medium and large reservoirs can be summarised into:

1. Environment management
2. Stocking
3. Gear and effort management
4. Exotic fish species
5. Fish stock monitoring
6. Other management measures
7. Unconventional production systems, and
8. Harvesting and post-harvest management

****

FISHERY RESOURCES OF THE NORTH-EASTERN REGION AND SCOPE FOR THEIR DEVELOPMENT

V. V. Sugunan
Central Inland Capture Fisheries Research Institute
Rajgarh Road, Bhangagarh
Guwahati-781 005

The seven north-eastern states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura, fondly called the seven sisters, constitute 8% of India's territory and 4% of its population. Located within the geographical coordinates 21° to 29° 30' N and 89° 46' to 97° 30'E, the north-east encompasses a geographic area of 2.55, 083 sqm. The region is a kaleidoscope of diverse topography, climate, race, language and culture where about 38 million people, affiliated to more than a 100 different ethnic tribes, live together sharing common problems, hopes and aspirations. The seven states, which among themselves share international border with five neighbouring countries, have always been a melting pot of political unrest often finding expression in the form of insurgency. Although a variety of historical and geopolitical factors play a role in such conflicts, for a discerning eye, it is apparent that the main source of discontent is the development - or ratherf the lack of it-which often manifests in the form of political upheaval. With breathtaking scenic beauty of the landscapes and the pristine environment teeming with wildlife, the north-east is the nation's pride. It is also culturally vibrant with excellent centres of learning, fine arts and performing arts. But somehow, this land of rich cultural heritage and endless beauty did not keep pace with the progress made by the rest of the country in terms of infrastructure building, industrialisation, urbanisation and communications during the last fifty years.

Development of agriculture in the north-east has always been under severe constraints such as non-availability of flat land for intensive cultivation and the necessary infrastructure facilities. It missed the green revolution mainly due to the absence of irrigation facilities and traditional practice of shifting (*jhoom*) cultivation by the tribals. That the people of north-east relish fish is borne out by the fact that 100% of the population are fish eaters (except Assam which reportedly has 90% fish eaters). Yet, fishery development was one of the most neglected areas till the recent past. Fish production from the region during 1986-87 was an abysmal 73,500 t which increased to just 112,250 t during 1990-91 at a per capita availability of 3.85 kg against 5.3 kg at national level. The first ever serious effort to prepare a Master Plan for comprehensive development of fisheries in the region was made by the North-Eastern Council (NEC) in 1988, when it assigned the task to the Agricultural Finance Corporation (AFC), Mumbai and Central Inland Capture Fisheries Research Institute (CIFRI), Barrackpore. The study, completed in 1991, assessed the fishery resources of the region and their production potential apart from proposing several action plans for their development for the future. Projections were also made upto 2000 AD.

Fishery Resources of the North-East

Except the Brahmaputra and Barak valleys in Assam and the Imphal valley in Manipur, the north-east mainly comprises hills and mountains which from 65% of its territory. Meghalaya and Mizoram have very little plain lands. Nevertheless the region has vast untapped potential for fish yield by enhancement from rivers, streams, floodplain wetlands, reservoirs, lakes, ponds and paddy-cum-fish culture systems.

Rivers

The mighty Brahmaputra and Barak along with their tributaries run into 2,000 km. In Assam, the Brahmaputra flows for 730 km, receiving 57 tributaries. The Barak drains the Cachar and North Cachar districts. The combined length of all rivers and their tributaries in Assam is estimated at 5,050 km. Manipur has two major rivers *viz.*, the Barak and the Manipur. The Barak with tributaries *viz.*, Irang, Leimatak, Nakaror, Makru, and Tuivai, mainly dissect the hills while the imphal river (as the river Manipur is known in the upper stretches) drains the valley districts. Iril, Thoubal, Chakpi and Khuga directly join the Manipur river, while Namol, Nambul, and several rivulets draining the eastern slopes of Tamenglong hills are connected to the river through the Loktak lake. Estimated length of rivers in Manipur is 2,000 km.

Meghalaya's 5,600 km of rivers mainly comprise the north-flowing ones like Umiam, Digaru, Kri, Dudhnoi, Krishnai and Jinjiram, all southern tributaries of Brahmaputra. the main south-flowing rivers of the State are Bala, Chancing and Samsung. There are 21 rivers in the hilly state of Mizoram, of which 16 are situated in the Aizwal district. These rivers, along with tributaries, streams and creeks run into 1,700 km forming an important fishery resource of the state Jahnzi, Dikhow, Diphu, Diyung, Dhansiri (all tributaries of Brahmaputra), Barak and Tizu are the main rivers of Nagaland which have a combined length of 1,600 km. rivers of Tripura are Longai, Juri, Deo, Manu, Dhalai, (all in North Tripura), Khowai, Howrah (both in West Tripura), Gumti, Mahuri and Feni (South Tripura). These rivers, along with other small streams and rivulets have a total length of 1,200 km.

Reservoirs

Although the north-east has enormous potential for creating impoundments for generating hydro-electric power, only few projects have come up. They are the two man-made lakes created under the Kopili hydro-electric Project in the North Cachar hill district of Assam (10,730 ha), the three reservoirs in Meghalaya *viz.*, Umiam, Kyrdemkulai, and Nongmahir (8,430 ha), the Gumti reservoir in Tripura (4,500 ha) Khopum dam of Manipur (100 ha) and the Palak lake of Mizoram (32 ha). However, more reservoirs are in the pipeline (Table 1).

Beels, Lakes and Swamps

Floodplain wetlands (oxbow lakes, tectonic depressions and other wetland formations on the floodplains of rivers) and associated swamps constitute an important fishery resource of the north-eastern region, especially in the State of Assam and

Manipur. Assam has an estimated 100,000 ha of floodplain wetlands (*beels)*. The Imphal valley of Manipur has 21,000 ha of *pats,* (as the floodplain wetlands are known in the State), which along with the 19,150 ha Loktak lake, make it the most potential State from inland fisheries point of view. If managed on scientific lines, fish yield from these lakes can be increased many a time production. Meghalaya has 375 ha of *beels.* the total area of *beels, pats,* lakes and swamps in the region is 143,740 ha.

Ponds and 'mini barrages'

Notwithstanding the limited availability of plain lands, difficult terrains and the constraints due to low temperature which have prevented the north-eastern region from keeping pace with the rapid strides made by the rest of the country in respect of aquaculture and fish seed production, some commendable progress has been achieved by some States like Tripura and Assam. Assam with 22,500 ha has the largest area of ponds in the region. Tripura has the highest yield rate among the north-eastern states. The State had 10,250 ha of aquaculture ponds in 1989, of which 3,500 were improvised impoundments created by blocking the streams. Locally called mini-barrages, this type of ponds are also popular in Mizoram where there is a dearth of plain land for digging ponds. Mizoram has 1,800 ha of ponds while Manipur, Meghalaya, and Nagaland respectively have 5,000 ha, 500 ha, and 500 ha of ponds. Arunachal Pradesh has 250 ha of ponds, some of which are suitable for coldwater fish culture. There is also scope for developing another 500 ha pond area. The state has 3 trout farms and 260 km of rivers (Tawang and West Kameng) under trout stocking and conservation. It is estimated that 59,100 ha of ponds can be developed in the region against which 9,150 ha are known to be utilised.

Paddy-cum-fish culture

Paddy-cum-fish culture is practised in some appreciable extent only in Nagaland where more than 2,000 ha were already under the system since 1989. there are some traditional practices of growing fish in the paddy fields in certain other areas like Juria block of Nagaon district (Assam) and the hill tracts of Ukhrul district (Manipur). But these culture practices are low yielding and mostly subsistence in nature. The AFC/CIFRI study has identified enormous potential for developing paddy cum fish culture in the north-east. Out of the potential 45,000 ha. only 2,780 ha were developed till 1991 (Table 1).

Fish production Trends

Population of the north-east during 1997, as projected on the basis of annual growth rate of individual States, is 36.9 million, which require 377,784 of fish at the rate of 11 kg of per head per year. The estimated fish production of the region during the year 1996-97 is 206, 769 t. equivalent to 6.0 kg percapita, which leaves a wide gap of 171,015 t (Table 2). this is despite the substantial increase in fish production achieved by some of the States in recent years. Nagaland has registered an increase from 8.30 t in 19990-91 to 4,000 t in 1996-97 and Assam has doubled its figures during the same period. However, the production declined in Mizoram from 2,950 t to 2,550 t, and the increase in Arunachal Pradesh was marginal during this period. Currently, Assam accounts for more than half of the fish (154,611 t) produced in the north-east, still the State's requairement is met only by 39.1%. Maximum per capita availability of fish (8.18 kg) is in Tripura which produces 27,743 t against the requirement of 36,900 t leaving a deficit of about 25.5% Arunachal Pradesh and Meghalaya have very poor per capita availability of fish.

Table 1. Inland fishery resources of the Northeastern States

States	Rivers (km)	Reservoirs (ha)	Beels, Lakes and Swamps (ha)	Ponds/Mini barrages (ha)	Paddy-cum fish (ha)
Arunachal	2,000	(160)	2,500	250 (1,250	575 (2,925)
Assam	5,050	10,730	100,000	22,500	- (20,000)
Manipur	2,000	100 (40,000)	Loktak 19,150 Others 21,000	5,000 (4,500)	- (10,000)
Meghalaya	5,600	8,430	375	500 (1,900)	85 (4,915)
Mizoram	1,700	32	-	1,795	120 (1,440)
Nagaland	1,600	- (27,100)	215	500 (1,500)	2,000 (3,000)
Tripura	1,200	4,500 (1500)	500	10,264 (3,136)	
Northeast	**19,150**	**23,792**	**143,700**	**40,809** **(12,286)**	**2,780** **(42,280)**

(Figures in parenthesis indicate resources which are yet to created/developed)

Table 2. Requirement, production and per capita availability of fish

States	Projected population (1997)	Requirement of fish (t)	Production 1996-97* (t)	Per capita availability (kg/year)	Deficit
Arunachal	1,061,314	11,674	1,852	1.74	84.1
Assam	25,643,695	253,872	154,611	** 6.7	39.1
Manipur	2,163,464	23,798	12,705	5.87	46.6
Meghalaya	2,126,891	23,396	3,578	1.68	84.7
Mizoram	863,285	9,496	2,550	2.95	73.1
Nagaland	1,695,239	18,648	4,000	2.35	78.5
Tripura	3,354,579	36,900	27,473	8.18	25.5
Northeast	**36,908,467**	**377,784**	**206,769**	**6.0**	**45.4**

****

METHODOLOGY OF EIA STUDIES IN OPEN WATERS

BY

K. Chandra
Division of Environmental Monitoring & Fish Health Protection, CIFRI, Barrackpore, W.B. 743101.

INTRODUCTION

Most of the developmental activities have an impact on environment in general and aquatic resources in particular. The procedure for assessing such impact and for ensuing appropriate environmental safeguards, has attracted the attention of scientists and developmental authorities. EIA has been made mandatory in case of all development projects and accordingly a detailed EIA or preliminary EIA will depend upon the type of project and its likely magnitude of impact on the environment EIA has become an essential tool for environmental planning and management. The EIA procedure can help to anticipate loss in biodiversity and deterioration of aquatic possible anticipatory preplanning and implementation of safeguards, especially for pollution abatement and mitigation action plan. Thus EIA is a most of efficient and effective tool to planners and industrial development in any country or organization. In India all round development is essential not only for meeting the basic minimum needs of the people but also enhancing the quality of life in the country.

EIA-STUDIES

1: Project description.

2: Site description.

3: Details of possible Impacts-chemical, physical, health, ecology, Socio-economic , both adverse and beneficial.

4: Impact Evaluation (qualitative and quantitative).

5: Assessment of Impact on Environment (land, water, air, forest flora, fauna, settlement, health) etc.

6: Prediction of short and long term environmental changes.(Identification or modification and safeguards to protect the environment, including modification of the production procedures).

7: Suggestions of Alternatives, Environment Safeguards, Monitoring process.

8. Review and Assessment in the Course and Completion Phase.

EIA-Assessment Measures.

In open water system, EIA studies are undertaken to assess long term and short term impact of waste for long scale monitoring. The following studies are essential to predict environmental impact of any developmental activities.

1. Water and Soil Quality Assessment.

Soil and water of the basic requirement of aquatic sustenance and controls qualitative and quantitative distribution of the organisms. Physic-chemical qualities of the soil and water are adequate in predicting the inhabitant population structure. For sediments, richness in nutrients, organic percentage and bacterial composition are indicative of the possible flora-fauna composition in the bottom of the aquatic system. Spatio-temporal monitoring of water and sediments qualities provide information in time scale shifting the bio-communities structure with environmental changes.

2. Toxicant Assessment.

Organic waste which form bulk of toxicant are persistent and not residual materials and thus produce toxicity effect for restricted period limited to the area of contamination. More problems are with non-biodegradable toxicant like, metals, pesticides and radioactive materials. However, toxic effect may have on the bio-components, these toxicant toxify the water and sediments, first, which immediately or in the long run often contaminant the inhabitant population

3. Bio-Concentration.

It is the accumulation of water born chemical by the aquatic animals and plants through non-dietary roots i.e. as a result of competing rates of chemical uptake and elimination. The bio-concentration of metal and others biodegradable materials varies greatly with the species and specific toxicants. The size of organism can also influence bio-concentration rate. Metals initially accumulate in the gills of both invertebrate and fish Bio-concentration is a complex system dependent upon the spectra toxicant.

4. Bio-Monitoring.

It is one of the important tools in EIA studies. This technique helps in evaluating the likely changes /impact on the bio-diversity as a result of proposed development project utilizing any of the natural resources whether land or water. Biological monitoring for detectable changes has the significance that the aquatic organisms will be reaching to the complexity of the inputs both in terms of the variety of chemicals presents and the range of their concentrations. As such, the evaluation of biological response has a distinct advantage over a chemical monitoring programme.

There is along history to the development of methods of measuring changes in the structure of aquatic communities, particularly in response to nutrient loading. Some organisms are sensitive to the reduction in the D.O. of the water whereas, others are more tolerant; however, it may be more accurate to say that the changes recorded or associated with changes in the D.O. because it is possible that there are other factors in the complex organic effluents which are responsible for adverse impacts on the organism. These effects can be analyzed in two basic ways. The presence or absence of key species that cause the spectrum of sensitivity to organic load, and the change in species diversity which is a reflection of the small number of tolerant species that are able to live in polluted water. Of these, two approaches the identification of key species is the less time consuming and this is important for routine bio-monitoring programme.

Methods used in Bio-monitoring.

Many approaches could be used to understand the ecosystem changes at species, community and physiological level to evaluate the gravity of the impact so that suitable mitigation action plan could be formulated. Some of the approaches are indicative below.

A. Eco-Taxonomical approach.

1. **Indicator species – Score system. Algae index and Trent biotic index.**
2. **Communities structure.**
3. **Species Diversity Index, Dominance Index, Events and Similarity Index.**

B. Physic-chemical approach.

1. **ATP, Primary Production and Chlorophyll Estimation.**
2. **Toxicity Testing:- Short Term, Acute Test, Long Term Toxicity Testing and Avoidance studies.**

Bio-indicators.

Bio-monitoring can not replace chemical monitoring where detailed inventories of pollution are required. The ecology of best indicators of ecosystem qualities or health is well established plankton, benthic invertebrates and diatoms. Some of the best indicator organisms are also reasonably abundant and relatively easy to detect. Changes in organisms morphology in addition to shift in the abundance of a species itself, can be used as indicators of change. Care must be taken at all times in interpreting the indicator potential of a change in a population or assemblage.

Limitations.

Bio-monitoring can also fail for a number of reasons. One of these can arise due to statutory authorities reluctance or inability to respond rapidly enough to reports the appearance of pollution if plankton, especially algae, are taken as indicator species. If bio-monitoring establishes the presence of a nuisance organism or and increased in its number to undesirable level, the ecosystem is already decline. Secondly, inadequate temporal and/or spatial sampling can lead to false interpretation as to the state of the water bodies. Dense, but patchy aggregation of surface blue green algae which are very noticeable may be perceived as serious even though such populations are likely to be very moderate if express on a lake-wise basis. An extremely densely mixed diatoms population and pass relatively unnoticed since they simply impart a general cloudiness to a water. Dense population of organic pollution indicators are restricted immediate vicinity of a spill. The third short coming of bio-monitoring system is from the lack of knowledge about the potential indicator value of many organisms. Fourthly, there is the problem of the very identity of the organisms recorded, and fifthly, among very small plankton some are likely to the completely overlooked even when present in enormous numbers.

Conclusion.

Bio-monitoring is an important tools in evaluating likely impacts on production functions in an ecosystem in an EIA studies of any developmental project utilizing natural resources directly or indirectly. By and large bio-monitoring based on macro invertebrates is proving to be very effective in a general surveillance programme while physiological and biochemical indices of test populations in ecosystems are being developed to pinpoint the stress induced damages on organisms due to positive or negative environmental impact. As such bio-monitoring has greater role in EIA studies.

Common Fish disease and their control

Manas Kr. Das
Central Inland Capture Fisheries Research Institute
Barrackpore-743 101, West Bengal

Parasite fish environment relationship

Fish disease is the culmination of an interaction between the susceptible fish, the pathogen and the environment. A clean environment always helps in the good growth of fish whereas a bad environment favours multiplication of pathogens. Fish is in a state of equilibrium with the environment and a change in the environmental parameters beyond the tolerance limit disturbs this equilibrium resulting in stress response in the fish and making it vulnerable to fish disease. The response of fish to stress from the environment is known as stress response. The most extreme response is mortality but below this level there may be other responses such as :

i) Changes in fish behaviour
ii) Reduced growth/food conversion efficiency
iii) Reduced tolerance to disease
iv) Reduced ability to tolerate further stress

Indicators of health condition of fish stock

Any occurrence of fish disease in a water body is generally recognised by fish becoming restless, rubbing its body against pond dykes, splashing, surfacing, whirling non-acceptance of food etc. However, there are some external symptoms of healthy fish as reflected by :

i) Escape reflex

Healthy fish react to external agitation such as quick motion, stamping on the bank, sound etc. and quickly submerge under water. Sick fish do not react to external agitation and can be caught easily.

ii) Defensive reflex

A freshly caught fish from water toss about quite violently when laid on ground. After a while the fish calms down. Sick fishes are sluggish in water as well as out of it.

iii) Tail reflex

When a live fish is held by the head and the posterior portion is free, it exhibits the tail reflex which occurs irregularly. Here the fish keeps the posterior and caudal fin in a horizontal position or even slightly obliquely upward, while the caudal fin is always stretched in a fan-shape.

Environmental parameters in relation to fish health

The environmental parameters of importance in fish culture operations are as follows :

Oxygen

Often fishes swim on the surface of water gulping air with mouth wide open. This stressed condition of fish is due to oxygen depletion in water. Three main factors influence the amount of oxygen which a water body can hold.

a) Temperature - water holds less oxygen at higher temperature.

b) Salinity - water holds less oxygen at higher salinities.

c) Atmospheric pressure - Water holds less oxygen at low atmospheric pressure. Other factors which affect the amount of DO in water include phytoplankton blooms, organic loading and respiration of fish and other aquatic vertebrates and invertebrates.

Ammonia

It is commonly the second important parameter after DO. The total ammonia concentration in water consists of two forms.

NH_3 - unionised ammonia
NH_4 - ionised ammonia

The unionised fraction is most toxic to fish. As a general rule, the higher the pH and temperature the higher the percentage of total ammonia i.e., the toxic unionised form. Ammonia in water originates from :

i) decomposing organic matter
ii) excretion of aquatic organisms
iii) death of phytoplankton bloom

Hydrogen sulphide

Very often the muck in the sediments smell like rotten eggs and the bottom dwelling fishes surface and die. This is due to accumulation of H_2S gas which is produced by chemical reduction of organic matter.

Nitrite

Fish gills frequently turn brick red in colour. This is because of excess nitrite in the water which is absorbed by fish and reacts with haemoglobin to form methaemoglobin and this gives brick red colour to the gills.

Suspended solids

It originates from phytoplankton blooms, uneaten food particles and fish fecal matter. Suspended solids are important in reducing the penetration of light thus reducing productivity.

pH

It is an important parameter affecting fish health. The optimum range of pH for most of the freshwater fishes is 6-9. The factors which affect the toxicity of acid to fish are :

i) CO_2 - high CO_2 increases the toxicity of acid

ii) Species size and age - The hatchlings or fry are normally most vulnerable to acids. Rapid changes in pH are very harmful to fish.

CO_2

Free CO_2 is toxic to fish. High concentration of 12-50 mg/l of free CO_2 hinders uptake of DO by fish and thus the effects of high CO_2 are accentuated at low DO concentrations.

Alkalinity

Water with low alkalinity of less than 20 mg/l have low buffering capacity and consequently are very vulnerable to fluctuations in pH due to rainfal or phytoplankton bloom.

Fish diseases caused by protozoan parasites

They are probably the most important group of animal parasites affecting fish. The protozoan parasites afflicting fish fall under the phylum Ciliophora with the typical parasites *Trichodina* and *Tripartiella;* Phylum Sarcomastigophora with the typical parasite *Costia* and Phylum Myxozoa with the typical parasite *Myxobolus* spp., *Thelohanellus* spp.

General morphology and identification of Trichodinid Parasites

The trichodinid parasites *viz., Trichodina* or *Tripartiella* are hemispherical-bell shaped. The aboral surface is concave. The adoral cilia surround the buccal cavity and the marginal cilia gives it a spiral rotating movement. The parasite attaches itself to the host surface by the attachment disc reinforced by border memberane. The ring of denticles and radial pins located internally provide rigidity to the parasite.

Life cycle and transmission

They have a simple life cycle and reproduce by binary fission and is directly transmitted from one host to the other.

Common disease encountered in fish culture

Trichodinosis

The disease is very common in the fry and fingerlings of cultured fishes. The most common symptom in an affected fish is pale colour of the gills with a creamish coating due to excessive secretion of mucus. The causative organism is urceolariid ciliates of the genus *Trichodina* and *Tripartiella.*

General morphology and identification of Myxozoan Parasites

The prominent feature of the myxozoan parasite is the spore. The spore usually consists of two valves joined by a suture. The valves are of various shapes. Within the spore there are one, two or more polar capsules. Within the capsule is the coiled polar filament opening outside the capsule by an apperture. The remainder of the spore cavity is occupied by the sporoplasma, the infective part of the spore.

Life cycle and transmission

It has a direct life cycle. The spores are ingested by the fish. The sporoplasma comes out and moves through the blood stream and reaches the appropriate site of infection. Here it undergoes repeated nuclear division in the trophozoit and forms mature spores.

Common diseases encountered in fish culture

White gill spot disease

The gills of fishes predominantly *Catla catla* are covered with whitish cysts of different sizes. This infection reduces the absorptive surface of gills. Excessive mucus secretion occurs and fishes surface for gulping air. The causative organisms are *Thelohanellus catlae* and *Myxobolus bengalensis*.

Scale spot disease

The scales are covered with whitish cysts. In acute cases scales become perforated and degenerated. Scales become loose with ulceration. The causative organisms are *Myxobolus rohitae* in *L.rohita* and *Myxobolus sphericum* in *C.mrigala.*

Fish diseases caused by helminth parasites

These flatworms are predominantly parasitic in fish and have a varied type of host-parasite relationship. They are mostly dorso-ventrally flattened and bilaterally symmetrical. They may be segmented or unsegmented and most of them are attached to the host by characteristic attachement organs. The flatworms which infect fishes in aquaculture or open waters broadly fall under three classes; the Monogenea, Cestoda and Trematoda.

Monogenea

General morphology and identification of Monogenean parasites :

They are small worms and ectoparasitic in nature. The posterior extremity of the body has the characteristic attachment organ called opisthapter. It is armed with chitinoid structures important for identification. The anterior end of the parasite bears a small sucker. Eyespots are frequently present anteriorly.

Life cycle and transmission

Monogeneans predominantly have direct life cycle. Most of them are oviparous depositing eggs which on hatching release a free swimming larva which seeks a host, becomes attached to it and metamorphose to adult ones. Some are viviparous and give birth to young worms which attach to new host on their release.

Common diseases encountered in fish culture

Dactylogyrosis and Gyrodactylosis : The causative organism for the disease is *Dactylogyrus* sp. and *Gyrodactylus* sp. While *Dactylogyrus* sp. predominantly infests the gills, *Gyrodactylus* sp. mostly infests different body surface and occassionally gills. When gills are infected their is hypersecretion of mucus affecting respiratory surface and very often the fishes are irritable and surfacing takes place. There is growth retardation and loss of weight.

Trematoda

General morphology and identification of trematodes parasites

They are dorso-ventrally flattened, unsegmented and usually oval in shape. Two attachement organs are present, the oral sucker near anterior end and the ventral sucker or acetabulum, a little below the oral sucker.

Life cycle and Transmission

The digeneans are oviparous and in most cases the eggs hatch outside the host to release a free swimming miracidium larva. This larva locates the first intermediate host *i.e.,* the gastropod. Within this host the parasite undergoes asexual reproduction and forms the cercaria larvae which, when released, locates the suitable second intermediate host, which is the fish. Here the cercaria encyst to form the metacercarial stage. The life cycle here is completed when the infected fish is eaten by a suitable final host i.e., the bird.

Common diseases encountered in fish culture

Black spot disease : The fingerlings and young ones of mostly *Catla catla* are affected with black ovoid patches on the body surface. These are pigment patches overlying metacercarial cysts of digenetic trematodes; *Diplostomum* sp. The presence of these black spots is the diagnostic feature of the disease.

Cestoda

General morphology and identification of cestoda parasite

Cestodes do not have an alimentary canal or any body cavity. Most of them are equipped with one attachment organ, scolex. The scolex is normally followed by a narrow unsegmented neck passing into the long body. They body is flattened dorso-ventrally. The body is segmented and is called proglottids.

Life cycle and Transmission

The eggs of this parasite is released by the faeces of bird (*Anhinga melanogaster*) in wate rwhere it hatches into a coracidium larva which enters the first intermediate host an invertebrate where it develop into a procercoid. The procercoid enters the second intermediate host, the fish and develops into the plerocercoid larvae .

Common diseases encountered in fish culture

Ligulosis

The pleurocercoid larva of the cestoda *Ligula intestinalis* cause this disease. This larval stage is very often found infecting *Catla catla*. The symptoms are abdominal distension, reduced growth and dark colouration.

Fish diseases caused by crustacean parasites

Crustacean parasites are frequently reported in fishes. Crustacean parasites in most cases do not cause serious problems to fish health except irritation and localised ulceration. But several instances are reported where severe infestation by the crustacean parasites resulted in mortality of fish in different fish culture areas.

The crustaceans which infest fishes in our fish cultute systems fall under the sub classes (1) Entomostracea - having the orders Copepoda and Branchiura and (2) Malacostraca - having the order Isopoda.

Copepoda

General morphology and identification of Copepoda parasites

They are ecto-parasites. In head region they bear six pairs of appendages *viz.*, two pairs of antenna, one pair of mandible, two pairs maxillae, and one pair of maxillipeds. The thoracie region bears six pairs of swimming legs. The abdomen consists of 1-4 segments, the last segment terminates into two flat branches the caudal rami. The shape of the body varies from oblongate to elongated shape in parasitic forms.

Life cycle and Transmission

The development of most parasitic copepodes is direct without change of host. Most of the larval development is completed within the eggs. Thus, when the eggs hatch they either give rise to metanauplius larva or copepodite larva. This process shortens the free living period. They produce 3-4 broods in a year. Females are generally the parasitic ones and attach themselves to the host fish.

Common diseases encountered in fish culture

Lernaeosis

The disease is caused by parasitic females of genus *Lernae*, commonly known as anchor worms. They are relatively large, 5-22 mm and during attachment to the host they assume a vermiform shape with anterior attachment organ buried deep in host tissue.

An infested fish exhibits symptoms of rubbing against the sides or bottom of the pond. Heavy infestation leads to lethargy, emaciation and retardation of growth. The parasite destroys scales and causes haemorrhagic and ulcerated areas at the point of penetration. A large number of fish species *viz., C.catla, L.rohita, O.gouramy, C.idella* and a number of minor carps are susceptible to lernaeosis.

Ergasilosis

The disease is caused by the parasitic females of the genus *Ergasilus, Neoergasilus* sp. They have a cyuclops like body, narrowing posteriorly and has a total length of 1.5-2.5 mm. They predominantly attach to the gills and fins of fish by means of the second antenna which is stout and clawed and feed on the blood and epithelium. Sometimes infestation may be to the tune of 150 number per square cm. Heavy infestation results in respiratory distress, anemia and retarded growth. Prominent symptoms exhibited by heavily infsted fishes are frequent surfacing, listlessness and mortality under oxygen depleted conditions.

Branchiura

General morphology and identification of branchiuran parasite

The most important fish parasite under Branchiura, as far as fish culture is concerned, is *Argulus* sp. The parasites, commonly called fish lice are flattened dorsoventrally. The cephalothorax is broad, the dorsal part has a convex cephalothoracic carapace, whose posterior part is heart shaped. The cephalothorax is sunken at the ventral side, on which there are two faceted eyes, first antenna is transformed into a clasping organ. The mamilla are transformed into enormous suckers. The abdomen is small and its rear end forms two lobes.

Life cycle and Transmission

Argulus matures remaining attached to the host. It is capable of free swimming for sometimes either to lay eggs or in search of new host. The fertilized females leave the host and lay eggs which ar stiking in nature on submerged vegetation, rocks, sticks etc. The nauplius, metanauplius and in some species the first copepodid stages develop within the eggs which hatch as metanauplius or copepodids. The copepodid stages are seven in number, finally forming adult. The period for completion of this life cycle is 3-6 weeks.

Because of the parasite infestation, affected areas develop ulceration. The toxic secretion of the buccal gland of the parasite causes intense inflammatory reaction. Infestation is accompanied by excessive mucus secretion, lethargy, irrigation and retarded growth.

Common fish diseases, their symptoms and control measures

Specific fish disease	Species prone to disease	Symptoms	Control measure
Environmental diseases			
Depletion of oxygen		Mouth remains open. Gills look pale	Aeration of the water areas growth of water hyacinth
Growth of algae		Pond water turn green fishes gape for like respiration	Sprinkhing of cowdung grwoth of water hyacinth
Increase of hydrogen sulphide		Pond muck smells like rotten eggs resulted is respiratory process.	Raking pond bottom and exchange of water.
Excess of CO_2 or high pH of water		Excessive secretion of mucus by gills and body surface	Aeration of the water areas.
Protozoan diseases			
Trichodiniasis	Indian major carps and exotic carp	Pale colour of gills with a coating of cream layer of mucus	3-5% common salt bath 25 ppm formalin treatment in pond.
White gill spot disease	Catla	Gills covered with white spots like pox	3-5% common salt bath Decreasing density of fish from affected pond.

White scale spot disease	Rohu, Mrigal	Scales covered with white spots	3-5% common salt solution bath Decreasing density of fishes in ponds.
Helminth diseases			
Dactylogyrosis and Gyrodactylosis	Catla, Rohu, Mrigal	Excessive secretion of mucus in gills Irritability and surfacing	3-5% common salt solution bath 200 ppm formalin bath
Black spot disese	Catla	Black oval shaped patches on body	Removal of molluscan population from water area
Ligulosis	Catla	Abdomen enlarges abnormally and body becomes dark	Removal of birds from around affected areas
Crustacean diseases			
Lernaeosis	Catla, Rohu, Mrigal	Rubbing against pond dykes or even bottom	Gammaxene @ 1 ppm application in the pond.
Ergasilosis Argulosis	Grass carp	Irritation and emaciation sometimes Parasites visible on gills and body surface	5% common salt bath to the effected fishes. Removal of eggs of Argulus by hanging corrugated sheets in water and removing them and drying after a week to kill eggs.

A few simple methods of fish stock assessment from open waters

S.K.Mandal
CIFRI, Barrackpore.

India has vast and potential open water resource. The marine resource of India is exploited more or less at the optimum level. Further increase in fishing activities in the marine sector may not enhance the catch appreciably. However, there is enough scope of enhancing the fish production from inland open water system, if proper management is adopted.

A fishery resource is a self-renewable living natural resource in a dynamic habitat. In the absence of exploitation the abundance or biomass of the population will tend to increase, since it is a living resource, it will balance itself by adjustment of its inherent biological characteristics like growth, recruitment and mortality. When fishing exploits a resource, it can still recover by growth and new recruitment and retain the original level, but it changes mortality and may alter all the biological characteristics and its behaviour pattern. As fishing activities have intensified during the past few decades, it has become essential to predict catches and particularly the effects on catches due to change in the fishing activity with a view to proposing steps to ensure that increasing fishing intensity (effort) will continue to give sufficiently increasing returns. The fish stock assessment may be described as the search for exploitation level, which in the long run gives the maximum yield in weight from the fishery. For a given fishery resource there is, however, a largest average catch or yield that can be continuously taken from a stock under existing environmental conditions so that the stock remains unaffected. Therefore, ultimate objective of management programme of a given fishery resource is to assess this maximum yield or what is termed as maximum sustainable yield.

OBJECTIVES OF THE FISH STOCK ASSESSMENT

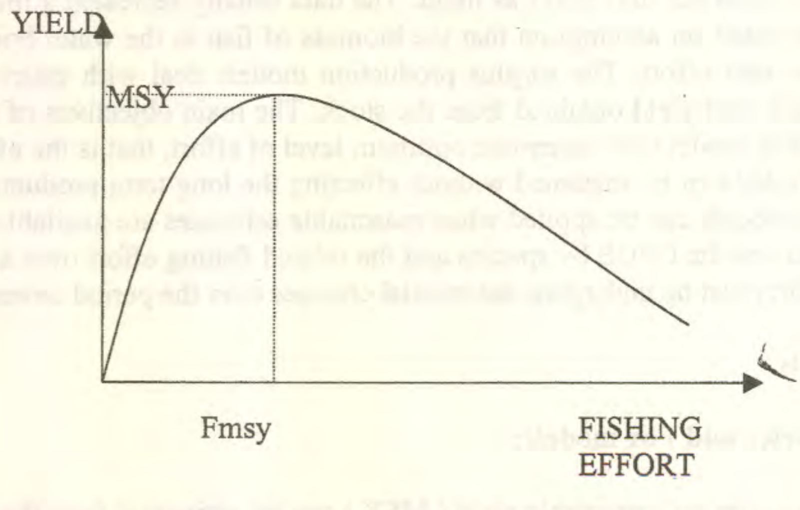

Fig 1 : The basic objective of fish stock assessment

Fig.1 illustrate the basic objectives of fish stock assessment. On the horizontal axis is the fishing effort and on the vertical axis is the yield i.e., the landing in weight. It shows that upto a certain level we gain by increasing the fishing effort, but after that level renewal of resource cannot keep pace with the removal caused by fishing and a further increase in exploitation level leads to a reduction in yield.

The fishing effort level, which in the long run gives the highest yield, is indicated by f_{msy} and the corresponding yield is " MSY ", which stands for maximum sustainable yield. The phrase "in the long term " is used because one may achieve a high yield in one year by sudden increase in fishing effort, but then meagre years will follow, because the resource have been fished down. Normally we are not aiming at such single year with maximum yield, but at a fishing strategy, which gives highest steady yield year after year.

A description of fishery consisting of three basic elements:

1) the input (the fishing effort)
2) the output (the fish landed)
3) the process which link input and output (the biological processes and the fishing operations).

Fish stock assessment aims at those processes, the link between input and output and the tools used for that are called " models ". A model is a simplified description of the links between input data and output data. It consists of a series of instructions on how to perform calculations and it is of what we can observed or measure, such as for example fishing effort and landing.

There are two groups of fish stock models - 'holistic models ' and 'analytical models '. The analytical models are based on a more detailed description of the stock and they are more demanding in terms of quality and quantity of the input data. These models are age structured models, working with concepts such as mortality rates and individual body growth rates etc.

The simple holistic models also called " surplus production models " use fewer population parameters than the analytical models and do not take into account, for example, the length or age structure of the stock. In this model stock is considered as one big unit of biomass. The model uses catch per unit effort as input. The data usually represent a time series of years. The models are based on assumption that the biomass of fish in the water body is proportional to the catch per unit effort. The surplus production models deal with entire stock, the entire fishing effort and total yield obtained from the stock. The main objectives of the application of surplus production model is to determine optimum level of effort, that is the effort that produces maximum yield that can be sustained without effecting the long term productivity of the stock. The production models can be applied when reasonable estimates are available of the total yield (by species) and / or the CPUE by species and the related fishing effort over a number of years. The fishing effort must be undergone substantial changes over the period covered.

Holistic models

The Schaefer and Fox models:

The maximum sustainable yield (MSY) can be estimated from the following input data

f(i) = effort in year i, i = 1,2,.......n
Y/f = yield (catch in weight) per unit effort in year i.

The simplest way of expressing yield per unit of effort, Y/f, as a function of the effort f, in the linear model suggested by Schaefer.

$$Y(i) / f(i) = a + b\, f(i)$$

An alternative model was introduced by Fox. It gives a curved line where Y/f are plotted on effort.

$$\log \{Y(i)/f(i)\} = c + d\, f(i)$$

which can also be written as

$$Y(i)/ f(i) = e^{c + d\, f(i)}$$

Both models conform to the assumption that Y/f declines as effort increases, but they differ in the sense that the Schaefer model implies one effort level for which Y/f equals zero, namely when $f = -a/b$ whereas in the Fox model , Y/f is greater than zero for all values of f.

This can easily be seen in Fig.3 where the plot of Y/f on f gives a straight line in case of the Schaefer model and a curved line , which approaches zero only at very high levels of effort, without ever reaching it in the case of the Fox model.

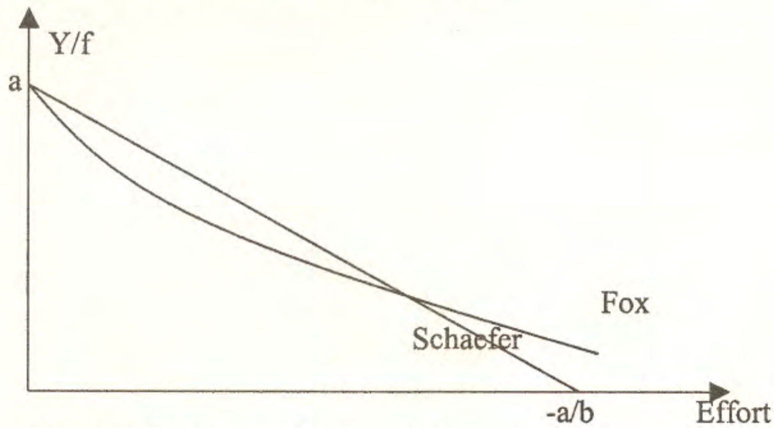

Fig 2: Schaefer and Fox model

The Schaefer's model can be written as

$$Y(i) = a\, f(i) + b\, f^2(i)$$

It has its maximum value of Y(i),the MSY level, at an effort level

$$f_{msy} = - 0.5\, a/b$$

and the corresponding yield

$$MSY = - 0.25\, a^2 / b$$

The Fox model can be written as

$$Y(i) = f(i)\, e^{c + d\, f(i)}$$

$$f_{msy} = - 1/d$$

$$MSY = - (1/d)\, e^{(c - 1)}$$

Year	Yield Y(i)	Effort f(i) X	Schaefer Y(i)/f(i) Y	Fox log{Y(i)/f(i)} Y
1969	50	623	0.080	-2.523
1970	49	628	0.078	-2.551
1971	47.5	520	0.091	-2.393
1972	45	513	0.088	-2.434
1973	51	661	0.077	-2.562
1974	56	919	0.061	-2.798
1975	66	1158	0.057	-2.865
1976	58	1970	0.029	-3.525
1977	52	1317	0.039	-3.232
Mean		923.22	0.0667	-2.7648

$a = 0.1065$ $c = -2.0403$
$b = -0.00004312$ $d = -0.0007848$

MSY Schaefer $-0.25\, a^2 / b = 65.8$

Fox $-(1/d)\, e^{(c-1)} = 60.9$

f_{msy}

Schaefer $-0.5a/b = 1235$

Fox $-1/d = 1274$

Relative Response model of Alagaraja (1984)

This model depends on successive catches to provide the maximum catch that the fishery can sustain. There are three assumptions for success of this model. These are (1) Stocks existing in a particular area are exploited by various types of gear that are not species specific. This implies that the effect of fishing a mixture of stocks by these gears is proportional to the relative abundance of stocks in the mixture. (2)The fishing is increased over a time till the optimum level is achieved . (3) When the effort is increased the catches also increases till a maximum level is reached, but the rate of increase increases first and then decreases and finally reaches to nil. In the progressive fisheries where multispecies are exploited by multigears and when evaluation of effective effort poses problems, particularly in tropical fisheries, this model is useful. The model in its simplified form is

$$C_{t+1} = a + b\, C_t$$

C_t is the catch of the t-th period, a and b are constants.

$C_{max} = a/(1-b)$

In the progressive fishery the level of maximum catch can be predicted and suitable management measures may be suggested.

Example

The following data relate to the catch record from the Hooghly-Matlah estuary for five years. Estimate the catchable potential yield from the data.

Year	Catch (t)
1	30578
2	37981
3	44628
4	48608
5	50713

Solution

C_t x	C_{t+1} y
30578	37981
37981	44628
44628	48608
48608	50713

$$C_{t+1} = 17038.8 + 0.703\, C_t$$
$$C_{max} = 17038.8/(1 - 0.703) = 17038.8/0.297 = 57369.7 \text{ t}$$

References:

Algaraja, K.,1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian J. Fish. 31(2) : 177 - 208.

Gulland, J.A.,1982 . Fish stock assessment, part- 1,U.K., John Wiley & Sons, 223 p.

Sparre, P. and S.C.Venema,1992. Introduction to tropical fish stock assessment, part 1 - Manual. FAO Fisheries Technical Paper, 306/1,Rev.1:376p

Mechanism of post-harvest operations in open water fisheries

Pradeep K. Katiha
Central Inland Capture Fisheries Research Institute,
Barrackpore (W.B.) 743 101

In our country, fishing in open waters dates back to time immemorial. It primarily consists of capture fishery operations, which form major source of livelihood to the fishers, particularly for the fishers residing nearby open waters. The fish harvest from these waters is reported to follow a declining trend. It has adversely affected the fishers' economic status. At places, it even resulted in occupational shift. This decrease in fish production and fishers income may be compensated to certain extent by providing remunerative prices for fish. It can only be possible through an efficient post-harvest mechanism. This mechanism includes all the operations conducted starting from disposal of catch by fishers to the stage catch finally reaches the consumer. Keeping these facts in mind, it is pertinent to discuss the post harvest mechanism of open water fisheries. Forthcoming paragraphs briefly describe Indian inland open waters alongwith the details of post-harvest mechanism of their fisheries and the related concepts.

Inland open waters of India

The rivers, reservoirs, floodplain wetlands and estuaries are the main inland open waters of our country. These resources are described briefly in following paragraphs.

Rivers

Indian rivers are classified into Himalayan and Peninsular rivers. The Himalayan rivers include Ganga, Brahamputra and Indus river systems, while the peninsular covers East and West Coast river systems. These systems comprise of 14 major, 44 medium and innumerable small rivers, desert streams and canals. The length of Indian riverine stretch is over 0.17 million kms with maximum in state of Uttar Pradesh followed by Jammu and Kashmir. All the rivers of Northeastern region are covered under Brahamputra river system.

Reservoir

Large number of river valley projects created a chain of impoundments. These man-made waters have area of 3.15 million ha, with 47% under small (<1000 ha.), 17% under medium (1000-5000 ha.) and 36% under large (> 5000 ha.) reservoirs. Among the states, maximum area is in Madhya Pradesh (0.46 million ha.) followed by Andhra (0.45 million ha.) and Karnataka (0.43 million ha.). The area of reservoirs in North–eastern states is 8074 ha.

Floodplain wetlands

India has extensive network of floodplain wetlands in the form of oxbow lakes, locally known as mauns, chaurs, jheels, pats and beels. These are concentrated in the states of Bihar, West Bengal and Northeastern states of Assam, Arunachal Pradesh, Manipur, Meghalaya and Tripura. The total area under floodplain wetlands is 0.2 million ha, out of which over 60% is in Northeastern states with maximum of 0.1 million ha. in Assam.

Estuaries

The estuaries are the important component of inland capture fishery waters. The open estuaries include Hoogly-Matlah and Mahanadi estuarine systems. In peninsular India, Godavari is the main estuary, with Adyar Mankanam and Mandovi as other estuaries and Chilka, Pulicat and Vembanad as important brackish water lagoons. The estuaries and lagoons are recognised as excellent source of natural fish and prawn seed. The mangroves occupied an area of 0.36 million ha. The Hoogly-Matlah estuarine system has the largest area of 0.23 million ha followed by Chilka lagoon 0.1 million ha.

Post- harvest mechanism of open-waters fisheries

The post-harvest fishery process covers the fishery activities conducted by fishers or other concerned people after completion of fishing operations. It means that once the fish harvest or catch is in the hand of fishers, the functions performed by him or other related persons form the constituents of post-harvest mechanism of fisheries. In India, most of the open waters' catch is consumed in fresh form. A negligible quantity of it is either dried and processed by traditional methods or used for non-edible purposes. Therefore, the post-harvest mechanism becomes a synonym for fish marketing. The marketing or post-harvest mechanism of riverine fisheries includes following operations.

1. Disposal of fish catch by fishers;
2. Transportation of catch to landing centre / wholesale or retail market;
3. Wholesaling;
4. Packaging; and
5. Retailing;

1. Disposal of catch by fisher

The unmanageable and vast magnitude of open waters resulted in diffused fishing operations. After completion of these operations, the next step is disposal of catch. The disposal of catch depends mainly on i) type of water body; ii) nature of fishing property regime in the water body; iii) quantum of catch; and iv) social and financial bindings of fishers.

The analysis of disposal of catch according to type of water body indicates that in case of rivers, most of stretches are in open access for fishing purpose. Individual fisher either disposes catch at river site to local dealer or brings it to in local fish market for sale or auction. The reservoirs are generally managed by some agency, it may be co-operative, contractor, state government or state fisheries federation, etc. Therefore, the fisher has to dispose it to them, who in turn bring the catch to local market or sell it to consumers directly. The floodplain wetlands are generally managed by co-operatives or privately. The catch from these waters is mostly auctioned at local landing centre. The local dealer collects the catch to dispose it to wholesalers or directly to consumers. The common property regime in estuaries provides open access to fishers for fishing and discretionary power for disposal of catch. The fishers hand over fish to local dealer or wholesaler cum commission agent.

Under different fishing rights, the probable options for disposal of catch are:

i) If fishing rights are exclusively with some contractor or co-operative, the fishers have to dispose their catch to these agencies.
ii) If these rights are in common property regime with open access, the fisher has to undertake decision making process for: i) where to dispose; ii) how to dispose; and iii) to whom to dispose the fish catch.

The disposal of catch in the option i) is prefixed, while for ii), it depends on a) quantum of fish catch; b) distance to the fish market; and c) type of fish marketing intermediaries. If quantum of catch is small, fishers prefer to dispose it locally to local dealer or fellow fisher. In case large quantum of catch, depending upon his experiences and prior fixtures, the fishers may dispose it i) locally to consumer / local dealer; ii) at nearby wholesale / retail fish market; and iii) directly to consumer as vendor.

2. Transportation of catch to landing centre / wholesale or retail market

Location and distance of landing centre / wholesale and retail market are the prime factors influencing frequency and quantum of open water catch transported from fishing site to fish market. If the fish market is very near to fishing sites or fishers villages, the frequency of transportation of catch to market will be higher, as comparatively, smaller quantity of catch is also disposed at the market. The agencies bringing catch to market may be individual fisher, contractor, co-operative or local dealer. The fish catch is either packed in gunny or plastic bags or buckets to transport to landing centre or fish market. The mode of transport of catch depends on the distance to market and means of transport available. It may be on foot, by auto rickshaw, bus, etc. In case of contractors or co-operatives the assembly of catch may be at fishing site, resulting in larger quantum of catch. It may be transported by vehicle to desired destination. In case of other option of fishing rights with contractor or co-operatives, the fishers may be asked to bring their catch at specific place, e.g. fish market or landing centre, so, the fishers have to transport it to prefixed place. A study conducted for rivers Ganga and Yamuna revealed that in case of common property regime, fishers generally prefer the nearest landing centre or fish market to dispose the catch, instead of taking it to bigger distant market. Almost similar observations have been made for other rivers.

The individual fishers generally continue to follow traditional custom to transport catch to particular market and market functionary, unless there is any payment or personal problem. In number of cases the fishers have to transport their catch to particular market functionary due to financial bindings.

The transportation costs included to and fro fares, octroi and some miscellaneous expenditure in terms of kind and money, paid by the fishers for smooth transport of their catch.

3. Wholesaling

The next step in post-harvest mechanism of open water fisheries is wholesaling. In most of the wholesale markets, market functionaries act as wholesaler cum commission agent or as wholesaler or commission agent. For majority of them, it is an ancestral occupation. If water body is leased out for fishing, contractors may act as wholesaler cum commission agent or wholesaler. Once the catch reaches wholesale market, it is displayed after segregation according to species, size and weight of fish, and individual fisher to whom it belongs. The wholesaling includes auctioning of the catch for local consumption and packaging for transport to terminal or outstation fish markets.

A. Auctioning of catch

The auctioning process starts, when the catch is ready for display to the buyers e.g. retailers, vendors or bulk consumers. There are two systems of auctioning:

i) Auction by lots without weighing

In this system, whole of the segregated lot of fish is auctioned by bidding either for whole lot or on per unit basis, i.e. per kg. In case of bid for whole lot, the highest bid price will be paid by the bidder, but, for per unit bid price, the lot is to be weighed after bid. The amount payable by bidder is calculated as the product of weight of lot and highest bid price.

ii) Auction by lots after weighing

The process for auction and calculation of payable amount by the highest bidder is same as without weighing. The only difference is that the lot of fish to be auctioned is weighed before beginning of auction process.

The auctioning is generally done in the early morning hours, when retailers, vendors and bulk consumers come to buy fish. After the completion of auctioning process, wholesaler cum commission agent or commission agent deduct their commission from the amount paid by buyer and pass on balance to fishers. The rate of commission varies from place to place. For the studied rivers, it ranged between 6 – 10%. At certain places, a practice of giving a discount to buyers is prevalent. It is in the form of 5-10% reduction in weight of the lot auctioned. This deduction is termed as "katta". It varies according to species, size and weight of fish, but there is no standard method for its deduction.

B. Transport to terminal markets

For local distribution of catch, the functionaries at wholesale market act as commission agent, but for outstation or terminal markets, they perform functions of wholesaler. With immense experience, they can guess probable local and outstation market prices for particular type of catch. Accordingly, they segregate the catch for local auction and transport to outstations. The transportation of catch to outstation markets primarily depends on consumer preferences or prices expected for different fish species at respective places. But, the most potential terminal or outstation market is Calcutta, where fish catch is transported from all over India. Nowadays, the increased consumer preferences for large sized catfishes have diverged the transportation of their catch towards northern India, particularly in the states of Punjab, Haryana and Delhi, while for remaining fishes, it is still directed to West Bengal.

A good information and documentation system is noticed between wholesalers of assembly and outstation fish markets. The business between two is based on trust. Sometimes, outstation market wholesalers finance their primary market counterparts by paying advance money, while on other occasions, it may be vice versa. The primary market wholesalers collect money, much later than dispatch of catch to outstation market.

The real profits in wholesaling are due to fluctuations of prices at outstation markets. The major items of costs of wholesaling are: i) procurement costs; ii) establishment cost; and iii) marketing cost for outstations. The major share of cost of wholesaling goes to procurement costs followed by marketing costs for outstations and establishment cost. There is no set pattern of costs of wholesaling. The variation in different items of cost at different centres is very high, which gives impression that wholesaling of fish catch is not standardised.

4. Packaging

The handling of a highly perishable commodity like fish involved greater risks, particularly in transportation to a distant place, with greater demand supply fish deficit and with comparatively better prices than local markets. It needs proper packaging and transportation facilities. After the decision for transportation of catch to outstation markets, next step is packaging. It should be with minimum loss due to decay of fish during transportation. The fish price varies significantly according to freshness and condition of fish; so, packaging should be given much-needed attention, to minimize these losses and to fetch the best possible price. Most of the open water fish is transported either in bamboo buckets or in wooden boxes covered with gunny bags. The adequate quantity of ice and proper packing materials are the crucial inputs for proper packaging of fish. Further, it is packed after segregation for different categories and sizes of fish, so, as to fetch better prices at outstation markets.

The major components of packaging costs are ice, packing material and labour. The maximum share of this cost is for purchase of ice. The quantity of ice varies according to season and the distance of transportation. For winter, it is less as compared to summer. The quantity of ice is proportional to distance of transportation. On an average, the ratio of ice and fish remains 1:1.

5. Retailing

Retailing of open water catch follows the activity of wholesaling, both at primary or terminal markets. Fishers, retailers, vendors, contractors, and co-operatives perform the retailing of fish. It is the ultimate activity of post-harvest mechanism of open water fisheries, which disposes fish catch to consumer in smaller quantities. Similar to wholesaling, retailing also involves display of riverine fish lots after segregating them according to type of fish and its size. The retailers take comparatively more liberty to display the fish by making lots favouring them to maximize their benefits. Furthermore, they fix the rate in accordance with wholesale price paid by them. Due to highly perishable nature of fish, the retailer has to undergo some loss because of spoilage. In most of the cases quantity of fish sold is less than quantity purchased.

The majors cost items of retailing are purchase of ice, transportation, labour and rent, etc.

Important concepts in post-harvest mechanism of open water fisheries

Various operations of post-harvest mechanism of open water fisheries are described above, but the very purpose of study is defeated without making a mention of some of the important basic concepts, usually utilised to appraise it. Some of these concepts are:

1. Marketing surplus;
2. Market intermediaries;
3. Marketing channels;
4. Marketing costs;
5. Marketing margins;
6. Price spread; and
7. Fish marketing efficiency.

1. Marketing surplus

The term marketing surplus may be defined as total quantity of open water fish catch, harvested by the fishers. Since, fishers keep some portion of catch for their own consumption or for some miscellaneous requirements, so, whole of fish marketing surplus may not actually reach the fish market. It is of two types

i) Marketable surplus

The quantity of catch, fishers willing to dispose in market or available for disposal is termed as marketable surplus. This quantity may be equal to or more than the fish catch actually disposed by the fishers. It may also be equal to or less than actual open water fish production.

ii) Marketed surplus

The fish catch actually reaches the market is termed as marketed surplus. Since, it is not necessary that the quantity available for disposal or fishers willing to dispose would actually reach the market, so, the marketed surplus must be equal to or less than marketable surplus. It is equal to difference between marketable surplus and quantity of open water catch retained by fishers for self-consumption and other miscellaneous purposes.

These concepts are important to estimate the total open water fish production at a centre and actual fish landings at assembly centres and fish markets. These also depict the share of fish harvest utilised for self-consumption and other miscellaneous purposes.

2. Market intermediaries

The term market intermediaries is used for market personnel involved in open water fish marketing or who performs post-harvest or fish marketing operations. These are also called market functionaries. In the process of open water fisheries, the market intermediaries include local dealers, wholesalers, wholesaler cum commission agents, commission agents, contractors, co-operatives, retailers, vendors and the fishers performing the marketing operation (s).

3. Marketing channel

The marketing channel is defined as the path through which open water catch passes, starting from fisher to the ultimate consumers. It includes all the market intermediaries, which handle and pass on the catch. The most prevalent open water fish marketing channels are presented in table 1.

4. **Marketing costs**

The costs of open water fish marketing include all the expenses incurred by the market functionaries and the fishermen for purpose of disposal of fish catch. These are the charges on/for i) handling of catch at fishing area; ii) assembling; iii) grading; iv) packing; v) transport; vi) storage; vii) finance; viii) commission agent; ix) market charges, e.g. octroi, etc.

Table 1 The fish marketing channels in open water fisheries

1	Fisherman → Wholesaler cum commission agent → Retailer → Consumer
2	Fisherman → Retailer → Consumer
3.	Fisherman → Local dealer/ Local dealer cum commission agent →Consumer
4.	Fisherman → Local dealer → Wholesaler cum commission agent → Retailer → Consumer
5.	Fisherman → Local dealer cum retailer → Consumer
6.	Fisherman → Contractor/ Contractor cum wholesaler → Retailer → Consumer
7.	Fisherman → Co-operative society → Contractor / Contractor cum wholesaler → Retailer → Consumer
8.	Fisherman → Co-operative society → Wholesaler cum commission agent → Retailer → Consumer
9.	Fisherman → Co-operative society →Consumer
10.	Fisherman → State Fisheries Department / State Fisheries development Corporation → Contractor→ Wholesaler cum Commission Agent→ Retailer → Consumer
11.	Fisherman → State Fisheries Department / State Fisheries development Corporation → Wholesaler cum Commission Agent→ Retailer → Consumer
12.	Fisherman → State Fisheries Department / State Fisheries development Corporation → Retailer → Consumer
13.	Fisherman → State Fisheries Department / State Fisheries development Corporation → Consumer
14.	Fisherman → Consumer

These costs may be incurred at all the stages of marketing channel starting from fisherman to consumer. To have an overview, these are described at fishermen and market level.

i) At fisherman level, marketing costs are in the form of commission paid to wholesaler cum commission agent / commission agent / local dealer / co-operative / contractor and transportation cost of fish catch to landing centre or fish market.

ii) At market level the expenditure done by different market intermediaries on various market operations like procurement, storage, grading, packing, loading, unloading, transportation, commission paid to wholesaler-cum-commission agent, octroi, market fee, postage, telephone charges, etc. form the costs..

5. Fish marketing margins

The fish marketing margins are the remuneration received by different open water fish market intermediaries towards performing different functions. These may be of following types

i) Gross margins (GM)

The gross margins are the difference between price received and price paid by a market intermediary is calculated as

$$GM = PR - PP$$

Where PR = price received by an intermediary;
PP = price paid by an intermediary;

ii) Net margins (NM)

The net margins are the difference between gross margins and marketing cost. It can be computed as

$$NM = GM - ME$$

Where ME = Market expenditure incurred by an intermediary.

6. Price spread

The price spread indicates the distribution of consumer's rupee among market intermediaries and the fisher. This is very important indicator of operational efficiency of any marketing system. It estimates the percentage share of different intermediaries in consumers' rupee. By comparing their share in consumer rupee or retail price and function performed, operational efficiency of fish marketing system can be assessed. It may be calculated as

$$S = \frac{GM}{RP} X 100$$

Where S = percentage share of an intermediary in retail price
RP = retail price per kg

7. Fish marketing efficiency (E)

The fish marketing efficiency indicates the movement of fish from fisherman to consumer at lowest price, in accordance with the provision of services desired by the consumers. For various markets and marketing channels it may be computed as

$$E = \frac{RP - ME}{RP} X 100$$

Where ME = market expenses incurred by all the market intermediaries and fishers during post-harvest process

ROLE OF EXTENSION IN FISHERIES DEVELOPMENT

Utpal Bhaumik
Central Inland Capture Fisheries Research Institute
Barrackpore-743101: West Bengal

The recent achievement in inland fisheries production triggered off by the new scientific innovations in Inland Fisheries Sector and their use in commercial scale particularly adoption of the modern inland fisheries technologies and strategy, has imparted a new dynamism to Indian fisheries development and has given new hopes and confidence to millions of fish farmers/fishermen. The Inland Fisheries of India has heaved itself out of the rutts of traditional practices based on customs and traditions and is increasingly assimilating the modern and most scientific techniques for stepping up the fish production.

As a result of breakthrough in Inland Fisheries Research and available large number of findings, several programmes in the development of Inland Fisheries have been initiated. The demands made upon transfer of technology for accelerating inland fish production are enormous and most formidable. therefore, the integrated functioning of research, education and extension has been the cardinal principles of Inland Fisheries Development. There are 4 major organisational streams devoted to extension work for inland fisheries department (i) The ICAR Extension System (ii) Extension System of the Ministry of Agriculture/State Fisheries Department. (iii) Extension System of the Ministry of Rural Development/State Development Department (iv) Development work done by Non Government Organisations. Most of the programmes of these systems are for tackling the problems of weaker sections, specially the Small, Marginal and Landless fish farmers/fishermen for improving their economic condition.

Characteristics of new technology

The new fisheries technologies are sophisticated in nature and high input-intensive. These are interdependent on so many inter-relatred practices, each one of which has to be applied rationally, in time and in the manner recommended by the scientists. Failure in any of them may upset the achievement of the desired yield level. A communicator of Inland Fisheries Technology, therefore, has to understand its characteristics in order to select appropriate extension methods and techniques for effective and rapid communication. This needs information transfer strategy for speedy dissemination of information through appropriate extension methods, techniques and media for increasing production with existing resources and for increasing the income of the fish farmers/fishermen and lowering the price of the produce for consumers.

Development potential of inland fisheries

Inland fisheries resources of India are noted as much for their heterogenity in composition as their opulent productive potential. Though it has long been recognised that the fish production form inland waters can play a definite role in mitigating the protein deficiency in the developing countries, but it is not contributing to the nutrition of Indian masses to the extent it should. Reasons for the slack development in this vital sector are manifold. They include lack of prioritisation in allocation of developmental projects and more emphasis given in favour of marine sector during the early years of India's planned development. Inadequate understanding of the ecosystems and their production functions leading to arbitrary, unscientific and even irrational exploitation policies, coupled with some socio-economic constraints added to the tardy progress in inland fisheries development. Aquaculture ventures are highly capital intensive and a good part of the returns in the aquaculture enterprise is siphoned off to the investores whereas the open water fisheries is a labour-intensive activity, having the potential to improve the quality of life of some of the most vulnerable sections of the society.

The present per capita availability of fish in the country is 3.2 kg against a world average of 12.1 kg and Japan's 86 kg. Considering the diverse inland fisheries resources of the country in the form of rivers, floodplains reservoirs, estuaries and lakes, the national target of 11 kg per capita is well within the realm of possibility.

The enormity and diversity of these systems demand separate, sector-wise approach in their development as they portray different pictures of environmental parameters and production dynamics. Many such ecosystems like floodplain lakes, reservoirs and estuarine impoundments are grossly underutilised, as their present yield rates are much below their actual potential. Research and pilot-scale studies conducted during the last few decades have unravelled may ecological principles operating in these systems and identified distinct characteristics, specific to a particular class of water body. Common property nature of the resources and the environmental implications make the management of open waters a complex and challenging job.

Despite the constraints mentioned above, fisheries based on the natural populations of the open waters contribute subtantially to the inland fish production in India.

Human Resource Development in the growth of inland fisheries

The human resource development in inland fisheries sector through extension education needs an individualistic approach rather than a purely technological approach. Extension education is a science dealing with the transfer of technology and behavioural changes involved in the process of technological transfer and adoption. The technology development and transfer system depend on the behavioural pattern of the clients. This involves the clients, their interests, attitudes, motivations, aspirations norms, traditions, value systems, customs and resources. Extension education based on a two-way flow system of communication, would help to work out and convey these basic facts and factors to scientists concerned and thereby, aid in the development of appropriate technology. Meaningful utilization of technology by the client system in turn would lead to the desired level of human resource development. Evolving a technology alone won't lead to its utilization. It requires the awareness and the need for a change from the existing pattern on the part of the client system. In other words adoption occurs only when there exists an imbalance between a person's needs and his actual situation. The role of an extension specialist here is in creating the awareness of the existing system if it is below the mark and help people to achieve the level of sel-actualization through adoption of improved technologies. According to the study on inland fishermen only 21% of them had education upto primary standard, 7% secondary and 2% continued studies above secondary level. Various studies have shown that fishermen are mostly low in literacy and usually belong to the poorer section of the society. Fishermen of India who form the back-bone of the fishing industry, are characterised by low socio-economic status resulting from poverty, remotness of dwelling places, lack of credit and low producrtivity of traditional fishing implements. This backwardness of fishermen often impedes their access to innovations and participation in welfeare programmes. Building up opinion leadership which will help in two-step-flow of communication may be the best approach in this context. Conducting non-formal education programmes and adult education campaigns will be helpful in building up leadership.

It is the fact that there are two major objectives of a fisheries extension service. The first and major goal is the welfare of people in fishing communities. the second goal is the conservation and efficient exploitation of the fishery. The first goal refers to socio-personal development while the second means technological development. The fulfilment of the first goal is a pre-requisite for the second.

Human resource development through transfer of technical ideas and skills comprising improved management measure, fish conservation, better infrastructure for marketing system, credit facilities and above all dissemination and efficient utilization of information at the grass-root level. The major fishery activities are discussed below for facilitating better understanding of the type and extent of extension needs.

a) Development

For maximum exploitation of the resources, fishermen should be equipped with modern crafts and gears for fishery operations. In agreement with findings on agricultural innovation, it is found in fisheries sector too that higher investments and higher returns are associated with higher adoption in capture innovations. It is observed that qualitative variables were found having better contribution that quantitative variable, regarding variance in adotion. Hence, in order to achieving the technologtical development in this area, the social variable should be paid proper attention. Fishermen being low in the socio-economic ladder and being mostly localite persons, need reinforcement of the information as the adoption period is usually very long. Hence, this area invites special attention of extension personnel who can convince at least the local leaders on a few innovations, the relative advantage and other benefits of the innovations in fisheries.

b) Fish handling and processing

Fish being easily perishable, has to be carefully handled once captured, until it reaches the consumer. Progress has been made in the development of post-harvest technologies involving efficient handling, preservation and product development. However, there are many constraints at the implementation level. It is not the lack of needed infrastructure like ice plant, cold storage and processing factories alone but also the lack of extension work for creating better understanding and climate which contribute to the constraints.

c) Marketing

Another impediment to the development of fisheries is the high fluctuations in the demand and supply of fish. Timely information service regarding demands for various types of fishes, wholesale and retail prices, storing and transport facilities can help to maintain a regulated market. To get rid of the exploitation by middlemen, Co-operative sector should step in a big way to purchase fish at the landing centre itself. The fishermen are lured by the immediate gains if he sells fish to the middlemen. So, proper extension work may educate the fishermen about the advantages of selling of the fishes to the Co-operatives for sustained income and short & long term benefits.

d) Credit and finance

In fishery industry especially in the small scale fisheries, middlemen and local money-lenders play a very vital role in financing the fishermen. The transaction is based on mutual trust but the rate of interest is usually very high. Fishermen borrow money during the lean season and pays back whenever he gets good catch. This often leads him into a vicious trap of borrowing and paying back. Hence, extension personnel has an important role here to educate the fishermen on the credit facilities available to him through approved financial agencies and the procedures to be followed in such transactions which may often look complicated to them. They may be also educated about various developmental programmes/schemes like IRDP through which they can availe subsidies and benefits for purchase of crafts and gears. Developmental communications would help to make the fishermen aware of the financial benefits available to him and to project his needs to the concerned authorities.

Status of extension in fisheries sector

When the community development programme was launched in 1957, the organizational set up for extension did not include an extension officer for fisheries and extension officer for agriculture or animal husbandry was considered to be responsible for giving advice to fishermen and fish farmers.

It was the Balvant Rai Mehta Commission of 1957 that focused attention on the need for separate extension officers for fisheries and training village level workers in fisheries also. Considering the need a number of fisheries extension units were established by Govt. of India to train village level workers and field staff of the departments of fisheries, but these establishments were prematurely closed down. Fisheries extension continues to be one of the weakest links in fisheries development in the country and the existing service is inadequate resulting from lack of trained man-power, confusion among different agencies involved in development regarding responsibilities and lack of clear understanding of the concept of fisheries extension among the fishery experts.

In compared to agriculture and animal husbandry, the challanges of fisheries sector are much more complex. The application of a fertilizer or sowing operation of a particular seed or animal husbandry practices like feeding, breeding and management of cattle can be convincingly shown to the farmers through lecture-cum-demonstration methods, field days and exhibitions. these types of exposures are quite difficult in fisheries sector. The impediments are the uncertainty of catch, site of work mostly in deep and vast water bodies beset with nature's fury and the socio-economic backwardness of the clients. Fishermen are one of the most impoverished groups perhaps this is because of out-moded practices and old techniques. Fishermen require better organisation, better management and better technology.

Dissemination of the available information on various fishery resources, their exploitation and utilisation should be given priority. All the developmental programmes should have a built-in-extension component for better utilization of the human resource. Extension programmes not only adds to the promotion of the current developmental programmes but also provides a wealth of feed-back data essential for planning methods/procedures for further improvement in the technology and its implementation. Proper extension education and linkages may accelerate growth of inalnd fishery in the country.

Communication planning for the development of fisheries

The prime objectives of the inland fishery developmental programmes can not be achieved unless communication is taken as an important component and ingredient towards development. The constructive application of communication for inland fishery development calls for proper planning that takes equal note of the national priorities & needs, preference of individual and social priorities. An essential ingredient of such communication planning is an understanding of the specific assets and limitation of different media. It may be appropriate to have an idea of the impact of each of these on the society. The different types of communication modes are given below.

1) Extension personnel through personal contacts can establish rapport with the receiver and will communicate well tested messages to improve their skills, attitude and knowledge.
2) The case studies may come from all the areas of extension activities on fishery. The case studies may be on achievements/activities of individual worker and experience of fishermen. The information can be compiled to give upto-date data.
3) Information on fish conservation measures could be widely circulated in the form of circular letter, handout, leaflet, pamphlet, mimeograph etc.
4) Joint field visits of researcher and extension worker will enable them to understand about success of the fish conservation programme and to identify the constraints.
5) Instead of the individual approach in communication, the group approach should be emphasised to get the desired results in the field.

6. Use of audio-visual aids for mass awareness of the target group

Audio-visual aids play important role in effective communication of information on management of open water fisheries. The extension functionaries working in open water fishery developmental programmes must be equipped with audio-visual equipments. Radio and Television have a great potential as a medium of mass communication. The authorities concerned with Radio and TV may be co-opted to ensure that they plan their programme to broadcast/telecast information in the subject regularly for mass awareness of the target group to strengthen efforts towards growth of inland fishery.

Extension education towards development of inland fishery

Extension is a system which is used as an instrument to bring about a desirable change, be it sociological or technological,. It is a multidimensional system with interrelationship, linkage and transactions between and among internal and external domains. It aims at causing planned change or progress in the target field as per the greater sociological and economic changes designed by the political will of the people. In view of its crucial role, fishery activities as well as the fish conservation programme planning for fisheries development also has to include the extension component as an intergral part.

The role of fisheries extension is much beyond mere dissemination of information. Extension has a central role to play in the process of transfer of ideas in relation its components like research, clients and support. This role becomes even more important when it comes to the question of influencing the adoption behaviour of resource poor fishermen who constitute a sizeable number in the country. Right from generation of developmental programmes, the extension system has to provide feed back to the research system about the characteristics of the target group, their needs, interest, enterprise and above all their resource constraints. Taking from such information, the research system should be engaged in the development of management policy *vis-a-vis* conservation plan in close associattion with the extension system as well as client's system. The fishery development programme, thus generated will be *tailor made* to the conditions of the clientele. The extension system has to translate fishery developmental measures into the form of messages understandable to the target group and organise a strategy, so that they are disseminated through the utilization of apporpriate media. As the target groups operate under resource constraints and become victim of underemployment while adopting conservation measures, the various suppport provisions are to be made available to them so that they can actually adopt the practices. In doing so, another very vital requirement on the part of extension system is to organise the members around functional group so that the bargaining power of the members is increased and common property resources can be pooled and utilized in more efficient manner. The final outcome of this process should be adoption of practices by the members of the target groups. The success of extension system on inland fishery development not only depends upon its capability in safeguarding fishery resources through adoption of conservation measures but also its ability to provide relevant technological base to various categories of fishing population operating under divergent resource endowments and aqua-ecological characteristics.