POSSIBLE EFFECTS OF ALTERED WATER REGIME ON FISH AND FISHERIES IN TARBELA LAKE (PAKISTAN)

by

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Abstract

In Pakistan there are a number of man-made lakes created for the multi-purpose development of the Indus River basin system and other streams. These meet the growing demand for water, both for extensive irrigation and for power. These include Mangla Lake on the Jhelum River, Warsak Lake on the River Kabul, Rawal Lake on Kurang Stream and the very recently created Tarbela Lake on the River Indus as well as many small reservoirs.

The prolonged and massive storage of water in river impoundments leads to significant changes that may affect their fisheries and living resources.

Such physico-biological and topographical characteristics have been studied by the author in the 100 mi^2 Tarbela Lake during pre-impoundment fishery surveys in 1974.

The main features resulting from the altered water regime in large man-made lakes and their possible effects on fish and fisheries are reviewed and discussed in this paper with special reference to Tarbela Lake. It is now widely recognized that fisheries development and exploitation in a large artificial lake has essentially to be based on the understanding of its physiographic, hydrological and morpho-ecological features.

CONTENTS

1. INTRODUCTION

The Indus River flows from Tibet to the Arabian Sea for nearly 1 800 mi, draining an area of about 37 000 mi². Its annual flow at Tarbela, where the world's largest earth and rock-fill dam was closed in 1975, is 65 million acre ft. The river basin above Tarbela is about 700 mi long, with an average watershed width of about 94 mi, thus making a total catchment area of about 65 500 mi². Out of this only 4 000 mi² in the lower catchment area is subjected to rainfall of 30 - 50 in. and has some vegetation cover. The rest of the catchment area is dry and receives 3 - 5 in. rainfall annually. The upper catchment includes glaciers and ice fields and is devoid of vegetation cover. The Tarbela Reservoir is about 100 mi² in area. Important tributaries flowing directly into the reservoir are Dor, Siran, Onar and Barandu Streams.

The climate of the catchment area is characterized by two seasons, summer from April to September, and winter from October to March. Maximum and minimum recorded water temperatures in May and December 1974 were 26°C (Siran River at Thapla) and 7°C (Indus River at Ghazi), respectively. Tarbela Dam is situated in the North West Frontier Province and covers parts of the districts of Hazara, Mardan and Swat. It is 65 mi northwest of Islamabad.

2. CHANGES AND THEIR POSSIBLE EFFECTS

Massive storage or river water in a man-made lake leads to significant changes that affect the fishery in a number of ways.

2.1 Extension of aquatic habitat

One of the immediate effects of damming a river or stream is an increase in submerged area. Some of the newly submerged ground is covered with vegetation which improves the production of organic food and plankton and provides protected spawning grounds for fish in the shallow marginal areas.

In some instances, an increase in area and volume of water fails to effect a corresponding increase in fish production as either the endemic species were not adapted to the new environment, or the newly submerged zones did not produce suitable food organisms for the endemic fish species. With a properly planned programme of stocking with suitable species of fish and rational fishery management, fish production in the reservoir may increase many times as compared to that of the original.

2.2 Population isolation and increase of lentic water species

The original species of the impounded waters face conditions of depth, temperature, oxygen content, substratum, etc., which differ greatly from those that existed in the river. Further invasion of species from downstream is completely blocked by the barrier caused by the dam. For large dams like Tarbela and Mangla (Pakistan), where conditions are comparatively static, a specific type of fish population, consisting largely of standing water (lentic) species becomes established. If there are no endemic species which can adapt to deep and standing water, appropriate species need be introduced to utilize fully the potential of the new environment. Species which normally spawn in still water have the best chances of propagation in an impoundment and their progressive increase is a factor in the ultimate reduction of typically riverine species. The increase of populations of species that make direct use of the available phyto- and zooplankton organisms and insects is generally greater than the increase of piscivorous or highly specialized feeders.

2.3 Breeding grounds

A common feature of deep, man-made reservoirs is that spawning areas for certain important food fishes are drowned. These may be riffles of streams, or quiet backwater areas of specific depth, bottom and cover, that took a long time to evolve. The loss of such areas may be very damaging to certain species.

2.4 Nutrients contents

The quality and quantity of dissolved salts and suspended matter borne by a stream or river depends on the structure and composition of the soil and the intesnity of land use in the catchment area. The Indus River and its tributaries above the Tarbela Dam do not have much flooded fertile lands with the result that primary production is generally poor.

During the early years of a reservoir's life soluble minerals and organic compounds are leached from flooded and submerged soils and the decaying vegetation. When river water is stored in a reservoir, the suspended matter settles. There is a slight tendency for dissolved substances to concentrate through evaporation and biotic activity and as a result concentrations of nitrates, phosphates, other inorganic salts and organic substances may be higher than in the tributary rivers and streams. However, the principal effect is to reduce the seasonal fluctuations in water quality which are so marked in the river systems.

With gradual stabilization of lacustrine conditions, the primary productivity of the water increases and added nutrients promote the growth of benthic and planktonic organisms which are of vital importance, forming, as they do, the staple diet for omnivorous and plankton feeding fishes.

It was found by the author, during 1974, that the productivity of bottom fauna was high in the tributaries and poor to average in the Indus River. Low productivity of bottom fauna was most probably due to fast flowing conditions and physical effects of turbidity.

2.5 Siltation

The Indus is one of the most silt-laden rivers. The reservoir traps the sediment load not only from the 11.1 million acre feet (MAF) of water which is the maximum storage capacity of the reservoir but also from the surplus of over 50 million acre feet of water passing through the reservoir. It is estimated that the reservoir will be silted up in about 60 years.

The suspended sediment load at Darband consists of clay, silt and sand. The clay portion with particles smaller than 0.002 mm is very nominal. The silt portion with particles up to 0.06 mm is about 40 percent and the remainder is sand with particles up to 1 mm.

Siltation has both beneficial and damaging effects on the fishery resources of the reservoir.

2.5.1 Advantages

The Indus River and its tributaries which have predominantly stony and gravelly beds interspersed with rocks, do not provide suitable breeding grounds for the transplanted indigenous major carps. These normally breed during the monsoon months in the shallow standing backwaters of rivers and streams where there are muddy bottoms and abundant vegetation. Silting up of the bed of the reservoir during the years to come will fill up the unevenness of the bottom and hence provide new spawning grounds.

Siltation will lead to reduction in the reservoir depth and more shallow areas suitable for fish breeding will become available.

Siltation will also augment the supply of nutrient salts and organic matter.

2.5.2 Disadvantages

Mahseer (*Tor putitora*), which is the dominant species of resident fishes in the Tarbela Reservoir, prefers to breed in rocky or gravelly areas. Its spawning grounds will be smothered and covered up by deposits of silt, making them unsuitable for breeding.

As benthic food organisms will be choked up by silt there is a potential threat to aquatic production.

2.6 Sub-stratum

In rivers impounded by dam construction the submerged bottom is sometimes covered with scattered boulders, shrubs and trees. Where the inundation covers inhabited areas, entire buildings may be left submerged as in the Mangla Reservoir, where during years of unusual drought, the remnants of the old Mirpur town emerge as the level in the lake goes down. Such remains can cause considerable problems with navigation and fishing.

2.7 Level fluctuations

Although the primary object of impoundment is to hold water by arresting the flow of the river, this water is subsequently passed through the turbines for the generation of electricity and also through the spillway and irrigation tunnels for agriculture. Evaporation at the surface is another important loss of water, especially in dry hot weather.

Some dams are only just filled by the inflow, while others have an inflow which is several times the capacity of the impoundment. This is the case with Tarbela Reservoir, where abstractions are concurrent with inflow. The reservoir will be subjected to level fluctuations either due to sudden natural inflow during the filling period (May to September) or manipulated discharge for irrigation during the drawdown period (October to April). Total normal drawdown of water will be 250 ft per year, reducing the water level from 1 550 SPD to 1 300 SPD.

2.8 Obstruction to fish migration

A river provides a route by which spawners reach their breeding grounds and other fishes move to their preferred feeding grounds. A dam prevents upstream migration, though fish might migrate downstream over the spillways and through the irrigation tunnels. Migrations of fish are primarily reflections of their physiological state and are initiated by suitable hydrological and climatological conditions. The conditions may be altered by the changed hydrological regime produced by the dam. Dams thus affect fisheries, particularly for migratory fish by impairing their efficient spawning and by the damage inflicted on fish during their passage through spillways, valves and turbines or in the turbulent water below the dam.

The provision of conventional fish ladders or fish-passes in the construction of dams could not entirely meet the fishery requirements in a multi-purpose project. In fact, several such devices built in barrages in the past have failed in their objective. Fish passes are very expensive and there will be need for them only where interruption of migration of fish will very seriously affect the fishery.

In the Indus River and its tributaries above the Tarbela Dam, Mahseer (*Tor putitora*) is the only migratory fish of economic importance. The fish is a popular game fish and reaches a considerable weight (the heaviest Mahseer caught on rod and line was recorded to weigh 119 lb.). It lives in the semi-mountain rivers and hill streams which are clear, rocky or gravelly. It migrates downstream to the plains as far down as Multan (Punjab) during the winter and travels upstream to Besham Qila and above (North West Frontier Province) as soon as the water in the plains starts to warm up and become turbid. Due to the construction of Tarbela Dam, Mahseer coming downstream at Tarbela over spillways or through the irrigation tunnels (particularly the left bank tunnel and the high level Candaf Tunnel) will not be able to return upstream for breeding purposes though it will congregate just below the dam in an attempt to find its way upstream. Its protection in the tail race area is, therefore, an important conservation measure.

There are, however, two redeeming features which may rescue Mahseer from extinction.

Firstly, there will always be water in the area below the dam between the tail race and the main river. Mahseer and other fish will therefore have free access to all parts of the Indus, downstream of Tarbela Dam, and would be able to find new breeding grounds in the shallow, gravelly areas between Tarbela and Attock. Secondly, there are the spawning grounds of Mahseer in the downstream tributaries of the Indus, namely the Kabul, Haro and Soan Rivers. Mahseer travelling down the reservoir through the outlets will have access to these tributaries and can breed in their upper reaches. The Mahseer fishery in the River Indus will probably not be much affected. Other major fishes undertake limited local migrations and will be stocked in the reservoir. Most migratory fish lost to the reservoir will be caught somewhere downstream.

2.9 Modification of fishing methods

With the alterations in the physical conditions of depth, bottom type, transparency and current and changes in the populations of fish and other aquatic biota in the Tarbela Reservoir, the traditional fishing methods would need to change. The bed of impoundment is mostly irregular and strewn with boulders, tree

trunks and other submerged objects. Fishing by active gear especially seine and trawl nets, will be very difficult since they catch in the obstacles. Suitably modified fishing techniques including the use of gillnets, trammel nets, longlining and other surface and mid-water fishing gear will be needed.

Changes in water level exert different effects on the various species of aquatic organisms and thereby on the species composition and the entire productivity of the reservoir. Such effects are co-related with many factors, such as the seasonality, frequency, intensity and duration of the water level fluctuation. The main adverse effects of level fluctuations on fisheries that have been observed by the writer in other reservoirs are :

(i) Decrease in bottom and bank food organisms

(ii) Reduction of rooted aquatic vegetation which harbour fish organisms

(iii) Impaired spawning due to exposure or deep submergence of the spawning grounds

(iv) Obstruction to migration up tributary streams due to exposure of natural barriers at low water

(v) Stranding of fish in pools and ditches that become separated from the main water body. These die due to drying up of the pools if they are not salvaged and transferred to safe waters.

The influence of level changes on the biota and the fishery is not always adverse. Enhancement of spawning and feeding facilities on flooded margins which are submerged for a reasonable duration is often a decided advantage for some species.

Unfavourable effects of drawdown may, in theory, be counteracted to some extent by means of special water level regulation schedules which may also take into account fishery management requirements. In practice, however, such schedules rarely prove feasible due to the demands of other users of impounded water.

2.10 Possibilities for culture

As water is confined in an impoundment, it becomes available for fish culture operations. Fish culture experiments in reservoirs in many countries, including the U.S.A., the U.S.S.R., India and Southern Rhodesia have yielded significant results.

The composition of the natural fishstocks in reservoirs is dependent upon the species distribution in the catchment area and the interspecific balance established within the reservoir. The composition may be modified by species transplanted into the reservoir so as to obtain the optimum combination and maximum fish production.

During pre-impoundment fishery surveys in 1974, 34 species were collected by the author from the River Indus and its tributaries in the area concerned. Of these, only six are of some economic value, and only four were observed in the areas above the dam site, including one species of Mahseer (*Tor putitora* Hamiltor) and three species of snow trout or swati (sub-family Schizothoracinae). As none of the species of snow trout is is suitable for culture due to their slow rate of growth and the unpopularity of their flesh, they have very little fishery value. The other 28 species are small, hardly exceeding 6 in. in length and cannot be considered even as a medium item of fishery, as there is very little demand for small-sized fish in Pakistan. Small species of fishes are, however, not to be neglected on biological grounds as they are an important link between the plankton and large predatory fish and serve as forage fish for Mahseer and other piscivorous species. There is therefore, only one species which is a popular game fish and has good market value. The presence of natural nurseries of Mahseer in Dor and Siran Rivers near Thapla Village (Hazara district) and Barandu River near Daggar (Swat district) indicated the existence of good spawning grounds but these have now been submerged deep in the reservoir and cannot be used by Mahseer any longer for breeding purposes. There will thus be a need for intensive stocking with high quality species capable of thriving in the new lake. Introduction of indigenous species of major carp, namely Mori or Morakhi (*Cirrhina mrigala*), Theila (*Catla catla*) and Rohu (*Labeo rohita*) as well as the exotic common carp (*Cyprinus carpio*) are very likely to create a major fishery in the reservoir and may begin to show good results in due course.