Gillnet fishing in Reservoirs: Problems and Solutions

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Reservoir fisheries in India

Reservoirs in India are prime resources for capture fisheries and extensive aquaculture. Although the main purposes of reservoirs are irrigation and hydro electricity, fisheries also forms an integral part as a natural resource. Reservoirs extending over an area of 3.15 million ha having average productivity of 20 kg/ha contribute considerably to the inland fish production in India (Sugunan, 1995 & 2011). Exploitation of fisheries in these areas was insignificant in the earlier years where fishing was being conducted purely on a subsistence level. The last few decades have witnessed many technological advances in fishing systems in reservoirs.

Indian reservoirs being tropical, have high primary productivity and also have the capacity to yield more fish production. Reservoirs in India mainly harbour rich variety of fishes in which the Indian Major Carps (IMCs) occupy a prominent place among commercially important species. They also harbour other carps, catfishes and miscellaneous species. Stocking is the mainstay of fish production in reservoirs and generally, the IMCs comprising fish species such as *Catla catla* , *Labeo rohita* and *Cirrhinus mrigala* form the core species for stocking across the country. Exploitation methods have great influence on the development of fishing and to harvest the multispecies fishery, different fishing gears and techniques are to be employed to realise optimum harvest.

Fishing methods in reservoirs

Fish capturing methods are varied in different inland water bodies depending on topography, ecology and habitat of the fishery resources. The indigenous or native gear operated in the riverine conditions are not suitable in the lacustrine condition of reservoirs which are rich in fishery resources and the fishery managers are facing problems due to lack of suitable fishing techniques. The presence of underwater obstacles such as stones, tree trunks, submerged plants and trenches restrict the use of active fishing gears like trawls in the reservoirs and fishers mostly depend on passive gears like gillnets. Due to its lower capital investment, simple design, construction and operation, gillnetting is widely practised in the reservoir which is recognised as an energy efficient, selective and profitable gear. Although other fishing gears such as seine nets, cast nets, scoop nets, hand lines and traps are also operated, their contribution is insignificant.

Gillnet fishing in reservoirs

Fishing gears in common use in reservoirs are gillnets and typical gillnets design have a head rope with floats and with or without footrope and sinkers. Gillnets are usually operated in the night, setting usually done before sunset and hauling by morning. However, operation during daytime is common during the migratory period of the fish and flood months. In majority of reservoirs gillnets made of Polyamide (PA) monofilaments are used (0.16mm to 0.4mm diameter) while PA multifilaments are also in use (210x1x2 to 210x6x3). Mesh size ranges from 20 mm to 310 mm. Floats are either of thermocol or expanded polystyrene and plastic. Nowadays

empty plastic bottles are mostly used as floats in gillnets operated in reservoirs. Lead is the most common sinker material used in gillnets where the size, shape and weight vary according to the type of net and mode of operation. Clay, concrete or pieces of stones are also used as sinkers. Gillnets are generally rigged at a hanging coefficient of 0.5. Nets range in size from 10 m to 1000 m and 1 to 15 m depth.

Based on operation, two types of gillnets are used in reservoirs, set gillnets and drift gillnets. Most prominently, set gillnets are used which are set either in the surface or column layers and anchored to the bottom by means of heavy weights like stone anchors or are tied to poles or sticks fixed to the ground (Fig 1 & 2). All kinds of fishes and prawns are caught in these nets. In drift gillnets used in reservoirs, the one end of the net is tied to the buoy while the other end flows freely and drifting is mainly due to wind action (Fig. 3).

Problems and issues in gillnet fishing

Although gillnet is known to be effective and highly selective for capturing fishes in reservoirs, some issues are also associated with gillnet fishing which are described below.
Improper design parameters and associated bycatches.

Incorrect mesh size, diameter of yarn/twine, incorrect hanging of the webbing to the float line, omission of lead line and breast lines, incorrect rigging with floats and sinkers and improper height may result in catching of bycatches. Bycatch which is the incidental capture of non-targeted organisms in commercial fisheries, is a growing concern and an important conservation issue causing mortality and injuries to the non-target species affecting the ecosystem and survival of population. Bycatch issues have increased exponentially in recent decades and studies have focused primarily on marine systems while bycatch issues in freshwater bodies are relatively less studied (Raby, 2011). Loosely hung nets lead to capture by entangling resulting catch of non-target species and juveniles.

Lack of fishing control measures

In reservoirs, due to the absence of mesh regulation as well as landing size limitation for fishes, fishers use meshsizes smaller than the optimum for a particular target species leading to capture of juveniles. Due to the gillnet selectivity effect, a specific mesh size is often most effective for a narrow size range of fish. But fishers often use multimesh gillnets which cause capture of different size groups of particular species. In addition, the fishing effort in relation to the fishing area of the reservoir might have been excessive and adversely affecting the fishery.

Ghost fishing

In most of the reservoirs in the country, gillnets are made of PA monofilament yarn of very thin diameter of 0.16mm to 0.2mm which lasts for hardly 3 to 6 months due to breakage, tear and weathering effects. Usually these fine gillnets are thrown by fishers after a season's use since they do not repair the net once damaged. This can be harmful to the ecosystem as once these nets ends up in reservoir, may lead to ghost fishing related problems. These nets will continue to catch fish and other aquatic organisms for indefinite period of time. Information on ghost nets in the oceans are relatively well known, but such nets may be present in reservoirs also, especially those which were flooded before being cleared of trees and undergrowth. There is limited information on the quantity of lost nets and their impacts in reservoirs. In 1990's over 5 tonnes of ghost fishing nets were retrieved under "ghost net eradication programme" launched in

Laos for the management of NamNgum reservoir (Matics, 1997) with the co operation of local fishers.

Post harvest losses

Set gillnets which are often left in reservoirs for hours extending 12 to 24 hours lead to spoilage of fish caught in the initial hours of setting. These losses occur due to inordinate delay in taking out the catches from gill nets. The extent of loss from 6.52 to 8.89% where reported in Hirakud reservoir area (Jeeva et al., 2006). In addition, the inflow of muddy water during post-monsoon season was also a factor causing mortality of fish caught in the gears.

Improper stocking and monitoring

The availability of commercially important high value species is less in reservoirs due to improper and inadequate stocking. Use of small meshed gillnets in reservoirs during the stocking period adversely affects the production.

Solutions to gillnet fishing problems

Most reservoirs have tree stumps in the bottom which create difficulty for fishers to use gillnets in those areas where nets get entangled. In such reservoirs, gillnets without footrope and sinkers can be operated to reduce the extent of this problem. Improvemnts /design modifications as well as optimum mesh parameters of gillnets suitable for Indian reservoirs have been discussed by Sulochenan *et al* (1968), Nair *et al* (1969), Kuriyan (1973), George *et al* (1973), Natarajan (1979), Kartha & Rao (1991), Pravin *et al* (2014), Sundaramoorthy (2013) and others. The efficiency of gillnets is influenced by factors such as mesh size, colour, fishing height, hanging ratio, yarn/twine diameter and gear material. In order to tackle many of the problems associated with reservoir gillnet fishing, solutions recommended are given below.

Gear material

Introduction of synthetic fibres like PA/ nylon in place of natural fibres improved the catching efficiency of gillnets in reservoirs. There is a gradual shift in the usage from PA multifilament to PA monofilament which have shown more improvement in catches due to their softness and very low visibility in water. High density polyethylene (HDPE) monofilament yarn, twine and fibrillated tape are later additions as new cheap and effective substitute to nylon multifilament. Recent studies also showed that Polyproplyene is also more efficient having equal fishing power and cost effective compared to other materials.

Design modifications & upgradations

Simple gillnets, mainly entangling type, the typical amongst them being *Rangoon* nets was the basic design adopted for fishing operation at the surface and column layers in almost all reservoirs in the country with local modifications based on fishery. The gear was introduced in Mettur reservoir and having a head rope with floats wheras footrope was absent to increase the entangling capacity. The first attempt to increase the efficiency of lacustrine gillnets were by modifying the gillnets having headrope and footrope and with floats and sinkers respectively at regular intervals.

Studies have shown that for relatively larger fishes, the mechanism of capture is more by entangling than gilling and to increase the entangling capacity, the webbing should have more slackness. There were many modifications made in simple gillnets to improve the slackness through vertical lines or framing. In vertical line nets, slackness is improved by providing vertical lines in the net from headrope to footrope. In framed nets, slackness is increased by passing vertical and horizontal lines between the mainlines dividing the main webbing into compartments (Fig 4). Framed nets are generally more efficient than 'simple gill nets because apart from having greater horizontal and vertical slackness, their design creates small net bags in which fish become tangled as well as gilled. Both framed nets and vertical line nets are found to be more effective especially in reservoirs where the fish population is less and consisting of larger species (George, 2002). However, simple gillnets are reported to be more effective in reservoirs where small size group of fishes are in abundance. Trammel nets, the three layered nets, with an inner loosely hung wall of small mesh and two outside armourings of large mesh wall on either side of the small mesh wall were also introduced and output was greater than simple gillnets, but was comparatively less efficient than framed nets.

Optimum mesh size

Gillnets are known to be size selective where one mesh size only is most selective for a small size interval of fish and therefore not catching smaller or larger fish at the same rate. Knowledge of size-selectivity is, therefore, important in fisheries management to understand developments of the fish stocks. It helps to make the right choice of mesh size to suit the available fish population. With the right choice of mesh size nets can allow fish to attain sexual maturity and reproduce at least once before capture. Thus by using appropriate mesh size, overexploitation and capture of juveniles can be avoided and bycatch can be reduced to a minimum, as not many species other than the targeted fishes will be caught. Optimal mesh size estimates for the major species in reservoirs are given in Table 1.

Mesh size regulations exist in reservoirs in different states of India. The management of reservoir fishing in Himachal Pradesh is noteworthy where control measures like mesh regulations, closed season are strictly monitored and can be followed by other states for maximum production and sustenance of fisheries.

Table1. Optimum meshsize estimates of gillnets for selected fish species in some reservoirs in India

Species	Reservoir	Optimum mesh size (mm)
Catla catla	Gandhisagar	148
Labeo rohita	Gandhisagar	89
Cirrhinus mrigala	Gandhisagar	60
Labeo calbasu	Gandhisagar	53
Catla catla	Hirakud	90
Silondia silondia	Hirakud	75
Labeo calbasu	Gobindsagar	53
Labeo diplostomus	Gobindsagar	50
Labeo bata	Gobindsagar	55
Catla catla	Aliyar	137
Catla catla	Nagarjunasagar	91
Cirrhinus mrigala	Nagarjunasagar	41
Labeo calbasu	Nagarjunasagar	52

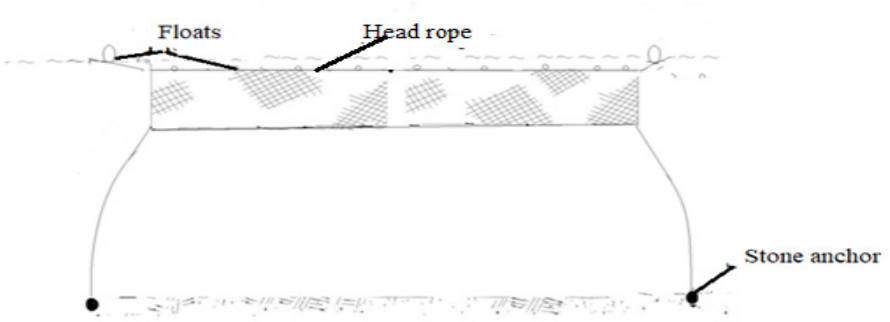

Fig. 1. Surface set gillnets (Catla nets) in reservoir with stone anchors

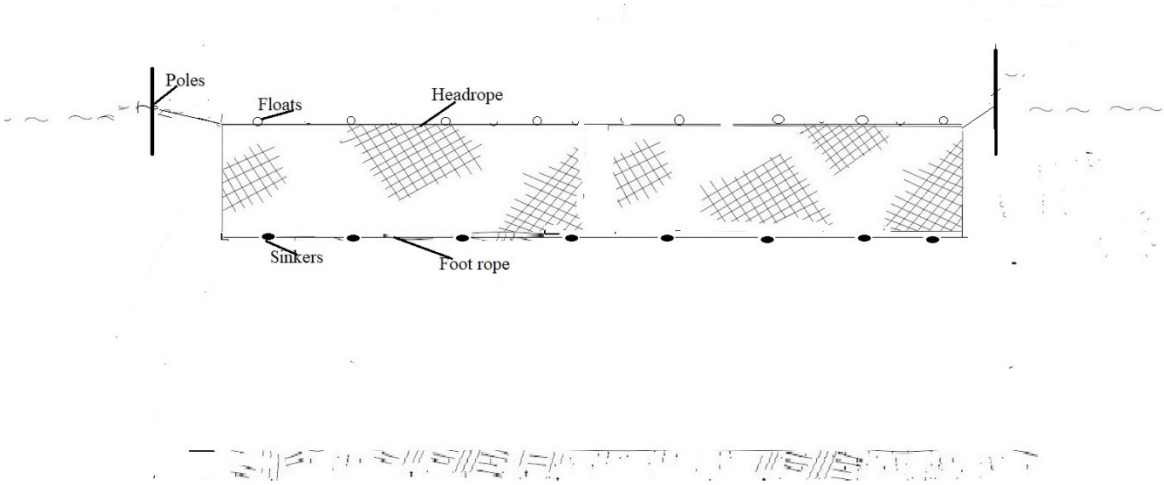

Fig. 2. Surface set gillnets in reservoirs anchored by poles

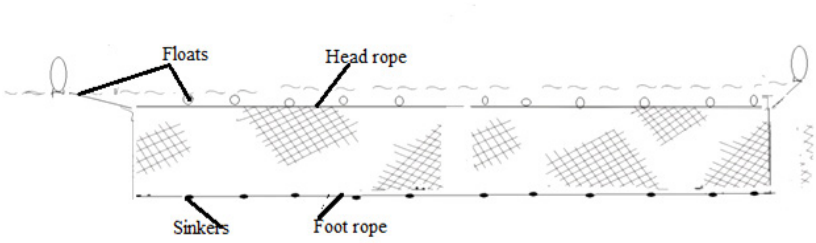

Fig. 3. Drift gillnets in reservoir

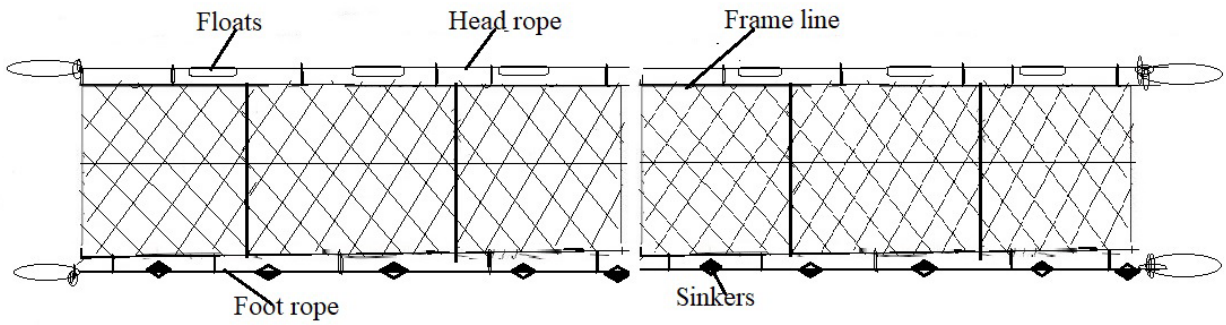

Fig. 4. Framed gillnet

Visibility of the net

Visibility of the nets depends on net colour, type of material, thickness of yarn/ twine and the tone contrast with the background, which can be affected by the time of day and the seasonal changes in water clarity or colour. Monofilament nets nearly invisible in water, are usually the most efficient. The effect of net colour can vary with species, because of differences in behaviour or colour sensitivity. Selection of right colour can reduce catches of unwanted species, without affecting catches of the target species. Studies in reservoirs by CIFT have showed that net materials of yellow and orange colour are most suited for Gobindsagar reservoir whereas in Hirakud reservoir better catches could be obtained by using green and yellow coloured nets. In Thirumoorthy reservoir, white coloured nets were found to give more catch (Velmurugan et al., 2016).

Thickness of netting material

Thickness of yarn/ twine in relation to mesh size play a vital role in determining the efficiency and durability of the net. It should have the maximum possible fineness and as soft as possible. Hence twines of smaller diameter having sufficient strength depending on the species of fish to be caught are to be selected. Firmness of fish body and extensibility of material are also to be taken into consideration while selecting the twine and mostly suited material are monofilament. Thinner netting materials are recommended where fish concentration is less and thicker materials where dense fish population exists.

Hanging coefficient

Hanging coefficient determines the shape and opening of mesh, the distribution of forces and is one of the most important factors affecting yield and selectivity of gillnet. The entangling property can be increased by a decreased hanging ratio. Generally, nets having low hanging ratio (<0.5) can catch the larger individuals of the same species by entangling than gilling. A hanging coefficient of 0.50 and above is suitable for both gilling and entangling of different fishes.

Fishing height

Fishing height of the net is resource specific and regarded as a factor of importance for efficient fishing. Fishing height of 5.25 m was recommended in Catla gillnets and 3 m for other fishes like *Labeo calbasu , L.bata, L.diplostomus* in Hirakud reservoir. In Gandhisagar reservoir a

fishing height of 3 m was found to be suitable for *Catla catla* and for *L. calbasu*. In different states the regulation on the length and height of the gillnet to be used in different reservoirs exist. In Himachal Pradesh which has a well managed reservoir fishery, height of gillnets in operation in reservoirs are limited to 80m and 5m respectively (Thomas, 2015).

Identification of potential fishing areas

Potential fishing ground can be located empirically in major reservoirs either by exploratory fishing or by productivity studies. Such studies were conducted in reservoirs such as Stanley, Thungabadra, Hirakud, Konar and Mettur. Acoustic methods have also been employed in Mettur and Dudhava reservoir. Similar studies can be expanded in other reservoirs also which will be helpful during post-impoundment studies where future fishing grounds can be predicted well in advance.

Future prospects

In the light of stabilizing marine fish catches, inland fisheries in particular, reservoir fishery potential need to be exploited. The gear suitability influences the fish catch in capture fisheries. It is a fact that a well-managed fishery is expected to use gear types that catch most of the available species at sizes that do not undermine the sustainability. The application of new technologies and innovations would be required to tap the fish production potential of the reservoirs in a sustainable manner. The following points can be taken into consideration for future development as well as making gillnet fishing an ecofriendly and sustainable fishing method in reservoirs.

- Updating of baseline data on the gillnet fishing in various reservoirs to evaluate the present status which are essential for their up-gradation in future in terms of efficiency as well as cost-effectiveness.
- Determination of the optimum mesh size for different species and size groups, determination of optimum fishing height and standardisation of other parameters in various reservoirs to improve the catching efficiency.
- Regular stocking programme with optimum stocking measures and exploitation policy especially in the small reservoirs and those under medium category where autostocking is

  not possible in order to use the productive potential of the reservoirs.
- Usage of gillnets with optimum mesh sizes should be encouraged to harvest different species by giving training and awareness to fishers. Mesh size regulations, size limits and total fishing effort have to be implemented and monitored for sustainable exploitation.
- Use of electronic fish detection devices, bottom profiling and mapping, clearing of tree stumps/trunks for catch improvements. Refinement of empirical information available on Potential Fishing Zones based on productivity studies, exploratory fishing, acoustic surveys and remote sensing for potential fishing area marking.

- Creating awareness among fishers on ecological impacts of abandoned, lost or otherwise discarded gear (ALDFG) and also removal programmes of these ALDFG can be promoted. Development of research strategies and counter measures to prevent gear losses, discards or abandonment.
- Post-harvest losses in gillnet fishing can be minimised by reducing the soaking time and avoiding the delay in harvest time.
- Transfer of developed techniques and appropriate training to fishers and stakeholders through extension to adopt these techniques and to cooperate in implementing management policies.

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