

The Future of the Cauvery Mahseer



W.A.S.I

**A report by the conservation sub-committee,
Wildlife Association of South India**

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Executive Summary

The 'Humpback Mahseer' of the Cauvery River Basin has been an enigmatic species amongst anglers the world over. The species has attracted the attention of professional and recreational anglers to the Cauvery River since the mid-18th century. This charismatic fish, often referred to as the tiger of the Cauvery River, has been WASI's primary conservation focus and, under the association's umbrella, has been the driving force behind one of South India's most successful ecotourism models, running over the last four decades. Anglers believe that the 'Humpback Mahseer' is the biggest / largest of all the species in the range of the mahseer's distribution. Surprisingly, till date, the Humpback Mahseer does not have a valid scientific name and its taxonomic identity is yet to be determined.

By analyzing angling catch records - a highly valuable database only available as a direct result of a 30 year old catch and release angling program - the Mahseer Trust (an NGO) and IUCN's Freshwater Fish Specialist Group (FFSG) have come to the conclusion that this species, characterized by its golden / red / orange fins, is on the decline (Pinder et al. 2015; in press). Recruitment within the species seems to be negligible as fewer smaller fish were caught by the anglers and landing of large fish became occasional toward the early 20th century (Pinder et al. 2015; in press).

Both the above organizations wished to conduct a study in the Cauvery Wildlife Sanctuary to capture adult / juvenile 'Humpback Mahseer' and establish its taxonomic position by conducting morphological and genetic analysis. Once the taxonomic identity of the fish is cleared, the conservation status of the fish could be assessed by the IUCN for its Red List of Threatened Species. Thereby, enabling planning of suitable scientifically informed conservation measures.

ROLE OF WASI

WASI's involvement in mahseer protection and conservation dates back to 1972. Ever since its establishment, WASI has contributed to wildlife and habitat protection from the village of Mutthatti downstream till Mokedattu, where the Cauvery River crosses the State border into Tamil Nadu. Three decades of catch and release angling has led to a deep understanding of the Cauvery River, its surrounding forests and the threats faced by this robust ecosystem. The association of the Mahseer Trust, IUCN and WASI was a logical partnership to pursue the long term conservation of the mahseer and its habitat. With the support of the Forest Department and the Fisheries Department, this conservation venture shows immense potential for success.

In view of this, WASI took the initiative and sought permission to conduct baseline research on the Humpback Mahseer in collaboration with the Mahseer Trust and Fresh Water Fish Specialist Group. The results of this research would inform further management plans and could potentially be used to establish the Humpback Mahseer as a 'flagship' in the Cauvery Wildlife Sanctuary (CWS) to not only protect the native fish

communities in the river, but also the multitude of mammals, birds and reptiles resident in the CWS.

Research permission was granted by the forest department but unfortunately small fin clippings and two scales for the purpose of genetic analysis were not allowed to be collected from any specimen caught. This did not allow for genetic analysis of the mahseer community and restricted the study to morphometric measurements of 65 individual mahseer that were caught and released during the study, a rough characterization of mahseer types largely based on the color of the body and opportunistic surveys on various fish species in the river. In addition to this, a river habitat assessment and socio-economic survey of local people benefitting from mahseer management was initiated.

Clarifying the taxonomy of the mahseer, documenting the impact of recreational angling on the local community, maintaining a data base of fish species occurring in the Cauvery River and monitoring the river itself over an extended period of time, are some of the long term goals that WASI wishes to pursue in the Cauvery Wildlife Sanctuary. Involving local ghillies (angling guides from the local community) in this conservation model is the key to its success.

WASI has attempted to add as much value as possible to the research permission granted for the field study. The detailed report follows this executive summary.



Fig 1. A photograph of Humpback Mahseer habitat, Mahamadda, Cauvery River. (PHOTO, Naren S.)

History

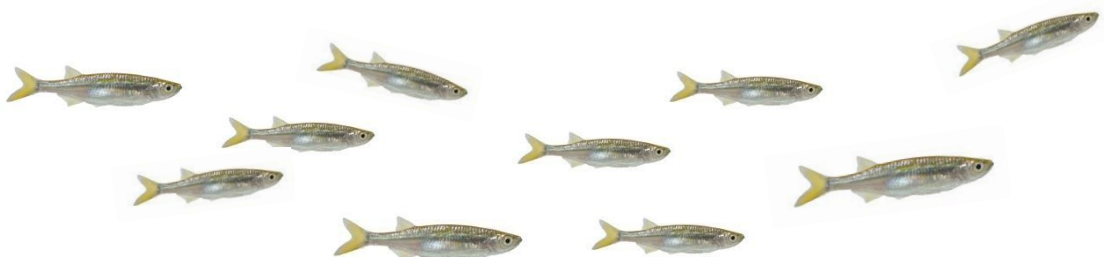
Angling literature is replete with records of the Humpback Mahseer captured on rod and line from the Cauvery River and its tributaries. The first recorded large mahseer, known as the “Sanderson Fish” was captured in 1870 and was estimated to weigh 110 lbs. In 1906, Mr. C.E. Murrey-Aynsley landed a 104 lbs. mahseer at Srirangapatna on rod and line. Thirteen years later, on 28th Dec.1919, Maj.J.S. Rivett-Carnac landed the most talked about mahseer in Indian Angling history (119 lbs) from the Cauvery near the hill temple of Mudhoktore. No history (however brief) of the mahseer would be complete without the mention of the Van Ingen family who captured several mahseer, including the officially recognized world record.

WASI’s association with “catch and release” mahseer angling in the Cauvery began in 1972-73, the year when the Indian Wildlife Protection Act (1972) was promulgated. This was long before the Cauvery Wildlife Sanctuary was extended to offer protection to both banks of the river. Reports from WASI anglers mention the abundance of the humpback mahseer, also locally referred to as the ‘golden mahseer’. Sightings of large Humpback Mahseer ‘rolling’ on the river was common during the day. By charging a license fee to its members, the association successfully deployed a 5 member patrolling team dedicated to stop illegal dynamiting and large scale netting of the river. A conservation driven ecotourism model was well established along 19 Km of the Cauvery River.

During the early 70’s, in a bid to fulfill its conservation goals, WASI agreed to work with the Department of Fisheries, when asked for assistance with a restocking program for the mahseer in the Cauvery River. This resulted in stocking the river with mahseer fingerlings sourced from the Lonavala Hatchery, Pune. In hindsight, although the effort was well intentioned, it may have been a ‘scientific blunder’ that, over the years, may have been one of the factors leading to the decline in the population of the original strain of the ‘Humpback Mahseer’.

Not enough is known as to why the population of the ‘Humpback Mahseer’ has declined in the Cauvery and its tributaries, but anthropogenic pressure is certainly a causative factor and an urgent need exists to scientifically document these various factors. It is also speculated that non-native species of mahseer including possible hybrids were stocked in the Cauvery and other major rivers in India during the early 1970s, which potentially led to competition with the native communities and a subsequent decline in Humpback Mahseer numbers (Pinder et al. 2015; in press).

The genesis of this research project was prompted by a lack of understanding as to *why this species is declining* and *to use modern science to understand, conserve, and manage a program to save the ‘Humpback Mahseer, from what could be the extinction of an endemic species*, in one of the last remaining stretches of the Cauvery River, that has the protection and habitat to support large mahseer.



Study site

The study was conducted between the 3rd of February 2015 and 14th of February 2015 between Haira (12°16'51.14"N, 77°21'26.03"E) and Ontigundu (12°16'30.05"N, 77°26'15.12"E) along the Cauvery River within the Cauvery Wildlife Sanctuary. Sampling was conducted at six locations along the river in deep pools and rapids. Six other locations were strategically chosen along the entire river stretch as sampling stations for a habitat assessment program.

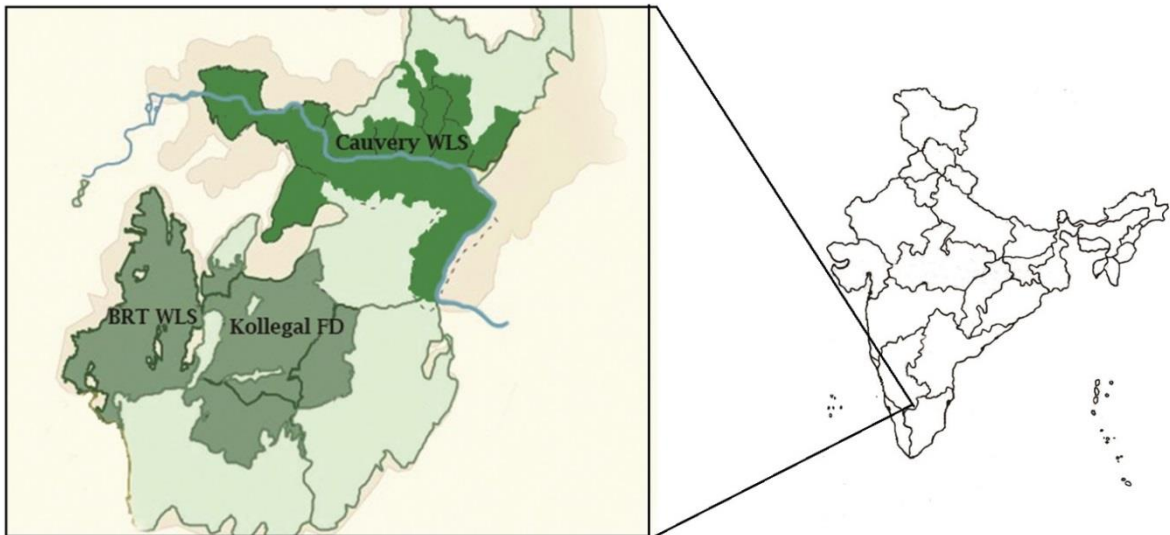


Fig 2. Cauvery Wildlife Sanctuary with reference to Biligiri Rangaswamy Temple wildlife sanctuary and Kollegal forest division.



Fig 3. Map showing habitat sampling locations.

Research Methodology / Techniques

The work carried out during the course of the study touched on five basic criteria, namely:

- A database of various fish species of the Cauvery Wildlife Sanctuary conducted through catch and release angling, opportunistic surveying and interviews.
- Characterization of Mahseer based on body colour and shape.
- A length-weight relationship for the various mahseer caught to help paint a rough picture of the health of the mahseer population in the river.
- A socio-economic survey conducted in collaboration with the MT team to assess the impact of a recreational angling program on local livelihoods.
- A water quality and habitat assessment of the Cauvery River to monitor seasonal changes in environmental flows and other parameters that influence biological activity.

WASI volunteers and staff were briefed on the correct sampling techniques while using meshed nets to sample small fish (up to 30 centimeter in length) in varying habitats. Volunteers were briefed on the proper implementation of best practices while catching larger specimens using rod and line. Samples were collected from different stretches of the river using a combination of artificial lures (spinners, spoons, plugs etc.,) and ragi/bread/atta as baits. Mahseers caught in nets and rod/line were measured, weighed, photographed, revived and released within 2 minutes of their capture. All other species were photographed and documented before release. Questionnaire surveys and snowball interviews were conducted with over 25 local ghillies in an attempt to begin documenting the impact of the 2010 ban on angling and its effect on the catch and release fishery and local livelihoods. Six sampling stations along the River were chosen to collect 14 water quality and habitat parameters with the intention of initiating a long term monitoring program. Digital meters were used for collecting physical parameters such as temperature, pH, conductivity, total dissolved solids (TDS) and incident light. Ocular estimations of canopy cover were conducted at 0m from the left bank of the river and half way between 0m and the monsoonal bank of the river (bank of the river at full flow). Surface water velocity was estimated using the floatation method. Water turbidity, dissolved oxygen (DO), Nitrate, ammonia and phosphorous levels were estimated using a Jal-Tara kit.



Fig 4. A black-fin Mahseer being processed.

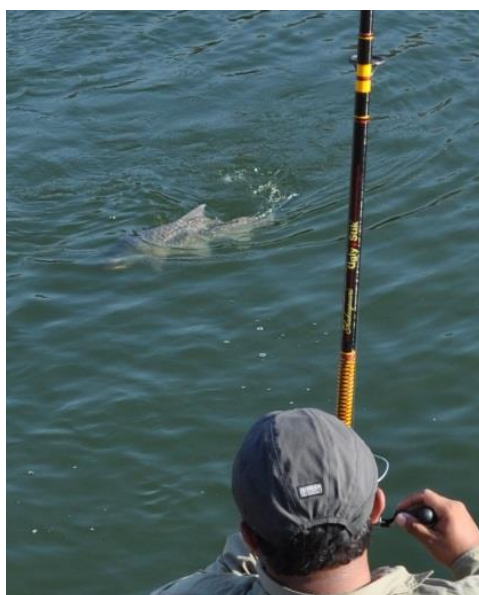


Fig 5. Retrieving a blue-fin mahseer.

Results

The total number of fish species found during the scope of this survey currently stands at thirty. However, the number of species in the Cauvery Wildlife Sanctuary is estimated to go up further with refined sampling/identification techniques and a thorough genetic analysis of the various mahseer types documented during this survey. Twenty five species were caught, photographed and are documented in this report; the rest are a result of evidence through visual encounters and interviews.

Various types of mahseer were found along the entire sampled stretch. Species such as the Rosy barb, Boopis Razorbelly Minnow and Striped Stone Sucker are among the most commonly found species within the study area. The angling catch rate was noticed to be relatively lower than previously estimated by anglers; this could be due to very low water levels in the river and a lack of pre-baiting deep pools. Evidences of mahseer larger than 12.24 Kg were not observed during the study period.

A socio-economic study was initiated to assess the role of ghillies in the conservation of mahseer, the overview of which is discussed below.

Mahseer

Out of the 65 mahseer caught and documented during this survey, only 13 specimens showed physical characters resembling the Humpback Mahseer (golden hue on the body and orange fins). All these specimens were juvenile fish measuring less than 20 cm in length. All were caught with nets in rapids and fast flowing channels. The two other distinct types observed during the survey were the 'blue-fin mahseer' and the 'black-fin mahseer'. The three largest mature adults caught were all 'blue-fin' and weighed in at 12, 12.02 and 12.24 kilograms. All three were caught in or near deep pools suggesting that the larger mahseer are using deep pools within the Cauvery Wildlife Sanctuary as refuge during low river flow conditions.

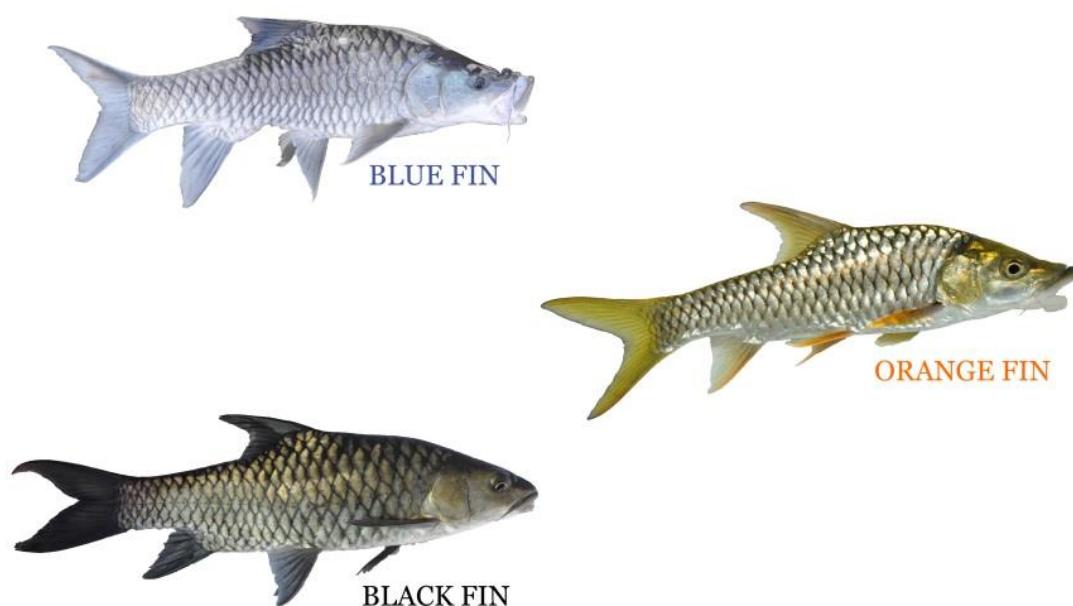


Fig 6. Three distinctly different morphotypes of Mahseer found during the course of the study.

Length-weight analysis of all the mahseer caught during this study reveals an Isometric growth pattern, which indicates a healthy growth rate in the study area. Although the Length-Weight relationship analysis is generally conducted on a species specific basis, we conducted the analysis after pooling all the mahseer data together due to the taxonomic inadequacies of the Cauvery mahseer community. Species-specific analysis in the future will provide in-depth information into the health of the community.

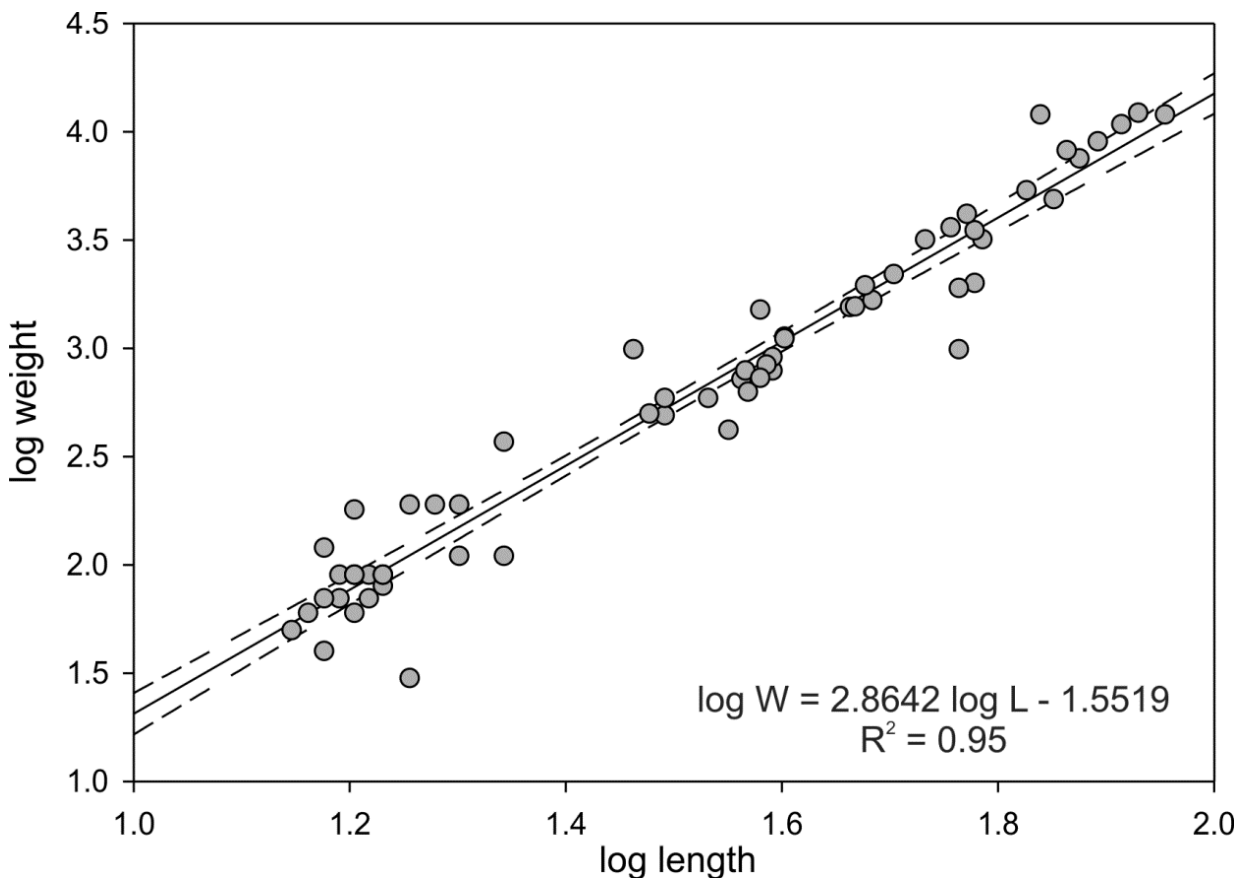


Fig 7. Length weight relation for Weight in g and length in cm. The r value is 0.9747 and is a significant relationship (P < 0.0001). Power b = 2.8642 (standard error = 0.0841) is not significantly different from expected cubic value as per isometry (t = 1.6135, df = 63, P = 0.1117). The mahseers in the Cauvery River are following an isometric growth pattern.

Species checklist

WASI’s current species checklist depicts the presence of thirty species of fish belonging to eleven families and twenty six genera. Five of these species are reported as endemic to the Cauvery River. The International Union for Conservation of Nature (IUCN) categorizes one of these endemics as Critically Endangered (CR), three as Endangered (EN) and one as Vulnerable (VU). Of the thirty species, twenty five were photo documented and identified to the species level. Due to non-availability of specimens for research, five species were identified down to their respective genera. Six species were identified through visual encounter surveys and interviews with ghilles and anglers.

Table1. Species Checklist of the Cauvery Wildlife Sanctuary

Common name	Species	Endemism	IUCN status
Cyprinidae			
Black Line Rasbora	<i>Rasbora dandia</i>		Not Evaluated
Rosy barb	<i>Pethia conchonius</i>		Least Concern
Swamp barb	<i>Systemus subnasutus</i>		Not Evaluated
Rohu	<i>Labeo rohita</i>		Least Concern
Catla	<i>Catla catla</i>		Least Concern
Mrigal	<i>Cirrhinus cirrhosus</i>	Endemic	Vulnerable
Carnatic Carp	<i>Barbodes carnaticus</i>		Least Concern
Boopis Razorbelly Minnow	<i>Salmophasia boopis</i>		Least Concern
Korhi barb	<i>Hypselobarbus micropogon</i>	Endemic	Endangered
Pigmouth carp	<i>Labeo kontius</i>		Least Concern
Nilgiri barb	<i>Hypselobarbus dubius</i>	Endemic	Endangered
Malabar danio	<i>Devario malabaricus</i>		Least Concern
Kantaka barb	<i>Osteochilichthys brevidorsalis</i>		Least Concern
Striped stone sucker	<i>Garra mullya</i>		Least Concern
Nash's barb	<i>Osteochilichthys nashii</i>		Least Concern
Fringe lipped carp	<i>Labeo fimbriatus</i>		Least Concern
Aruli barb	<i>Dawkinsia arulius</i>	Endemic	Endangered
Indian carplet	<i>Amblypharyngodon microlepis</i>		Least Concern
South Indian Flying barb	<i>Esomus barbatus</i>		Least Concern
Cichlidae			
Pearl Spot	<i>Etoplus suratensis</i>		Least Concern
Channidae			
Giant Snakehead	<i>Channa marulius</i>		Least Concern
Mastacembelidae			
Malabar Tyre-track Eel	<i>Mastacembelus malabaricus</i>		Not Evaluated
Ambassidae			
Indian Glass Fish	<i>Parambassis ranga</i>		Least Concern
Elongate Glassy Perchlet	<i>Chanda nama</i>		Least Concern
Adrianichthyidae			
Carnatic Rice Fish	<i>Oryzias carnaticus</i>		Least Concern
Badidae			
Blue Perch	<i>Badis badis</i>		Least Concern
Gobiidae			
	<i>Awaous spp.</i>		Least Concern
Bagridae			
Cauvery Giant Catfish	<i>Hemibagrus punctatus</i>	Endemic	Critically Endangered
Schilbeidae			
Silund	<i>Silonia childreni</i>		Not Evaluated
Clariidae			
African Catfish	<i>Clarius gariepinus</i>		Not Evaluated

Habitat assessment

A reconnaissance study was conducted on the 31st of March 2015 at six sampling stations between the confluence of the Cauvery River with that of the Shimsha and Arkavathi Rivers. The aim of the study was to test the water quality within the CWS and to begin a data set of 14 parameters significant to river water quality and fisheries. The parameters collected were surface water temperature, pH, Conductivity, TDS (total dissolved solids), light intensity, surface water velocity, canopy cover (at the 'dry-season bank' and half way to the 'monsoonal bank'), oil and grease, turbidity, benthic diversity, DO (dissolved oxygen), Nitrates, Ammonia and Phosphates.

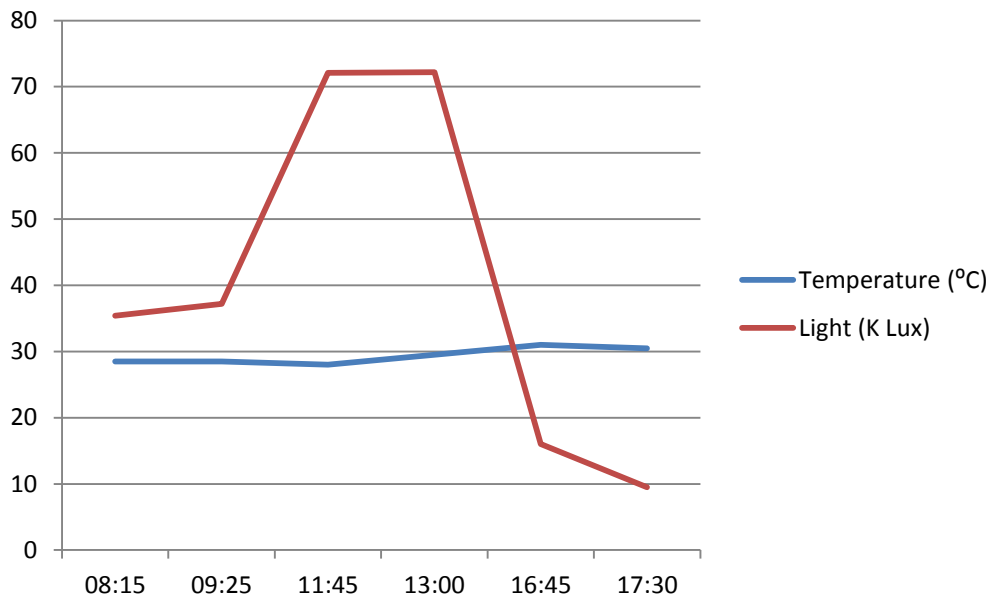


Fig 8. Line plot showing stable surface water temperature through the day and a typical bell curve for lux readings.

Water temperature was constant through the day with a spike in light (lux) readings as seen in Fig 8. pH levels at all sampling stations was between 8.5 and 8.8 which lies within accepted pH levels for inland fisheries. Average conductivity for the Cauvery and Shimsha lies at 441.8 μ s and that of the Arkavathi was observed to be higher at 1325 μ s. TDS level at the Shimsha and Cauvery showed low variation averaging at 221 ppm; the TDS level in the Arkavathi River was observed to be higher at 663 ppm. The average surface water velocity over the entire reach was observed to be very low, ranging between 0.9 m/s in pools to 4.5 m/s in the Arkavathi River. A 25.6% average canopy cover was estimated along the left bank of the river at the six sampling stations; further canopy cover data will paint a better picture of the canopy cover available to the river reach. Small amounts of oil and grease was noticed on the Arkavathi River but not on the Cauvery and Shimsha Rivers. Turbidity was highest on the Arkavathi at 18 NTU and lowest in the deep pools at 3.5 NTU. DO levels in the Cauvery, Arkavathi and Shimsha were

observed to be at good levels measuring 11.5 mg/L, 11.2 mg/L and 12.4 mg/L respectively. Nitrate levels in the Arkavathi River was the highest at 10 mg/L whereas all other stations measured in at less than 10 mg/L. Ammonia levels in all samples were observed to be below 1.0 mg/L. Phosphorous levels were observed to be at 0.1 mg/L at the higher parts of the reach and at 1.0 mg/L in the Arkavathi and 0.5 mg/L in the Cauvery below the Cauvery-Arkavathi confluence. Benthic lifeforms could not be sampled from the river bed as sample collection was not possible from the bank of the river.

Table 2. Ideal values for different parameters and their effects on biodiversity.

Sl	Parameter	Accepted levels	Effects
1	Temperature	24 - 32 °C	At higher temperatures gases like oxygen and carbon di-oxide dissolve to a lesser extent; aquatic organisms are weakened and most affected by lack of oxygen.
2	pH	5-9	pH levels directly affect biodiversity
3	Conductivity	50-1500 μ s	A spike in readings may be an indicator that pollutants have entered the water.
4	TDS	>1000 ppm	TDS is an aggregate indicator of the presence of a broad array of chemical contaminants.
5	Turbidity	-	High turbidity reduces availability of light to algae and plant life; sediments that cause high turbidity harm fish gills and eggs and also increases water temperature.
6	Canopy cover	-	Riparian canopy, in addition to providing shade and reducing water temperature also provides an avenue for feed to enter water bodies.
7	Light intensity	-	Low light levels have a negative effect on plant and algal growth. High light intensity can lead to increased water temperature.
8	Surface Water velocity	-	Fluctuation in water velocity could possibly trigger or inhibit migratory/spawning behaviour in certain fish. It can also severely affect chemical, physical and biological conditions along the river.
9	DO	5-11 mg/L	Lower dissolved oxygen levels translate to less oxygen available for aquatic organisms.
10	Nitrates	<90 mg/L	High nitrate levels in combination with low DO levels can be highly toxic to fish
11	Ammonia	.06-1mg/L	Higher pH increases the toxicity of ammonia. Ammonia in high concentrations are toxic to fish species.
12	Phosphates	0.01-1 mg/L	Phosphates in high concentrations promote algal blooms which have effects on local fisheries.

The above results lead us to believe that the CWS harbors a stretch of the Cauvery River that is ideal for fish to thrive and breed in. Although the above information, collected over a span of one day, is by no means adequate to comment on the health of the river system, it is encouraging to see elevated levels of dissolved oxygen even during low flow months. Concentrations of nitrates over 10 mg/L generally have an effect on the freshwater aquatic environment (*Behar. Montpelier, VT: River Watch Network, 1997*); the levels in the CWS must be monitored as elevated nitrogen levels were observed in the Arkavathi River. Concentrations of phosphates in a river, although not directly harmful to an organism, can cause algal blooms which have a negative effect on water quality, the phosphate level in the Arkavathi was observed to be high and may have an effect on the river system. Water turbidity, conductivity and TDS levels are not alarming but were noticed to be relatively higher in the Arkavathi River.



Fig 9. WASI volunteer conducting a test for dissolved oxygen at the crocodile rock pool.



The role of local ghillies (angling guides) in the conservation of mahseer.

A socio economic survey with 25 ghillies (recreational angling guides) was carried out in the month of February. The objective of the study was to assess the effectiveness of angling ecotourism as a conservation tool, taking into consideration the ghillies' perspectives over the timeline of their work tenure and different management regimes that have accorded protection to the Gaganchuki-Mekedattu Cauvery reach.

Most importantly, gathering from the interviews, the study led to indicate a severe discrepancy between ghillies and the current wardens of the river, showing a difference in the amount of protection ascribed to it. The interviews show that the ghillies, most of whom previously belonged to the local fisherman community, were convinced otherwise by members of the Wildlife Association of South India (WASI) to protect the river stretch by using their knowledge and skills as a ghillie. Their responsibilities included feeding fish with ragi (a local millet) during fishing season, guiding anglers and monitoring the river daily to ensure all illegal activities and high impact fishing practices were curbed with night patrols and day patrols. This not only ensured constant protection for the river, but it also provided a stable source of livelihood for the ghillies, along with respect from their community members. The same responsibilities were applied with a change in management when JLR (Jungle Lodges and Resorts) was given charge of the lease. WASI continued to have their own anti-poaching team patrolling between three anti-poaching camps (APC's), working alongside the JLR team and Police Department.

With the angling ban in place they (ghillies) openly confessed to losing a sense of identity and moreover, respect from fellow community members, since they no longer possess authority to safeguard the river from illegal activities. The ghillies also confessed that community members are now fearless of carrying out illegal commercial fishing in the protected area. They also suggest that they be accepted as *the guardians of the river* and be included in the patrolling force which now belongs to the jurisdiction of the Karnataka Forest Department. They strongly state with conviction that angling curbed a lot of illegal activities such as dynamiting, gill netting, hunting, simply with the presence of people in an area so vast which can otherwise prove to be difficult to manage with fewer people on the ground. The interviews are yet to be analyzed and we will know over a period of time if this can contribute to future management and conservation plans for the Gaganchuki-Mekedattu reach of the Cauvery River in the Cauvery Wildlife Sanctuary.

- Article by Neethi Mahesh



Fig 10. Bola, one of the most experienced Cauvery ghillies assisting in sample collection.



Fig 11. Ghilles hired from the local community being interviewed by a member of the Mahseer Trust Team.

Summary discussion

The Cauvery Wildlife Sanctuary serves as a source and corridor habitat for the several species of the Deccan landscape. Numerous terrestrial species of birds, mammals, reptiles, and amphibians call the sanctuary their home. During WASI's presence in the area, many important species protected by India's Wildlife Protection Act, 1972 were encountered regularly. The wildlife sanctuary also serves as an important elephant corridor between the neighboring forests of Kollegal and the Bannerghatta National Park. The lifeline of the CWS is the Cauvery River, a robust river that not only irrigates agricultural fields of Tamil Nadu and Karnataka but also supports the large sugar industry of the Mandya district in Karnataka and provides drinking water to rapidly developing cities such as Bengaluru and Mysore. This study has established the presence of various aquatic species that are also dependent on this water source, some endemic to the Cauvery drainage. The Humpback Mahseer's significance is not only restricted to the angling community but has immense potential as a 'flagship' for the Cauvery Wildlife Sanctuary, that could be used to protect the entire ecosystem. A long term conservation initiative for the Humpback Mahseer will be beneficial not only to the local flora and fauna but also to the rural and urban sectors of Karnataka and Tamil Nadu that are dependent on the natural bounty of the River Cauvery.

Threats

Protection: Following the course of the Cauvery River from Talakaveri, its point of origin, down to the point where the river exits the state of Karnataka and enters Tamil Nadu, it is apparent that the only significant stretch of the river which is offered protection on both banks by the Forest Department is limited to roughly 40 kilometers and lies within the Cauvery Wildlife Sanctuary. It is common practice by local fisherman to dynamite and net the river in order to catch fish in large quantities for sale, even in places where only one bank of the river is protected by the Forest Department. As we are aware, fish do not recognize human-defined boundaries and it is suspected that this has taken a deadly toll on the Humpback Mahseer population. It is for this reason that the Cauvery Wildlife Sanctuary offers a stretch of the river that is ideal as a Mahseer sanctuary. It is not only the Mahseer population that suffers huge losses due to indiscriminate commercial fishing practices. There have been unofficial reports of catches of up to 50 Kilograms of various species being poached during a single dynamiting/netting operation which may span as little as an hour during the night. A casual inquiry with a fish sales man at a local market at 'Hand Post' revealed sales of 200 to 500 kilograms per day. One can only imagine the effect this would have on other taxa such as the Indian Mugger, the Smooth-Coated Otter and the lesser grey-headed fishing eagle that directly depend on fish as a food source.

Monitoring: From a science and conservation perspective, terrestrial species have been given more attention than aquatic species. It is much harder to judge human impact on animals that we cannot visually monitor over large periods of time. So far, monitoring of fishes along the Cauvery River has been solely restricted to talk of fluctuations in catches among the fishing community and by the angling community, whose interest in catch and release angling has led them to observe anecdotal evidences which in itself suggests a noticeable decline in Humpback Mahseer numbers. After the ban on catch and release angling was imposed in protected areas, the status of the mahseer population of the CWS is largely reduced to sightings of fish rolling on the surface of the water and even this suggests a massive decline in the presence of large fish.

Regular 'feeding' of the river to maintain a resident fish population for the catch and release fishery might have ensured that the larger fish did not leave the protection of the sanctuary, but it is feared that post –angling ban, many of the large fish have migrated downstream in search of feed and could have possibly ended up in local markets.

River health: The decline in Humpback Mahseer may not be solely due to overfishing of the Cauvery River. In fact, in a country such as India where a large part of the protein source for the rural sector is fish, sustainable fishing practices have to be implemented and such a conservation initiative will only be successful after looking after the needs of the local community. What scientists and conservationists believe is that the degrading health of the Cauvery River itself could be responsible for huge losses in the fish community. Water quality can be affected by a multitude of causes, from direct addition of nitrates, ammoniates, and phosphates through the use of fertilizers and pesticides in agricultural fields to heavy siltation due to runoff and fluctuations in river flow. The river Cauvery along Srirangapatna town stretch (upriver of the study site) is prone to anthropogenic activities such as bathing, washing and disposal of wastes (*Sudevi Basu and Lokesh K.S., 2012*). During the course of this study, extremely low water levels were noticed in the river suggesting that large fish are restricted to deep pools. Rapids are the lungs of a river and dried up rapids lead to a reduced amount of dissolved oxygen available to aquatic organisms, especially in pools where they become more sluggish and thus more prone to predation. Changes in environmental parameters over seasons must be recorded in order to understand the Rivers dynamics.

Humpback Mahseer population: There exists an urgent need to clarify the mahseer's taxonomy. This study shows evidence of at least three distinct morphotypes of mahseer present within the CWS. It is not known whether these constitute distinct species, or phenotypes. It is important that this question is addressed as quickly as possible, as the presence of any non-native species of mahseer (due to the reason that non-native species may have been historically stocked in the river) could further result in the decline of the native humpback mahseer. Furthermore, the presence of alien-invasive species of fishes in the river also poses a grave threat to the Humpback Mahseer by way of competition for food and increased predation on juveniles.

Local community: What is probably most alarming is the plight of a conservation initiative that has been in place in the area for over four decades - a program spearheaded by WASI that recruited local fisherman who were unaware of the consequences of indiscriminate fishing and turned them into some of the most driven conservationists in India, some of whom have been featured in international literature and stand as the world's authority on mahseer angling today. A community of fisherman who have literally built their homes and lives from catch and release angling now speak with reverence of the Humpback Mahseer. Without a mahseer management program in place, the future of this community is now on the brink of slipping back into less sustainable livelihoods that was once their only means of survival.

Recommendations

- ***The urgency to run genetic studies and clarify the mahseer taxonomy in the Cauvery River is of primary importance.*** From this study, it is evident that there exist three different types of Mahseer in the CWS, one of which is suspected to be the Humpback Mahseer. Once the genetic analysis is carried out and the taxonomic identities of the mahseers in the river are clarified, informed management plans must be implemented.
- The current WASI fish checklist stands at 31 species, some endemic to the Cauvery drainage and some whose populations are highly threatened. Better sampling techniques show promise in revealing more species. ***Completing the WASI species checklist is a must in order to understand the fish community dynamics in the River.***
- As a result of Forest Department presence in the Cauvery Wildlife Sanctuary, the river stretch flowing through it offers a perfect cocktail of protection, deep pools, rapids and breeding sites to serve as a sanctuary for the Humpback Mahseer. WASI recommends that the ***Humpback Mahseer be used as an ambassador for the CWS to help build awareness and human interest in protecting this pristine riparian ecosystem.***
- The Forest Department must make use of the interest and dedication ingrained in the Cauvery ghillies over the last 30 years. ***Ghillies must be empowered as ‘guardians of the river’ to assist the department in providing protection from commercial fishing practices,*** especially within the Cauvery Wildlife Sanctuary, the last refuge for the Cauvery Mahseer.
- ***There should be no further stocking of mahseer fingerlings in the Cauvery River and its tributaries*** until DNA analysis determines the identity of the mahseer species naturally occurring in the River.
- ***Mahseer breeding sites must be identified, documented and monitored*** in order to ensure successful annual recruitment.
- ***WASI must work alongside the Forest Department to set up a fish monitoring program*** in order to collect information regarding the movement patterns of mahseer in the Cauvery Wildlife Sanctuary and also to document the various alien-invasive species that potentially pose a threat to native species. This can be carried out by a catch and release program that incorporates a mark-recapture/radio-telemetry study on mahseer during select periods of the year.
- ***A long term water quality and habitat assessment program is recommended*** in order to understand flow dynamics and changes in other water quality parameters that significantly influence flora and fauna of the Cauvery River. In such a case where a mahseer breeding or stocking program is to be implemented, the success of the program can be estimated by analyzing the river dynamics through spatial data collected from a long term habitat assessment.
- ***WASI, the Forest Department and Fisheries Department must work together in order to influence existing and future development projects*** that may take place along the Cauvery River. The study site possesses one of the last remaining riparian habitats along the 800Km long Cauvery River. It is home to animals that are highly protected by the Indian Wildlife Protection Act, 1972 such as the Smooth-coated otter, Grizzled giant squirrel and Indian marsh crocodile that are highly dependent on this riparian habitat. It must also be ensured that an adequate amount of water is allowed to flow through the CWS in order to maintain a viable, breeding population of Mahseer.

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References

A. Pinder, R. Raghavan & R. Britton (0000) Efficacy of data from sport angler catches as a monitoring and conservation tool for the flagship mahseer fishes (*Tor* spp.) of Southern India. *Aquatic Conservation: Marine and Freshwater Ecosystems* (In Press)

Basu, S and Lokesh, K.S. (October 2012) :Evaluation of Cauvery River Water Quality at Srirangapatna in Karnataka using Principal Component Analysis.

A. Pinder, R. Raghavan & R.J. Britton (2015) The legendary humpback mahseer (*Tor* sp) of India's River Cauvery: an endemic fish swimming towards extinction. *Endangered Species Research* 28: 11–17.

Basu, S and Lokesh, K.S. (2014) Application of multiple Linear Regression and Manova to evaluate health impacts due to changing river water quality. *Applied mathematics*, 5, 799-807

Testing the Waters: *Chemical and Physical Vital Signs of a River* by Sharon Behar. Montpelier, VT: River Watch Network, 1997. ISBN-0-782-3492-3.

Jal-TARA Water Testing Kit – User's Manual.

Quality Criteria for Water, U.S. Environmental Protection Agency, July 1976.

Water Quality Criteria, Environmental Studies Board, National Academy of Sciences, 1972.

