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Impact of hydroelectric projects on finfish diversity in the Sharavathi River estuary of Uttara Kannada District, central west coast of India

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ABSTRACT

Estuarine areas, associated with high biological productivity and rich fishery, are also often densely settled by humans. Seldom was any comprehensive study ever made in India on the impact on estuarine fin fish diversity due to execution of hydroelectric projects in the upstream of rivers. The study here in the Sharavathi River estuary in central west coast of India illustrates how too low salinity conditions, resultant of incessant fresh water releases form upstream hydro-electric projects, created in the estuary conditions unfavorable for many high and medium stenohaline fishes retaining only euryhaline ones tolerant of wide ranges of salinity and perhaps adding few species characteristic of low salinity to fresh water conditions. Scope of EIA on dam projects should be expanded to include even estuaries and immediate marine areas.

Key words: Sharavathi River estuary, Hydro-electric projects, Salinity, Finfish diversity.

1. Introduction

The estuaries, in general, are places of high productivity and biodiversity, being rich in nutrients, inputs from the land and from upwelling in the marine areas brought in by the tides. The mangroves and marshes with reeds and grasses provide additional nutrients and habitats for a variety of fishes, most of them moving in from the sea, some resident in the estuary itself or sharing even fresh water habitats. The estuaries thus are ideal for fishery development, as important areas for spawning, nurseries and feeding. They are essential habitats in the life cycle of many organisms, in particular fish. Estuaries are important seed sources for many shrimps and fishes for culturing. Fishes and many invertebrates being valuable food resources calls for integrated management of the coastal zone of which estuaries are integral parts Laegdsgaard & Johnson (1995); Blaber *et al.* (2000); Brinda *et al.* (2010); McLusky and Elliott, (2004); Breine *et al.* (2011). Despite rising awareness on their importance estuaries are among the most modified and threatened environments today. Estuarine fish community is an indicator of its health and reflects the ecological dynamics within the estuary. Thiel *et al.* (1995); Marshall and Elliott, (1998); Paperno and Brodie (2004); Gutierrez Estrada, *et al.* (2008).

Composition of fish community provides a first approach to the health level of the estuarine ecosystem. Of the physico-chemical characteristics decisive on estuarine fish diversity salinity is a crucial one Barletta *et al.* (2005). Gutierrez Estrada *et al.* (2008). Attempts at comprehensive inventorisation estuarine fish diversity, in relation to salinity factor, are practically new to the

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south-west Indian State of Karnataka, characterized by over a dozen rivers flowing westward into the Arabian Sea from the Western Ghats, one of the global biodiversity hotspots.

The coast of Uttara Kannada district of Karnataka (longitude 74º and 78º East and latitude 11º and 18º North) has played important role in Indian fishery scenario, through especially marine and estuarine fishery. Nevertheless, comprehensive studies on estuarine fish diversity are practically lacking barring isolated works, such as of Naik (2003) on fish seed resources of Kali estuary, Roopa *et al.* (2011) on fin fishes of the same estuary and Shirodkar (2013) on the fish diversity of Gangavali estuary. Except some allusions hardly any notable work exists for Sharavathi River estuary. A fishery collapse in the estuary was widely known locally and the fishermen link it to the execution of hydro-electric projects in the Sharavathi River. The first major hydroelectric dam in the river at Linganmakki in Shimoga district became operative from 1964 and the second at Gersoppa in Uttara Kannada district from1999. The fishery collapse made us undertake a study on fish inventorisation in the estuary in relation to salinity, a factor that got altered in a big way since the hydroelectric dams.

2. Materials and methods

Sharavathi estuary (Lat 14.211894º to 14.304110ºN Long 74.421160º to 74.675575ºE) is situated towards the centre of South Indian west coast, in Honavar taluk of Uttara Kannada. Originating in the central Western Ghats region of Shimoga district in Karnataka, the river runs through a rugged mountainous terrain before plunging into a deep gorge at Jog, creating one of the most majestic waterfalls of India. From there on it flows westward through landscapes of rocky precipices, evergreen forests, spice gardens and rice fields and merges with the Arabian Sea in the vicinity of the coastal town of Honavar forming an estuary at the confluence.

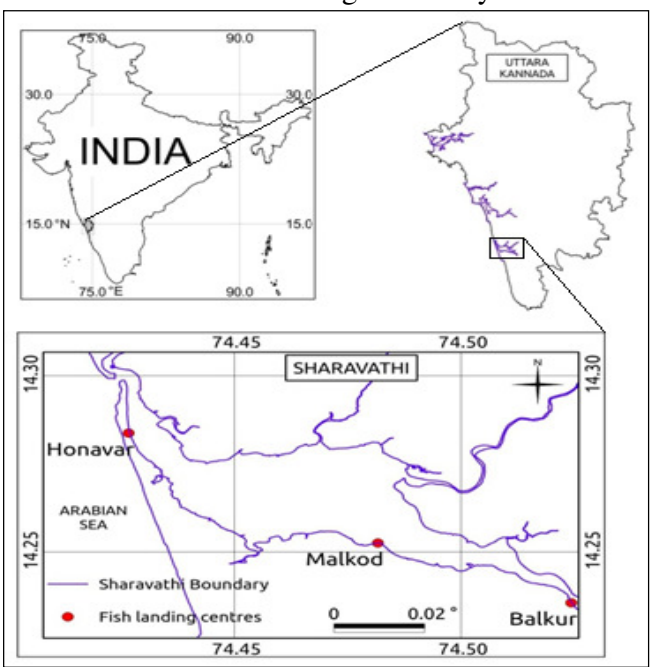


Figure 1: Sharavathi estuary and locations of sampling stations

The observations on fish diversity and salinity were carried out for one year from June 2011 to May 2012. Cast-net catches were monitored from three fish landing stations namely Honavar, Malkod and Balkur (Figure1), situated closer to the river mouth, mid and upstream estuary respectively, for one day every month. During each sampling day, station-wise, fish species caught by fishermen from five consecutive hauls of the cast-net were examined. In addition fishermen were interviewed regarding the availability of fishes in different seasons.(Premonsoon, monsoon, postmonsoon) Fish specimens collected for identification were preserved in 70% alcohol and kept in the Kumta field station of the Centre for Ecological Sciences of the Indian Institute of Science, Bangalore. Standard keys by Jayaram (1984), Day (1889), Talwar & Jhingran (1991), Munro (2000), and fish base website (www.fishbase.org) were used for identification. Monthly monitoring of surface water salinity, during high tide, was monitored using digital salinity meter.

3. Results and discussion

Altogether 29 species of fin fishes from 24 families were collected during study period (Table-1). Family Lutjanidae was leading with 3 species, followed by Engraulidae, Gerridae and Mugilidae, each with 2 species. The rest had each single species only. Sillaginid fish *Sillago sihama* and mullets (*Mugil cephalus*, *Liza parsia*) were available throughout the year. Bulk catches of Gerreids (*Gerres filamentosus* and *Gerres limbatus*) happened only during the monsoon season. Notable of marine euryhaline fishes (tolerant of wide ranges of salinity) included *Stolephorus commersonii, Stolephorus indicus* and *Arius arius.* Whereas *Stolephorus* spp. was present year-round in station I nearest to the sea, *Arius arius* occurred throughout the estuary, mainly during pre-monsoon and post-monsoon. Closeness to the sea seems an important factor for fish richness more than salinity factor which was uniformly low for the entire estuary. Thus Honavar station (2 km from river mouth), had all the 29 species recorded, followed by mid-estuarine Malkod (8.5 km away) with 23 species and the most upstream Balkur (14.km away) which had 19 species, lowest of the three (Figure2).

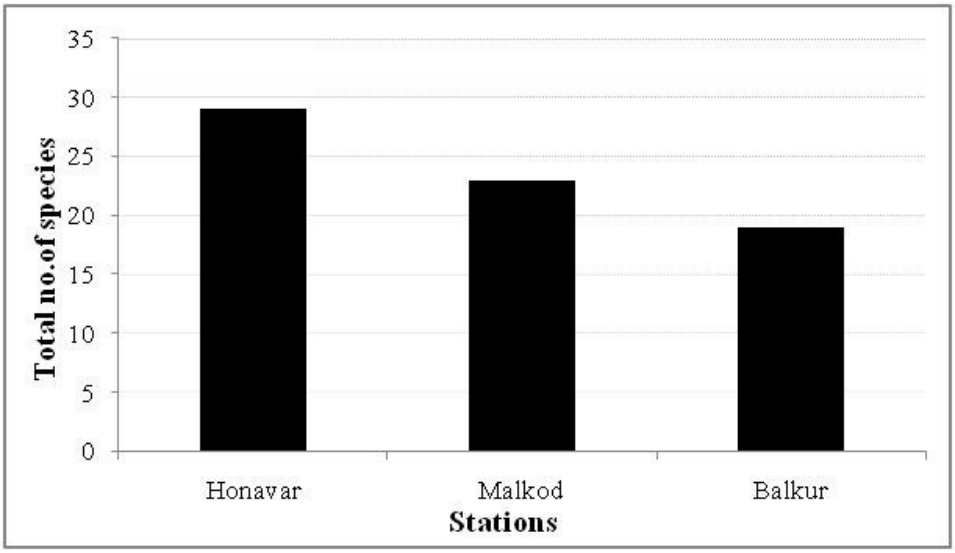


Figure 2: Station-wise fish species diversity in Sharavathi

Not many studies were made hitherto on estuarine fish diversity of the district. Naik (2003) reported seed resources of 46 species of fin fishes from Kali estuary while Roopa *et al.* (2011) listed 37 fish species from it. Shirodkar (2013) inventorised 46 species belonging to 39 genera from Gangavali estuary. However, recent studies by our group revealed 61 fish species of 50 genera from Kali estuary, 55 species of 48 genera from Gangavali estuary and 80 species of 64 genera from Aghanashini estuary Ramachandra *et al.* (2013). Further south, in Kerala, Bijukumar and Sushama (2000) reported 52 basically marine species from Ponnani estuary.

It was quite intriguing how Sharavathi estuary (1336 ha) was quite impoverished in fish diversity in comparison to Gangavali an estuary much smaller (558ha) in water-spread. Higher salinity in Gangavali and for that matter in Aghanashini also (2842ha) may be considered the major environmental factor for higher diversity of fishes in them than in Sharavathi. What separates Sharavathi from the other two is mainly the functioning of two important hydel projects in it. The salinity conditions in the Sharavathi estuary was very low in all stations even during post monsoon times (Figure3). It was indeed below 0.5 ppt indicating fresh water conditions. Way back in 1984, working on the clam resources, Rao *et al.* (1989) had already noticed that water salinity was down to 1 ppt in the Sharavathi estuary, as near as 2 kms from the bar mouth, during February, even three months after the rainy season.

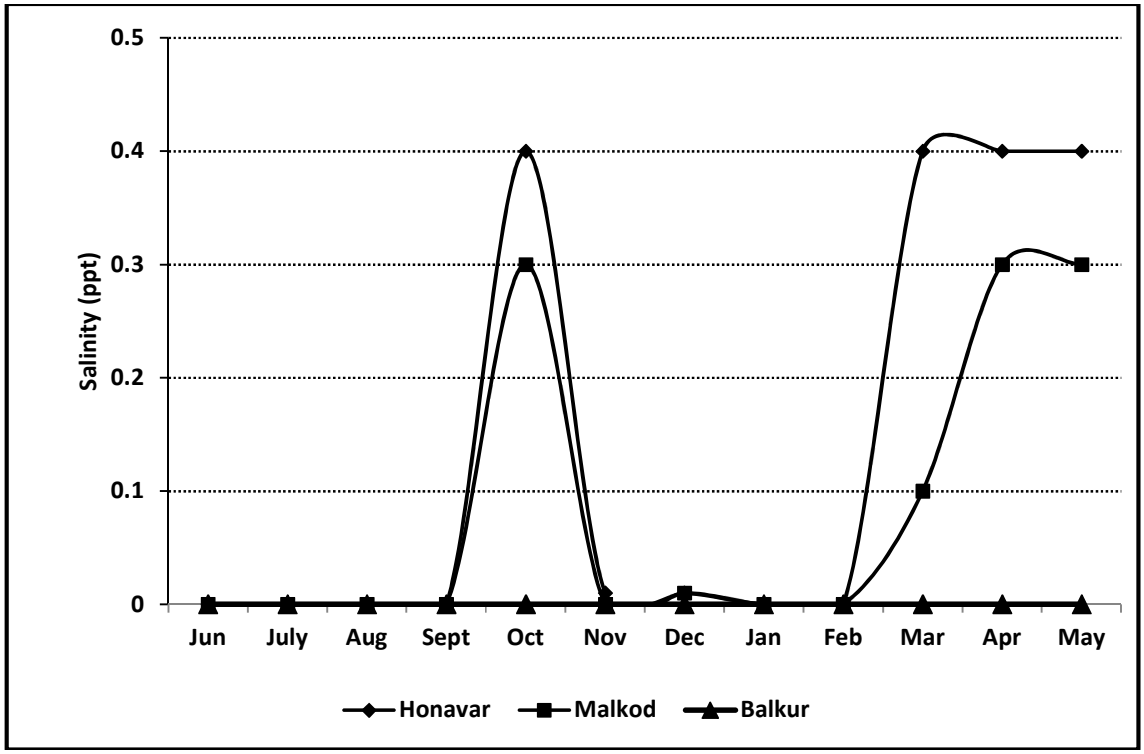
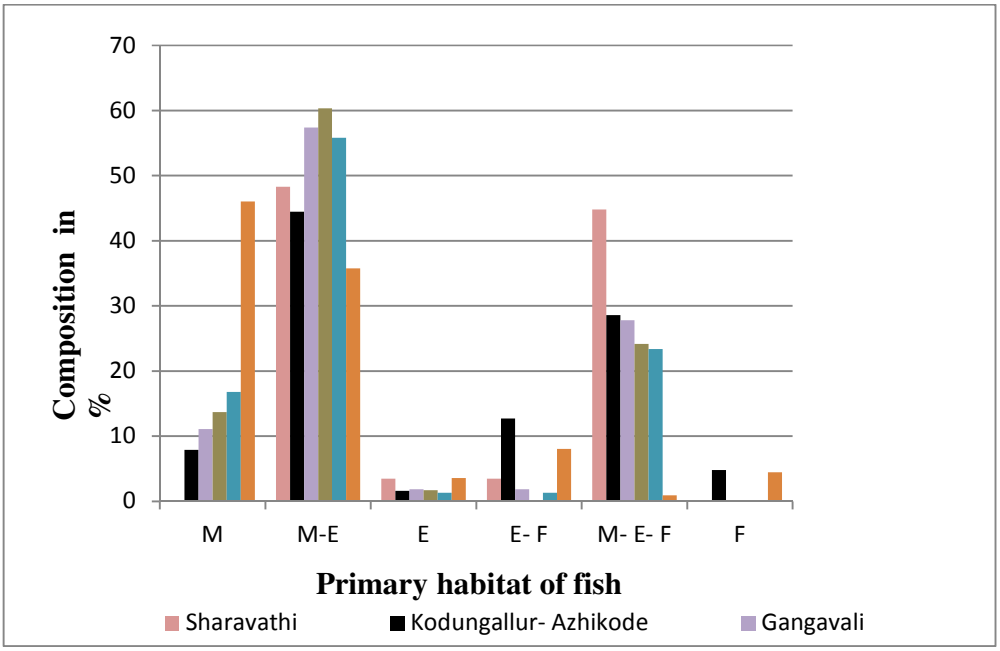


Figure 3: Salinity variation observed along the study sites of Sharavathi Estuary during 2011-2012.

The movement of many marine fishes into Indian estuaries has been linked to favourable hydro-biological conditions within them Sinha *et al.* (1996); Bijukumar and Sushama (2000). In both Aghanashini and Gangavali, without hydel projects, salinity was down to zero ppt in peak rainy months of 2011, rising steadily thereafter to 30-34 ppt towards the river-mouth, decreasing

gradually upstream. At least 7 fishes of Aghanashini and 2 of Gangavali were basically stenohaline marine fishes which entered these estuaries when salinity rose to nearly marine level Ramachandra *et al.* (2013). Sharavathi estuary, overwhelmed by fresh water releases from hydroelectric dams, was poorest in fish species (29 only) and with conspicuous absence of stenohaline marine fishes. Most were euryhaline tolerant of wide range of salinity. Notable species were *Sillago sihama, Lates calcarifer, Glossogobius giuris, Lutjanus argentimaculatus, Scatophagus argus, Mugil cephalus, Stolephorus indicus, Etroplus suratensis* etc. A comparison has been attempted here of the primary habitats of fishes from five different estuaries of South Indian west coast, available from different studies: viz. Kali, Gangavali and Aghanashini in Uttara Kannada, Ramachandra *et al.* (2013), Ponnani, Bijukumar and Sushama (2000) and Kodungallur Azhikode, (Nandan B. S. *et al.* 2012) in Kerala, of which good profiles of fishes are available for comparison with that of Sharavathi. It is noticeable that compared to other estuaries Sharavathi has been very adversely affected by too low salinity as good proportion of fishes are basically of marine-estuarine and of marine-estuarine-fresh water categories (figure 4). Some stenohaline species of very low salinity to fresh water conditions like *Dawkinisia filamentosa, Hyporhampus xanthopterus* also occurred in the estuary.



M-Marine; M-E-Marine, Estuarine; E-Estuarine; E-F-Estuarine, Freshwater; M-E-F-Marine, Estuarine, Freshwater; F- Fresh water.

Figure 4: Primary habitat-wise fish community composition (%) in some south Indian estuaries (Based on Nandan B.S. *et al*. 2012 for Kodungallur-Azhikode; Ramachandra *et al.* (2013) for Kali Gangavali, Aghanashini; Bijukumar and Sushama 2000 for Ponnani).

A sand bar across the river mouth (Figure 5) leaving only a narrow outlet into the sea, probably also would be limiting the entry of sea water against the force of fresh water outflow. Dredging at the river mouth, aimed at removal of the sand bar at least partially, is likely to facilitate better mixing of fresh and salt water, and improve the estuarine fishery, involving also shrimps, bivalves and crabs, resources that are crucial for the livelihoods and nutrition of scores of coastal

people, who have become unintentional victims of developmental interventions like hydro-electric projects (at Linganmakki and Gersoppa in Sharavathi River). The environmental impact assessment protocols on dam construction, anywhere in India, hardly touches upon impact on estuarine ecosystems and this study highlights the need for widening the scope of EIA on developmental projects to even far off ecosystems, if they are connected with project areas especially by water, as is depicted in the current study.

Figure 5: Sandbar formation blocking the mouth of Sharavathi estuary (Google imagery)

Table - 1: List of fish species collected from the Sharavathi estuary (station wise).
Presence (+) Absence (-)

S.No	Family	Scientific name	Common name	Honnavar	Malkod	Balkur
1	Ambassidae	*Ambassis ambassis*	Commersons glass perchlet	+	+	-
2	Ariidae	*Arius arius*	Threadfin sea cat fish	+	+	+
3	Belonidae	*Strongylura strongylura*	Spottail needle fish	+	+	+
4	Carangidae	*Carangoides chrysophrys*	Longnose trevally	+	-	-
5	Cichlidae	*Etroplus suratensis*	Pearlspot	+	+	+
6	Clupeidae	*Sardinella fimbriata*	Fringescale sardinella	+	-	-
7	Cyprinidae	*Dawkinsia filamentosa*	Blackspot barb	+	+	+
8	Engraulidae	*Stolephorus indicus*	Indian anchovy	+	-	-

9	Engraulidae	*Stolephorus commersonii*	Commerson's anchovy	+	-	-
10	Gerridae	*Gerres filamentosus*	Whipfin silver-biddy	+	+	+
11	Gerridae	*Gerres limbatus*	Saddleback silver-biddy	+	+	+
12	Gobiidae	*Glossogobius giuris*	Tank goby	+	+	+
13	Hemiramphidae	*Hyporhamphus xanthopterus*	Red-tipped halfbeak	+	+	+
14	Centropomidae	*Lates calcarifer*	Barramundi	+	+	+
15	Leiognathidae	*Secutor ruconius*	Deep pugnose ponyfish	+	-	-
16	Lutjanidae	*Lutjanus johnii*	John's snapper	+	+	+
17	Lutjanidae	*Lutjanus russellii*	Rusell's snapper	+	+	+
18	Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper	+	+	+
19	Mugilidae	*Mugil cephalus*	Flat head grey mullet	+	+	+
20	Mugilidae	*Liza parsia*	Goldspot mullet	+	+	+
21	Platycephalidae	*Grammoplites scaber*	Rough flathead	+	+	+
22	Polynemidae	*Eleutheronema tetradactylum*	Fourfinger threadfin	+	+	-
23	Scatophagidae	*Scatophagus argus*	Spotted scat	+	+	-
24	Sciaenidae	*Otolithes ruber*	Tigertooth croaker	+	+	+
25	Siganidae	*Siganus vermiculatus*	Vermiculated spinefoot	+	+	-
26	Sillaginidae	*Sillago sihama*	Silver sillago	+	+	+
27	Sphyraenidae	*Sphyraena barracuda*	Great barracuda	+	-	-
28	Terapontidae	*Terapon jarbua*	Jarbua terapon	+	+	+
29	Tetraodontidae	*Arothron stellatus*	Stellate puffer	+	+	+

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4. References

1. Barletta, M., Barletta, A., Bergan, U., Saint-paul and Hubold, G. (2005), The role of salinity in structuring the fish assemblages in a tropical estuary, Journal of fish biology 66, pp 45–72.

2. Bijukumar, A. and Sushama, S. (2000), Ichthyofauna of Ponnani estuary, Kerala, Journal of Marine Biology Association of India, 42 (1 and 2), pp 182–189.

3. Blaber, S.J.M., Cyrus, D.P., Albaret, J.J., Chong Ving Ching, J.W., Day, M., Elliott, M.S., Fonseca, D.E., Orensanz, J., Potter, I.C. and Silvert, W. (2000), Effects of fishing on the structure and functioning of estuarine and near shore ecosystems, Journal of Marine Science, 57, pp 590–602.

4. Breine, J., Maes, J., Ollevier, F. and Stevan, M. (2011), Fish assemblages across a salinity gradient in the Zeeschelde estuary (Belgium), Belgium Journal of zoology, 141, pp 21-44.

5. Brinda, S., Srinivasan, M and Balakrishnan, S. 2010, Studies on Diversity of Fin Fish Larvae in Vellar Estuary, Southeast Coast of India, Journal of Fish and Marine Science, 2 (1), pp 44-50.

6. Day, F. (1889), The fauna of British India including Ceylon and Burma. 'Today and Tomorrow's printers and publishers', vol. I & II. Reprinted 1989.

7. Gutierrez-Estrada, J.C., Vasconcelos, R., and Costa, M.J. (2008), Estimating fish community diversity from environmental features in the Tagus estuary (Portugal): multiple linear regression and artificial neural network approaches Journal of Appllied Ichth., 24, pp 150–162.

8. Fishbase.org, available at http://fishbase.org/search.php, accessed during January 2014.

9. Jayaram, K.C. (1984), In W. Fischer and G. Bianchi (eds.) FAO species identification sheets for fishery purposes. Western Indian Ocean fishing area 51. Vol. I to VI: FAO, Rome.

10. Laegdsgaard, P. and Johnson, C.R. (1995), Mangrove habitats as nurseries: unique assemblages of juvenile fish in subtropical mangroves in eastern Australia. Marine Ecology Progress Series, 126, pp 67-81.

11. Marshall, S. and Elliott, M. (1998), Environmental influences on the fish assemblage of the Humber Estuary, U.K. Estuarine, Coastal and Shelf Science, 46, pp 175–184.

12. McLusky, D.S. and Elliott, M. (2004), the estuarine ecosystem; ecology, threats and management, 3rd edn. OUP, Oxford, p.216.

13. Munro, S.R. (2000), the marine and fresh water fishes of Ceylon. Published by Biotech Books, p. 349.

14. Naik, A. (2003), Studies of fish seed resources of Kali estuary Karwar, Karnataka, India, Ph.D. thesis submitted to Karnatak University, Dharwad, Karntataka, India.

15. Nandan, B.S., Jayachandran, P.R. and Sreedevi, O.K. (2012), Temporal pattern of fish production in a micro tidal tropical estuary in the south-west coast of India, Indian Journal of Fishery, 59(2), pp 17-26.

16. Paperno, R. and Brodie, R.B. (2004), Effects of environmental variables upon the spatial and temporal structure of a fish community in a small, freshwater tributary of the Indian River Lagoon, Florida, Estuary and Coastal shelf science, 61(2), pp 229-241.

17. Ramachandra, T.V., Subash Chandran, M.D., Joshi, N.V., Mahima, B., Prakash, N.M. and Sreekanth, N. (2013), Estuarine Fish Diversity and Livelihoods in Uttara Kannada district, Karnataka State, Sahyadri Conservation Series 34, ENVIS Technical Report 64., CES, Indian Institute of Science, Bangalore 560012, India.

18. Rao, G.S., Kurialcose, P.S., Ramachandran, N., Meiyappan M.M. Achary., G.P.K. Nagaraja, D. and Shivanna H.S. (1989), Atlas of clam resources of Karnataka CMFRI Special Publication., Number 46, pp 1-56.

19. Roopa, S.V. Rathod, J.L. and Vasanthkumar, B. (2011), Fin Fish Diversity in Kali Estuarine Ecosystem of Karwar, Karnataka. World Journal of Science and Technology, 1(3), pp 22-25.

20. Shirodkar, S.R. (2013), Faunal diversity of Gangavali estuary Uttara Kannada, Karnataka, Ph.D. thesis submitted to Karnatak University, Dharwad, Karnataka, India.

21. Sinha, M., Mukhopadhyay, M.K., Mitra, P.M., Bagchi, M.M. and Karamkar, H.C. (1996), Estuaries, 19(3), pp 710-722.

22. Talwar, P. and Jhingran, A. (1991), Inland fishes of India and Adjacent Countries, oxford and IBH Publishing company private limited, 1(2).

23. Thiel, R., Sepulveda, A., Kafemann, R. and Nellen, W. (1995), Environmental factors as forces structuring the fish community of the Elbe Estuary. Journal of Fish Biology, 46, pp 47–69.