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ROLE OF ESTUARY IN SUSTAINING MARINE FISHERY RESOURCES: A CASE STUDY FROM AGHANASHINI ESTUARY IN UTTARA KANNADA, WEST COAST OF KARNATAKA, INDIA

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ABSTRACT
Aghanashini estuary of Uttara Kannada, one of the richest in fish diversity, is a meeting place of fishes with diverse habitat and microhabitat requirements and caters to the nursery and feeding needs of several species of marine fishes. Estuary has a crucial role in the completion of the life cycles of these marine fishes, a fact seldom considered when such an estuary is used for alternative purposes. Of the 77 fish species from 47 families recorded 17% were basically marine and 57% marine-estuarine. Of wide ranging habitats, the euryhaline fishes with tolerances for fluctuating salinity conditions and some even adapted to fresh water constitute 24%. Exclusive estuarine fishes and estuarine to fresh water migrating ones compose only negligible fraction. Such assemblage of fishes in the estuary is possible due to the dynamic nature of estuarine ecological conditions, especially salinity, decided primarily by the mixing up of fresh water from the river and the salt water from the sea. The case study discusses the role of the estuary in the life cycle of many basically marine fishes and calls forth safeguarding such vital habitat from ever increasing human impacts.

KEYWORDS: Uttara Kannada, Aghanashini estuary, Fish, life cycle

INTRODUCTION

Coastal and estuarine systems are highly productive environments and essential fish habitats noted for their role as nursery grounds for many marine species, especially those associated with the continental shelf (Beck et al., 2001; Peterson, 2003). Estuaries are known the world over as breeding and nursery grounds for a variety of marine fishes. Most of the estuarine fishes are indeed not permanent residents there but seasonal migrants from marine areas, especially during their early stages of life. Apart from several marine fishes many other marine organisms, like several shrimp species use estuaries as feeding grounds especially during their early stages (McHugh 1967; Staples 1980; Haedrich 1983; Kannappan and Karthikeyan, 2013). Anadromous species of fishes migrate from sea through the estuary into the freshwater to spawn whereas catadromous fishes move seawards from fresh water en-route to their marine breeding/feeding areas (Haedrich, 1983; Dando, 1984). The marine-estuarine inter-dependence is indispensable for the life cycles of many organisms (Jhingran, 1982, Chao *et al.,* 1982, 1986; Muelbert and Weiss, 1991; Vieira and Castello, 1997).

Estuarine areas are densely populated by humans due to their high productivity, especially from the point of fisheries, apart from mangroves, salt production, as habitats of salt tolerant rice, for coconut cultivation, aquaculture, water transport etc (Nandan, 2008, Ramachandra *et al.,* 2013). Few habitats offer a more challenging environment to marine fishes than bays and estuaries. These interfaces between land and sea at river mouths present highly variable physical and chemical conditions for marine fishes many of which have narrow tolerances to these environmental gradations such as water temperature, salinity, dissolved oxygen, and pH, which change dramatically over space and time in the relatively shallow estuaries, unlike in the sea. Additional complexity in estuarine habitats is created by waterscape elements like mangroves, mudflats and salt marshes

associated or in continuity with them, which react differently to water currents, undergo different degrees of aerial exposure, creating even isolated pools of water during low tides. These dramatic environmental fluctuations notwithstanding, bays and estuaries throughout the world are recognized as important fish habitats, serving as spawning and nursery sites, migration routes, and areas naturally supporting large populations of certain coastal fish species (McHugh, 1967; Haedrich, 1983; Elliott, 2002). Estuarine fishes can be divided into two broad categories according to where they spawn, i.e. spawning in the estuary itself or in the sea. The life cycle of many marine fishes usually involves a predominantly estuarine juvenile phase and a more marine based adult phase. Some species may attain sexual maturity within the estuarine environment but spawning might occur in the sea, due to the more stable environment for the survival of the egg, embryonic and larval stages (Wallace, 1975a; 1975b).

OBJECTIVES

The main objectives of the current study are:

- To inventorise fin-fish diversity of Aghanashini through field survey.
- To bring out the role of the estuary in the life cycle of many commercially important fin fishes, from secondary sources.

MATERIALS AND METHODS

Study area: The study was carried out in the estuary of Aghanashini estuary (Lat 14.391^{O} to 14.585 ^{O} N Long 74.304 ^{O} to 74.516 ^{O} E) of Kumta taluk in the Uttara Kannada district of central west coast in the Karnataka State of India **(Fig. 1)**. Aghanashini is a 121 km long, west flowing river from central Western Ghats of South-west India. Its confluence with the Arabian Sea is a wide estuarine spread of about 48 sq.km area.

Sampling methods: Fish samples were collected on monthly basis from June 2011 to May 2012 from the cast-net hauls, with the help of local fishermen. In addition fishermen were interviewed regarding the availability of fishes in different seasons (pre-monsoon, monsoon, post-monsoon). 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 (1989), Talwar & Jhingran (1991), Munro (2000), and fish base website (www.fishbase.org) were used for identification.

RESULTS AND DISCUSSION

Altogether 77 fish species from 47 families were recorded from Aghanashini estuary. Of them 17% were basically marine, 57% marine-estuarine and 24% of wide ranging habitats sh ifting from marine to estuary and even moving into fresh water. Only a single species *Etroplus suratensis* used estuarine to fresh water habitat zone **(Fig. 2)**. *Tenualosa ilisha,* the famed table fish River shad, is an anadromous fish of Aghanashini estuary, the adults of which are known to move from the foreshore and lower estuary into the upstream fresh water portions of the rivers for spawning (Panhwar *et,al.* 2011). Various studies elsewhere reveal most of the Aghanashini estuary fishes have adult stage in the Sea and juveniles enter the estuary which performs the role of nursery and feeding grounds. These on attaining maturity, or as sub-adults return to the sea for egg laying. Notable commercial fishes of this category are *Terapon jarbua, Gerres filamentosus, Liza parsia, Lutjanus ruselli*, *Lates calcarifer* etc (Krishnamurthy and Jayaseelan 1983; Blaber 1986; Robertson & Duke 1987; Krishnamurthy *et al*., 1978; Davis, 1988; Blaber and Milton 1990; Miu *et al*., 1990; Thollot *et al*., 1990).

Yet another category of marine fishes like *Carangoides Praeustus*, *Rastrelliger kanagurta*, *Nemipterus japonicas, Cephalopholis boenak*, *Pseudorhombus javanicus, Scomberomorus commerson, Pampus argenteus, Glaucostegus halavi* etc. are strictly stenohaline marine fishes which enter the downstream estuary portion during pre-monsoon high salinity period only, obviously for feeding purposes. Few of the marine Herrings, Cods and Whitings, recorded from Aghanashini, are reported elsewhere as utilising estuarine habitats as nursery

grounds (Wheeler, 1978; Potter *et al*., 1988; Henderson & Holmes, 1989; Rogers *et al*., 1998, Power *et al*., 2000b).

According to Ellis *et al.,* (2012) Horse mackerel (*Trachurus trachurus*), a fully marine fish, occasionally occurred in estuaries; it holds good for Mackerel (*Scomber scombrus)* as well. It has been suggested that nursery grounds are those sites where juveniles occur at higher densities, have reduced rates of predation and have faster growth rates than in other habitats, which should result in nursery grounds providing a greater relative contribution to adult recruitment in comparison to non-nursery ground habitats (Beck *et al*., 2003; Heupel *et al*., 2007). Some Soles or flatfishes are marine species that utilise estuarine areas as nursery grounds (Claridge & Potter, 1987). Aghanashini estuary is rich in soles as we have already recorded 6 species.

We recorded the juveniles and adults of several euryhaline fish species (tolerant of wide ranging salinity) such as *Thryssa species, Secutor insidiator, Opisthopterus tardoore, Ambassis ambassis, Otolithes ruber, Carangoides praeustus, Cephalophalis boenak, Nemipterus Japonicus, Arius species, Mugil cephalus* etc. in the Aghanashini estuary. Premcharoen (2013) found some of these fishes in Mae Klong Estuary of Thailand. Robertson and Blaber (1992) associated their juvenile stages with the estuary. Costa and Bruxelas (1989) studied the structure of fish communities in Tagus estuary Portugal state that, since the estuary has high production of suitable food it acts as a nursery ground. *Terapon jarbua* occurs throughout the Aghanashini estuary in all stages. Miu (1990) observed the larvae and Juveniles of the species as entering the estuary of Tamshui river for feeding and retreat to the deeper water farther away from the mouth for spawning when fully grown. The Seabass (*Lates calcarifer*) estuarine to fresh water fish requires greater depths (10-15 m) and higher salinity for spawning. Therefore most adults move into the river mouth areas and the sea for gonadial maturity, during the monsoon period. The larvae / fry /fingerlings move into the estuary for further development and feeding (James and Marchamy, 1987; Mathew, 2009).

CONCLUSION

Tropical estuaries, rated among the highest productive and biodiversity rich ecosystems of the world are also most impacted by humans, directly or indirectly. Direct impacts are related to overharvests of resources, clearances of mangroves, reclamation for housing and agriculture, dredging and constructions for ports, construction of embankments, conversions into aquaculture, sand and shell mining etc. Indirect impacts are mostly related to upstream execution of dams which alter the water flow regime into the estuary, deforestation in catchment areas, pollution and dumping of wastes etc. Estuarine areas being densely populated places resource extraction is of high order with scanty concern for sustainability of the system. It is seldom ever seen by decision makers and developers that the estuarine areas are crucial places for not only estuarine fishery but also for healthy marine fishery. Several marine fishes are known to use the estuarine areas as nurseries for their young ones, which on maturity or as sub-adults return to the sea for breeding purpose. Therefore ecological degradation of estuaries directly or indirectly are going to have far reaching adverse consequences not only on fishery associated with estuary but also will lead towards impoverishment of marine fishery. The case study conducted in Aghanashini estuary goes to illustrate its vital role in sheltering and nurturing marine fishes and calls forth an integrated approach towards more concerted studies and efforts towards conservation of the waterscape and landscape elements associated with the estuary.

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REFERENCES

Beck, M., Heck, K., Able, K., Childers, D., Eggleston, D., Gillanders, B.M., Halpern, B., Hays, C., Hostino, K., Minello, T.J., Orth, R., Sheridan, P., Weinstein, M.P., 2001. The role of nearshore ecosystems as fish and shellfish nurseries. *Bioscience,* 51: 633–641.

Beck, M.W., Heck, K.L.J., Able, K.W., Childers, D.L., Eggleston, D.B., Gillanders, B.M., Halpern, B.S., Hays, C.G., Hoshino, K., Minello, T.J., Orth, R.J., Sheridan, P.F. and Weinstein, M.P. 2003. The role of near shore ecosystems as fish and shellfish nurseries. *Issues in Ecology,* 11: 1–12.

Blaber S.J.M. 1986. Feeding selectivity of a guild of piscivorous fish in mangrove areas of north –west Australia. *Australian journal of Marine and fresh water research,* 37:337-345.

Blaber, S.J.M. 1997.Fish and fisheries of tropical estuaries. Fish and Fisheries Ser, 22, Chapman and Hall, London, pp.367.

Blaber, S.J.M. and Milton D.A. 1990. Species composition community structure and zoogeography of fishes of mangrove estuaries in Salmon islands, *Marine Biology.* 105:259-267.

Chao, L.N., Pereira, L.E., Vieira, J.P., Bemvenuti, M.A. and Cunha, L.P.R. 1982. Relação preliminar dospeixes estuarinos e marinhos da Lagoa dos Patos e região costeira adjacent, Rio Grande do Sul, Brasil. Atlântica, 5: 67-75.

Chao, L.N., Vieira, J. P. and Pereira, L.E. 1986. Lagoa dos Patos as a nursery ground for shore fishes off Southern Brazil. IOC/FAO, Oceanographic Commission *Workshop Report. UNESCO,* 44: 143–150.

Claridge, P.N. and Potter, I.C. 1987. Size composition and seasonal changes in abundance of juvenile sole, Solea solea, in the Severn Estuary and Inner Bristol Channel. J. of the Mar. Bio. Ass. of the Uni. King, 67: 561–569.

Costa M. J., Bruxellas A., 1989. The structure of fish communities in the Tagus Estuary, Portugal, and its role as a nursery for commercial fish species. *Tropics in Marine Biology*, Ros J.D.(Ed) *Scient. Mar*. 53(2-3): 561-566.

Dando, P.R. 1984. Reproduction in estuarine fish in: Potts, G.W., Wootton, R.J. (eds.) Fish reproduction strategies and tactics, Academic Press, London. 155-170.

Day, F. 1989. *The Fauna of British India Including Ceylon and Burma* vol. I & II.

Devis, T.L.O 1988 Temporal changes in the fish fauna entering a tidal swamp system in tropical Australia. *Environmental Biology of fishes*, 21(3): 161-172.

Divakaran N. and Kuttyamma V.J. 2014. Reproductive biology of common silver Biddy, *Gerres filamentosus* (Cuvier) *Advances in Applied Science Research,* 5(4): 144-152.

Elliot, M., and McLusky, D.S. 2002. The need for definitions in understanding estuaries. *Estuar. Coast. Shelf Sci*. 55:815–827.

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. 2012. Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147:156.

FAO Species Identification Guide for Fishery Purposes, 2001. The Living Marine Resources of the Western Central Pacific, FAO, Rome. Fishing Area 51. Vol. 1: FAO, Rome.

Haedrich, R.L. 1983. Estuarine fishes. In: Ecosystems of the world. B. H. Ketchum (ed.). *Elsevier, Amsterdam*, 183–207.

Henderson, P.A. and Holmes, R.H.A. 1989. Whiting migration in the Bristol Channel: A predator-prey relationship. *J. of Fish Bio,* 34: 409–416.

Heupel, M.R., Carlson, J.K. and Simpf endorfer, C.A. 2007. Shark nursery areas: concepts, definition, characterization and assumptions. *Mar. Eco.Prog. Ser*, 337: 287–297.

http://fishbase.sinica.edu.tw.

James, P.S.B.R. and Marichamy, R. 1987. Status of sea bass (*Lates calcarifer*) culture in India, Management of Wild and. Cultured. Seabass /Barramundi (Lates calcarifer) In : J.W. Copland and D.L. Grey (Eds.) *Proc. International Workshop Dai-win, N.T. Australia*, Sept. 1986, ACIR Proc. No. 20.

Jayaram, K.C. 1984. FAO species identification sheets for fishery purposes. Western Indian Ocean fishing area 51. FAO, Rome; volume I–VI, In: W. Fischer and G. Bianchi (ed).

Jayasselan,M._l. and Krishnamurthy,K. 1980. Role of mangrove forests of pichavaram as fish nurseries. *Proc.lndian Natn.Sci.Acad.,* 46 B (1): 48-53.

Jhingran, V.G. 1982. Fish and fisheries of India. 2nd edn. Hindustan Publishing Corporation, Delhi, India, 666 pp.

Jhingran,V.G. and Natarajan, A.V. 1969. A study of the fisheries and fish populations of the Chilka lake during the period 1957-65. *J.Inland Fish. Soc. India*, 1: 49-126.

Kannappan, T. and Karthikeyan M.M. 2013 Diversity of fishes in relation to physcio-chemical properties of Manakudy estuary, Southwest coast of India *International Journal of Biodiversity and Conservation*, 5(7): 396-407.

Krishnamurthy, K. and Jeyaseelan, M.J.P 1981. The early life history of fishes t'rom Pichavaram mangrove ecosystem of India. Rapp. gv. Reun. *Cons. Inst. Enolot Mer*. 178: 416-423.

Krishnamurthy, K. and Jayaseelan, M.J.P. 1983. The Pichavaram (India) mangrove ecosystem. *Int. J. Ecol. Environ. Sci.,* 9: 79-85.

Krishnamurthy, K. and Jayaseelan, M.J.P.1984. Humans Impacts on the Pichavaram mangrove ecosystem: a case study from Southern India. *In proc.Asia. Symp. Mangr.Env. Res.*& *Manag*: 432.pp.

Krishnamurthy, K. and Jayaseelan, M.J.P.1986. Prospects of aquaculture in mangrove ecosystem. *In proc.Coastal aquaculture,* 4:1059-1067.

Krishnamurthy, K., Jayaseelan M.J.P. and Palaniappan, R. 1978. An appraisal of the juvenile fish populations inhabiting the mangroves. *Proc. Symp. on Ecology of animal population,* Calcutta.

Mathew, G., Taxonomy, identification and biology of Seabass (*Lates calcarifer*). In National Training on 'Cage Culture of Seabass', CMFRI, Kochi, 2009, pp. 38–43.

McHugh, J.L. 1967. Estuarine nekton. In: Estuaries. G. H. Lauff (ed.). Vol. 83. *Am. Assoc. Adv. Sci., Spec. Publ.*, Washington, DC. 581–619.

Miu, T.C., Lee, S.C., and Tzeng, W.N.1990. Reproductive Biology of *Terapon jarbua* from the Estuary of Tamshui River. *J.Fish. Soc*.Taiwan 17(1): 9-20.

Muelbert, J.H. and Weiss, G. 1991. Abundance and distribution of fish larvae in the channel area of Patos Lagoon estuary, Brazil. In: Dhbyt, R. (Ed.), Larval fish recruitment and research in the Americas. Proceedings of the thirteenth annual fish conference, *Springfield, Virginia*, 95: 43-54.

Munro, S.R. 2000. *The Marine and Fresh Water Fishes of Ceylon*. Published by Biotech Books. 349 pp.

Nandan, B.S. 2008. Current status and biodiversity modification in the coastal wetland ecosystems of India with objectives for its sustainable management. *Proceedings of conserve-vision conference,* University of Waikato, The University of Waikato, www.waikato.ac.n/ wtass/conservation.

Panhwar, H.K., Siddiqui, G. Ayub, Z. 2011. Reproductive pattern and some biological features of anadromous fish Tenulosa ilisha (family: clupeidae) from Pakistan. *Indian Journal of Geo- Marine Sciencce,* 40(5): 687-696.

Peterson, M. 2003. A conceptual view of environment-habitat-production linkages in tidal river estuaries. *Reviews in Fisheries science* 11(4) : 291-313.

Potter, I.C., Gardner, D.C. and Claridge, P.N. 1988. Age composition, growth, movements, meristics and parasites of the whiting, Merlangius merlangus, in the Severn Estuary and Bristol Channel. *J. of the Mar. Bio.Ass. of the Uni. King*, 68: 295–313.

Power, M., Attrill, M.J. and Tho mas, R.M. 2000b. Temporal abundance patterns and growth of juvenile herring and sprat from the Thames estuary 1977–1992. *J. of Fish Bio*, 56: 1408–1426.

Premcharoen, S., 2013. Ozdemir, S., Şahinkaya, E., Kalıpcı, M.K., Oden (editors). Use of Intertidal Mangrove by Juvenile Fishes: the Case of Mae Klong Estuary, Inner Gulf of Thailand. *Digital Proceeding of the ICOESTC.*

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. 100 pp.

Robertson A.I. and Blaber, S.J.M. 1992. Plankton, epibenthos and fish communities. In: Robertson, A.I., Alongi, D.M. (eds.), Tropical Mangrove Ecosystem, Washington DC: American Geophysical Union, 173-224.

Robertson, A.I.and Duke N.C. 1987. Mangroves as nursery sites: comparisions of the abundance and species composition of fish and crustaceans in mangroves and other nearshore habitats in tropical Australia. *Marine Biology*, 96: 193-205.

Rogers, S.I., Millner, R.S. and Mead, T.A. 1998. The distribution and abundance of young fish on the east and south coast of England (1981 to 1997). *Science Series, Technical Report*, CEFAS, Lowestoft, 108, 130 pp.

Staples, D.J. 1980. Ecology of juvenile and adolescent banana prawns, *Penueus merguiensis*. in a mangrove estuary and adjacent off-shore area of the Gulf of Carpcnteria. *Australian Journal of Marine Freshwater Research* 31: 635-652.

Talwar, P. and Jhingran, A. (1991). *Inland fishes of India and Adjacent Countries* Vol.1, 2.

Thollot P., Kulbicki, M. and Wntiez, L. 1990. Temporal pattern of fish populations in three habitats of the three habitats of the St.Vincent Bay area (New Caledonia): Coral reefs, soft bottoms and mangroves *proceedings ISRS Congress Noumea*, 127-136.

Vieira, J.P. and Castello, J. P. 1997. Fish fauna. In: Seeliger, U., Odebrecht, C. and Castello, J. P. (Eds.), Subtropical convergence environment: The coast and sea in the southwestern Atlantic. Springer, New York, 56-61.

Wallace, J.H. 1975a. The estuarine fishes of the east coast of South Africa. Part I. Species composition and length distribution in the estuarine and marine environments. Part II. Seasonal abundance and migrations. *Oceanographic Research Institute Investigational Report* No. 40.

Wallace, J.H. 1975b. The estuarine fishes of the east coast of South Africa. Part III. Reproduction. Oceanographic Research Institute Investigational Report No. 41.

Wheeler, A. 1978. Key To the fishes of northern Europe. Frederick Warne, 380 pp.

http://www.fishbase.org.

Table 1: The role of estuary in the life cycle of some species/Family/Group of fishes, from available sources.

NAME (Species/ Family/Group)	Relation with estuary	Reference
Acentrogobius griseus	Entire life cycle	Blaber,1997.
Ambassidae	Entire life cycle	Blaber, 1997
Ambassis commersoni	Nursery	Jayaseelan & Krishnamurthy, 1980
Apogon hyalosoma	Entire life cycle	Blaber, 1997
Aridae	Adults	Blaber, 1997
Arrids and Mugillids	Juvenile stage (nursery)	Robertson. & Blaber. 1992.
Carangidae	Juveniles	Blaber 1997
Clupeids(Ophisthopterus tardoore)	Entire life cycle	Blaber 1997
Cynoglossus punticeps	Nursery	Krishnamurthy & Jayaseelan 1983
Engraullidae	Entire life cycle	Blaber 1997
Ephinephelus	Juveniles and Adults	Blaber and Milton 1990,Thollot et al., 1990
Etroplus suratensis	Adults & juveniles in estuary; even enters fresh water	Jayaseelan & Krishnamurthy, 1980
Gerres filamentosus	Fry move into mangrove areas etc.	Divakaran & Kuttyamma, 2014.
Gerres limbatus	Nursery & adults	http://fishbase.sinica.edu.tw
Gobidae	Entire life cycle	Blaber, 1997
Herrings, Cods and Whitings	Nursery	Power et al., 2000b, Wheeler, 1978; Rogers et al., 1998.
Lates calcarifer	Nursery & adults; breeding in sea	Jhingran & Natarajan, 1969
Lates Calcarifer	Adults and Juveniles	Krishnamurthy & Jayaseelan 1986
Leiognathidae,Engraulidae, Siganidae	Nursery	Sichum & Tantichodok 2013
Liza parsia	Spawning in sea; estuary nursery to adults	Talwar and Jhingran 1991
Lutjanus argentimaculatus	Juveniles, young adults in mangrove areas	Talbot 1985; Blaber and Milton, 1990; Thollot et al., 1990
Lutjanus ruselli	Juveniles in mangroves	Blaber & Milton 1990, Davis, 1988
Mugil cephalus	Fry enter estuary, feed on algae & vegetable debris	Krishnamurthy & Jayaseelan, 1984, Maha. St. Gazett
Platax orbicularis	Juveniles and Adults	FAO, 2001
Polynemidae	Juveniles	Blaber, 1997
Pomadasyidae	Adults and juveniles	Blaber, 1997
Scatophagus argus	Nursery	Jayaseelan & Krishnamurthy1980
Secutor ruconius	Nursery	Jayaseelan & Krishnamurthy1980
Sharks and Rays	Nurseries; feed on clams, oysters etc	Maha. St. Gazett
Siganus vermiculatus	Entire life cycle	Blaber, 1997
Sillago sihama	Nursery & adults also use estuary	Jayaseelan & Krishnamurthy1987
Sole	Nursery	Claridge & Potter, 1987
Tenualosa ilisha	Ascends into fresh water for spawning	Panhwar et,al., (2011)
Terapon jarbua	Feeding; breeding in estuary reported	Tsu –ChanMiu (1990)
Thryssa malabarica	Nursery	Krishnamurthy & Jayaseelan 1981
Thryssa mystax	Nursery	Jayaseelan & Krishnamurthy1980
Tylosurus strongylurus	Nursery	Jayaseelan & Krishnamurthy1980

Figure 1: The present study area map

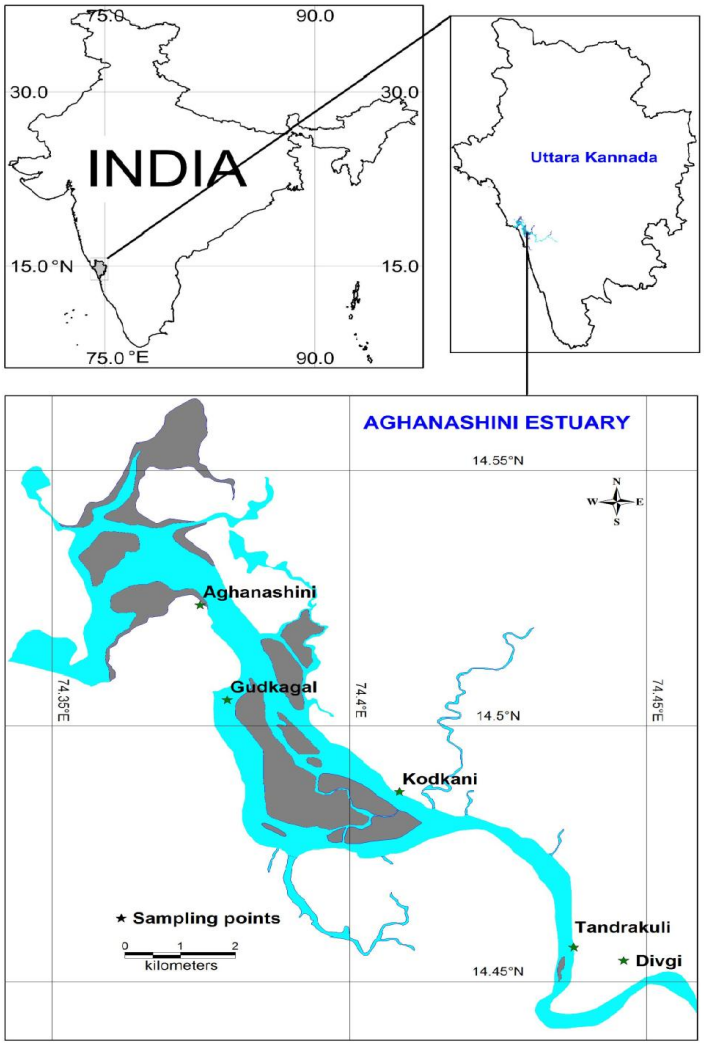
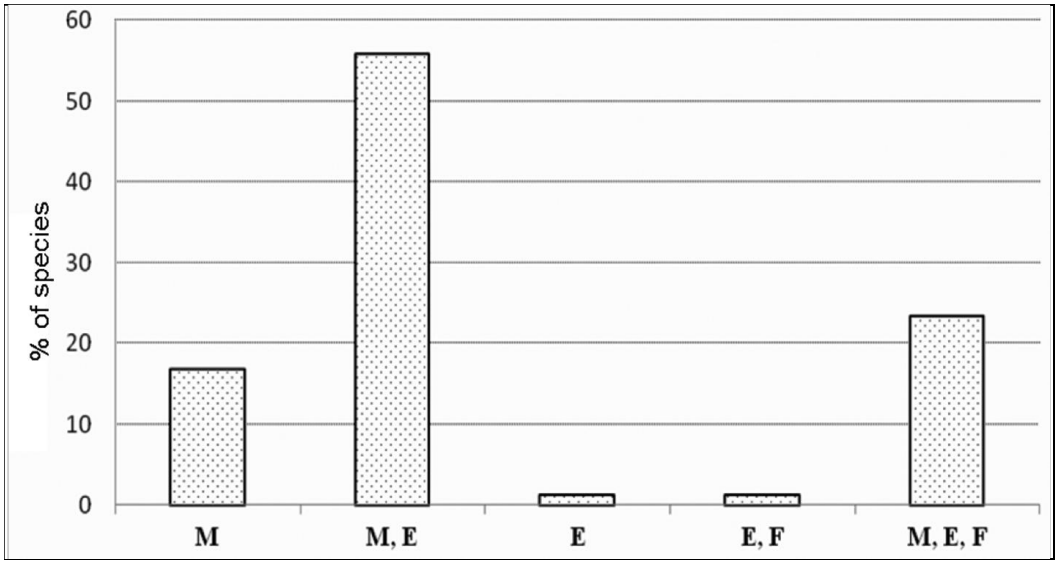


Fig. 2 Habitat combinations of estuarine fishes of Aghanashini (based on www.fishbase.org)



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