Sahyadri Conservation Series 34

ESTUARINE FISH DIVERSITY AND LIVELIHOOD IN UTTARA KANNADA DISTRICT, KARNATAKA STATE

Ramachandra T.V.	Subash Chandran M.D	Joshi N.V.
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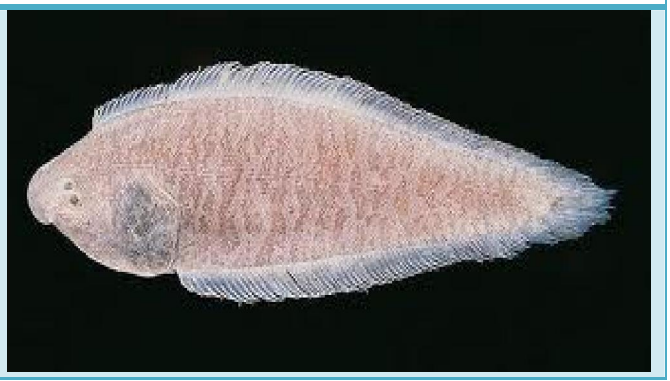

Western Ghats Task Force, Government of Karnataka
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ENVIS Technical Report: 64

August 2013

Environmental Information System [ENVIS]
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SUMMARY AND RECOMMENDATIONS

Estuaries are zones of transition between river and ocean environments and are subject to both riverine and marine influences, such as tides, waves, and the influx of saline water. The freshwater brought in by the rivers mixes with seawater in the estuary. These transitional zones between river and sea are home to several taxonomic groups of fishes and many are of commercial importance. From the fishery development perspective they have high potential as grounds for feeding, spawning and nursery areas for several kinds of fin fishes and shellfishes. Most of coastal aquaculture activities depend on estuaries as centers of seed collection. The fluctuation of physico-chemical characters in estuarine environment has a profound influence on the seasonal occurrence of the juveniles and fish stocks. Estuaries are ranked among the highest productive ecosystems of the world.

Four estuaries of Uttara Kannada, namely Kali, Gangavali, Aghanashini and Sharavathi were studied for fish diversity in relation to water salinity, for capture fishery based livelihoods, for estimating, estuary-wise, numbers of dependent fishermen, their annual income from fisheries, and for problems and prospects for estuarine fishery. Two of the estuaries, Kali and Sharavathi, are impacted by hydroelectric projects in the upstream areas, Gangavali and Aghanashini are unaffected thus far. The water-spread areas of the estuaries, excluding privately owned rice-field cum fish growing areas and prawn farms are excluded.

- ***Fish diversity:*** Kali estuary has 61 fish species from 50 genera and 40 families, Gangavali has 55species from 48 genera and 39 families, Aghanashini has highest diversity of 80 species identified (some by local names yet to be traced out), of 64 genera and 47 families and Sharavathi has lowest number with 31 species identified from 27 genera and 25 families (some by local names yet to be traced out). This high diversity in Aghanashini estuary is obviously due to the relative naturalness of the river, unaffected

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by dams or other major developmental projects. However, shell and sand mining, intensified in the recent decades, have telling effects on estuarine fishery and livelihoods. Intensive prawn culturing activities that vigorously happened in Kali and Aghanashini estuaries during 1970's and 80's, also causing heavy toll on mangroves and fisheries, is on the decline now.

- ***Restoration of abandoned/unused prawn farms/gajnis****:* The Government may consider converting suitable parts of private, unused or abandoned prawn farms/*gajni* fields into mangrove areas through the involvement of the Forest Department/local Self Help Groups/Village Forest Committees so as to increase production of fish, prawns and crabs, in the natural way, and fodder from marsh grasses, apart from facilitating breeding of these organisms. Such steps will also improve nutrient flow in the estuaries and marine areas. Restoration will create healthy, functioning natural coastal ecosystems. The farmers can continue to hold fishing rights through the involvement of local fishermen, if necessary, eliminating contract system.
- ***Safeguarding fishery based employment****:* The four estuaries studied, altogether, constitute a very important employment sector, accounting for about 2,092,000 fishing days/year, benefiting altogether an estimated 3,086 families of estuarine fishermen, earning for them an income of Rs.66.55 crores annually. The four estuaries, together have 7,549 ha area, excluding the private fish/prawn farms and *gajni* rice field cum fishing areas. This works out to the fact that every hectare of estuarine area generates 277 days of fishing work per year and earns an income of Rs.88,157/- ha/year. This is all the more significant that so much of income is without any input from humans except on fishing efforts through human energy alone, as mechanized fishing is not practiced in the estuaries of the district.
- ***Income from edible bivalves (clams and oysters):*** The production of clams and oysters, widely used as food in coastal areas, has been the subject of another report. This is an informal sector of non-specialized fisheries, engaged in also by good number of women and children. When a detailed study was carried out in Aghanashini estuary it came to the light that about 22,000 tons of bivalves were collected in the year 2008-09. About 1738

males and 609 females were engaged in bivalve collection. Many women are involved in sorting of bivalves for sale in outside market. The local sales, including house to house sales are exclusively by women. With the current market value of Rs.30,000/- ton, at Rs.30/- kg. total pricing of the output is estimated at Rs.66 crores annually. Considering the fact so much of produce comes from less than 250 ha of clam beds in Aghanashini, highlights that the annual productivity of one hectare of bivalve bed could be around 88 tons, worth Rs.26.4 lakh at current market prices. As the market value of bivalves, which was known as poor man's food, is steadily rising due to exports to distant markets, the collection is feared to be on a non-sustainable scale. The production of this magnitude is astounding, yet not improbable, as James et al., way back in 1972, had estimated production of 10 kg of clams/sq.m in stretches of estuaries up to one mile from the bar mouth and half that quantity up to 6 miles interior in some of the Dakshina Kannada estuaries. This works out to 100 tons of clams/ha nearer to the estuary mouth in Dakshina Kannada, supporting our estimate of 88 tons/ha especially towards estuary mouth of Aghanashini, and lesser quantities more interior. An estuarine clam collector in the Ashtamudi backwaters of Kerala was estimated to collect approximately 40-50 kg of clams within 3 to 4 hours of collection time per day, way back in 1980's (Appukuttan et al., 1985), which would have been worth at least Rs.1200 to Rs.1500/day if the resource remained to this day!

- ***Bivalve fishery crossing sustainable limits:*** Until some years ago bivalves were very cheap and abundantly available. According to James *et al*., (1972) the price of clams was 20 paise to 50 paise for hundred in Kundapur. As demand was more local the exploitation was limited to 500 to 1200 kg per day. Similar conditions prevailed in Uttara Kannada also. The situation changed drastically today as in Uttara Kannada bulk of the product is being sent to Goa and to other far away markets for higher prices. The clams are sold today in coastal Uttara Kannada markets for Rs.40-60 per hundred and in Goa for Rs.100 for the same number of clams. The exploitation is happening on a big commercial scale without adhering to any norms. This stresses the need for integrated, participatory ecosystem management of estuaries for judicious use of this great food resource.

- ***Reducing pressure on estuarine fishery****:* Fish fauna was abundant some decades ago when fishing efforts were minimal and prices very low. Marine fishing had reached peak in 1980's all over Karnataka coast, when estuarine fish catch was within sustainable limits, as most of the fishing gear was directed towards marine fishing. According to James *et al*., (1972), in the peak estuarine fishing season in the then South Kanara district 400-600 kg of fish was caught from any estuary within two mile distance from the river mouth. The catch was obviously could have been lower to availability levels, as prices were very low ranging between 50 paise to one rupee per kg. Uttara Kannada situation was not much different then. Today the demand for estuarine fish has escalated as the demand is also from far and wide, and the prices have shot up ranging from minimum of Rs.120/- kg to about Rs.600/- kg. Fishing pressure is very high, so much so, estuarine capture fishery (of fin fishes, prawns and crabs) is passing through a critical phase. All the estuaries surveyed are being overfished, as evident from average fishing days/ha. There is not much scope currently to improve fisheries in the dam affected Sharavathi and Kali estuaries. Percentage of fishermen dependent on estuary partially or fully in Aghanashini and Gangavali, unaffected by dams (marine fishermen of non-estuarine village of Belamber excluded from Gangavali estimate) were 71% and 59% respectively. In dam affected Kali and Sharavathi 57% and 21%, respectively, of fishermen from estuarine families fished in estuaries. The estuarine area available/ head for fishing was 0.56 ha in Gangavali and 0.46 ha in Aghanashini (both without hydel projects), 1.58 ha in Kali and a whopping 4.72 ha in Sharavathi (both impacted by hydel projects).
- ***One hectare water for a fisherman:*** Whereas small-scale cage culturing may be promoted in Kali and Sharavathi backwaters to improve fishing community livelihoods it is desirable to reduce fishing pressure in Aghanashini and Gangavali so as to ensure at least one ha of fishing waters/fisherman that could yield, on a simplistic calculation, approximately Rs.195,000/fisherman/year in Gangavali and Rs.154,000/fisherman/year in Aghanashini, from the current levels of Rs.109,265 from 0.56 ha in Gangavali and Rs.70,870 from 0.46 in Aghanashini.

- ***Enriching estuarine vegetation to aid fish breeding and protection of nurserei*s:** Specific areas within the estuaries, especially marshes with vegetation and mangrove areas support much greater densities of organisms, mainly as nurseries, than unvegetated parts (Minello, 1999; Beck *et al*., 2001). Generally an area has been termed as "nursery" if it supports juvenile fish or invertebrates in higher densities, provides greater protection from predators, or grows faster than in other habitats (Beck *et al*., 2001). Identification of fish nurseries within estuaries, where young ones grow faster and in greater numbers than in other areas, is a task to be achieved expeditiously, for future protection through involvement of village communities.
- ***Self-help groups of bivalve collectors:*** Village-wise self-help groups, constituted through local environmental NGO groups, may be organized for evaluation and better sustainability of the resource.
- ***Bivalve collection holidays:*** A concept of two days per week of bivalve collection holidays may be enforced through SHGs' for voluntary acceptance. NGOs have to play key role in this.
- ***People as integral part of estuarine ecosystems:*** Modern concepts of ecosystem management try to consider people as parts of ecosystems. Estuaries of Uttara Kannada were reasonably well protected through generations by traditional communities, despite interventions for livelihoods, almost until late 1960's. The estuarine farmers grew salt tolerant rice in reclaimed portions, the *gajnis*, protected by earthen bunds and strengthened by growing mangroves alongside. Fishing was mainly by fisher-folks, even within *gajnis*. The catches were within sustainable limits as there was not much trade in it beyond the district's limits. Shell collection was mainly for lime making locally. Salt was prepared only in designated areas. Sand mining was in limited quantities to cater mostly for local needs. The situation changed when the Government built permanent embankments for *gajnis* replacing the traditional earthen ones. Mangrove destruction became widespread as they were not needed for strengthening bunds and to meet growing fuel demands. Farmers started auctioning to contractors fishing rights within *gajnis*, which turned out to be virtual shallow dams for storing estuarine water after harvest of

paddy, because of building of permanent bunds. Thus the role of fishermen in catching fish for livelihoods in the *gajnis*, a traditional practice through ages, was replaced with contract system. The fishing pressure thereafter is expected to have intensified in the open water areas of the estuary. The proliferation of ice factories and intensive prawn farming systems destroyed traditional community based management leading to exhaustive catches of fish in markets expanding beyond the district. Considering this background seriously we recommend awareness creation, and people's involvement in fishery management and declaration of parts of estuarine portions rich in mangroves and marsh vegetation as fish nurseries, to be protected through local fishing community involvement.

- **Need for integrative management:** Estuary is a multi-stake-holder based complex ecosystem and a hub of human activities like traditional fishing, edible bivalve harvesting, modern prawns and fish farming systems, cultivation of salt tolerant rice in *gajni* fields, sand mining, shell mining, water transport, salt making, port activities, tourism *etc*. all activities simultaneously going on. The Central Government has made Coastal Regulation Zone Notification applicable to the estuaries. Of the State departments concerned with estuaries in Karnataka are Public Works, Ports and Inland Water Transport, Forests (as regards mangrove afforestation and protection), Agriculture, Fisheries, Brackish Water Fisheries, MPEDA, Mines and Geology etc. Lack of co-ordination among these departments and conflicts with traditional, community based management systems have caused the collapse of the latter, which were more informal. Therefore to safeguard and sustainably use estuarine systems integrated, participatory management is immediate necessity. The Government should evolve an estuarine management policy for safeguarding and restoring integrity of these ecosystems so as to ensure continuity of ecosystem services and the tremendous livelihood support they provide, with practically very little inputs from humans. We need to ensure that estuarine ecosystems are unharmed so that such services are passed on undiminished to future generations as well. Our studies reveal that Sharavathi has nearly lost its estuarine nature and Kali is in the mid-course to its denigration due to upstream hydroelectric projects.

- ***Estuary management to be ecosystem based:*** The present management of estuaries, of which fisheries constitute a vital part, as already explained, is by multiple agencies without any co-ordination, disjointed and disoriented, keeping away the local people, thereby causing enormous harm to the estuarine health and productivity. Therefore, we wish to impress upon the State about evolving ecosystem-based management plans through people's involvement, to be implemented by a single agency. The major issues of such a management plan should be:
    i. Define the physical and functional domain of any estuary through scientific studies.
    ii. Identifying the key components of the given estuary, which need to be considered for upkeep or restoration of estuarine integrity. These components may be physical (salinity, bathymetry, tidal regimes, soils and hydrology) biological, social (stakeholder analysis), natural resource estimate based while taking into account harvesting pressures.
    iii. Analysis of estuarine potential for rendering ecosystem services and livelihood security, threats.
    iv. Preparation of estuary-wise management plans through research, with specifically define management objectives encompassing hydrology, restoration of ecosystem, pollution control, identification and containment of threats, zoning for human uses (fishing, fish conservation and protection of breeding areas, bivalve collection, sand and shell mining, salt production, aquaculture, mangrove and bird conservation, ecotourism etc.) under principles of sustainability through people's participation.
    v. Ongoing monitoring mechanism through research for measuring successes and failures, and estimating progress achieved in fulfilling management objectives.
    vi. Monitoring agency should be able to set norms for extraction of estuarine goods fixing the quotas to be harvested/gathered based on sustainable outputs and should come out with periodical progress reports.
    vii. Involvement of stakeholders is a necessity in designing management plan.

- ***Biodiversity Heritage Sites in estuaries:*** Using the provision of Biodiversity Act-2002, suitable areas within each estuary need to be declared as Biodiversity Heritage Sites, under local panchayat management, through specially constituted Biodiversity Management Committees as per the Act. We have already submitted a separate report depicting the most important mud flats close to Aghanashini village, known for prolific production of edible bivalves and a small island, surrounded by rich mangroves, in mid estuary as Aghanashini Biodiversity Heritage Site. A similar report was prepared and submitted by Dr.V.N. Nayak for portions of Kali estuary to be declared as Heritage Site. Such Heritage Sites are bound to be buffers against the strong exploitative forces operating today in the estuarine ecosystems. We urge that as the declaration of Heritage sites in estuaries will further the cause of fish breeding and enhancement of harvestable fish, such measures may be taken expeditiously after due consultations with local panchayats.

- ***Protecting estuaries from destructive developmental interventions:*** Estuaries are centres of biodiversity, especially supporting rich fisheries. Even several marine fish species are dependent on them for spawning and nursery purposes. At the same time they are constantly under threat of developmental projects, such as dams in upstream areas and industrial interventions. A good portion of Aghanashini estuarine fields were acquired from local farmers and given to an industry – BILT at Binaga in Karwar, in 1970's, for conversion into salt pans. Subsequently the industry abandoned this plan and returned the areas (1815 acres) to Government after conversion of part of the lands into salt pans, at the cost of ecology and fisheries, and depriving local farmers of their estuarine rice fields, as salt production was found to be uneconomic. Thereafter the same estuarine portion was considered for starting a coal-based ultra-mega thermal plant, a plan that was also abandoned under public pressure and reports of adverse environmental impacts. Any conversion of fishery and mangrove rich estuaries, which are also known for their bird fauna, into industrial hubs will be most unimaginative use of such vital places which

provide sustenance to thousands of families. Considering the ecosystem collapse of Sharavathi estuary and impoverishment of Kali estuary, compelling scores of dependent people, particularly fishermen, to look for alternative employment, it is strongly recommended not to utilize estuarine areas, most of which fall within the domain of CRZ-I, for detrimental developmental interventions challenging the functional integrity of these unique ecosystems.

- **Sand mining associated problems:** Sand mining is rampantly happening in all the estuaries of Uttara Kannada. Increased demand for sand from far and wide, coupled with widespread unemployment in fishermen community along the estuarine villages, the resultant of overfishing and fishery collapse due to hydro-electric projects, have attracted many fishermen, having skills in boating and maneuvering in water to work with sand mining contractors and sand traders. This constitutes a well-organized work force in the coastal taluks, who along with main operators try to thwart any attempts to bring controls on sand mining. Whereas periodical sand removal might be necessary to clear the accumulated erosion from land, as a natural process, the present sand policies are being implemented without ascertaining sustainable extraction limits. Environmental problems occur when the rate of extraction of sand exceeds the rate at which natural processes generate these materials. Sand mining licenses are given on administrative terms without any consideration of ecosystem that is affected. Unrestrained sand removal can destroy the estuaries and therefore estuarine fishery and to some extent marine fishery on following counts:

    i. Estuarine bottom getting deepened causing subsidence of banks
    ii. Habitats of bottom-dwelling fishes, fish nurseries and of other benthic organisms like bivalves and crustaceans are destroyed through siltation. It is reported that intensive sand mining in the Chapora River at Kolvale, Goa, for the last three decades, has eliminated the edible black clam (Times of India, Goa, 17-2-2011).

iii. As total load of suspended particles, which are too small to settle down, increases, light penetration is bound to be affected thereby affecting the photosynthetic phytoplankton and zooplankton which constitute foundation for food chains.

iv. No studies are carried out yet in Uttara Kannada on radiation hazards to biological systems and humans because of sand mining.

v. Adverse effect on ground water systems

vi. Adverse impacts on fishery and fish breeding from oil slicks from boats and noise pollution

vii. Filter feeders like bivalves get clogged with siltation and death takes places in masses.

Recommendations on sand mining

i. Estimate annual sand deposit patterns in the estuarine areas

ii. Limit sand mining operations strictly to areas which have highest deposits and least impacts on physical and biological characters of estuaries

iii. Limit sand mining to sustainable limits (matching deposit and extraction)

iv. Movement of extracted sand for local uses should be limited to within the coastal zone of Uttara Kannada only (from Karwar to Bhatkal).

v. The Biodiversity Management Committees of local panchayats and the Village Forest Committees may be authorized to monitor and report any illegality in adhering to established norms.

vi. The parties transgressing the regulations should pay for mitigation costs and contribute to the welfare of fisher-folks and bivalve collectors of the respective areas damaged

vii. The mussel and clam beds of estuarine areas with peripheral buffer zones of at least one km radius are to be strictly protected under CRZ provisions.

- **Regulations on shell mining:** Rich deposits of bivalve shells, which have happened through millions of years, have already been mined for industrial purposes, on large scale, over the last few decades, from especially Aghanashini and Kali estuaries. Shell mining is in need of moratorium, pending critical ecological evaluation, through a transparent process, as the extraction of shell deposits from the bottom of the estuary creates ecological devastations with consequences on fisheries, edible bivalves and mangroves and plankton which are critical initiators of food chains in the estuary.

- **Alternative employment for fisher-folks:** To reduce pressure on fishing it is suggested to increase and create alternative venues for eco-friendly employment such as mangrove based bee-keeping, mangrove planting and protection (fishing folks to be preferred for employment), eco-tourism, value addition to fishes and edible bivalves and similar kinds of alternative employment.

1.0 INTRODUCTION

An estuary is a partially enclosed body of water, where saltwater from the ocean mixes with fresh water from rivers or streams (Pritchard 1967). Estuaries are zones of transition between river and ocean environments and are subject to both marine influences, such as tides, waves, and the influx of saline water, and riverine influences. Being a channel or an embayment with a sea at one end and one or more rivers at the other the freshwater brought in by the rivers mixes with seawater in the estuary (Satish, 2011). These transitional zones between river and sea, throughout the world, are home to several taxonomic groups of fishes, many of commercial importance. The estuarine environment is more challenging than proper marine areas because of its highly variable physical and chemical conditions as most marine organisms tend to have narrow tolerances to environmental gradations. The dynamic estuarine systems provide diverse habitats for the proliferation of distinctly diverse organisms (Jha *et al.,* 2008).

Estuaries are ranked among the highest productive ecosystems of the world. From the fishery development perspective they have high potential as grounds for feeding, spawning and nursery areas for several kinds of fin fishes and shellfishes. Most of coastal aquaculture activities depend on estuaries as centers of seed collection. The fluctuation of physico-chemical characters in estuarine environment has a profound influence on the seasonal occurrence of the juveniles and fish stocks. Fish juveniles are abundantly available in the shallow coastal, estuarine and brackish waters because of relative safety from predators and their composition keep changing with seasons. Dynamic changes in the hydrographical features of estuarine environment cause fluctuations on the survival, growth and breeding of fishes. Estuaries provide an opportunity to study the influence of thermohaline properties on fish distribution. River runoff often creates steep gradients of temperature, salinity, turbidity and nutrients in river mouths. Estuaries provide an ever fluctuating environment because of changes in salinity on a daily basis due to high and low tides and on seasonal basis, as salts are diluted in the rainy season due to the influx of fresh water. Once the rains are past and the fresh water flow diminishes the salinity rises causing shifting of habitats within it by various faunal species, particularly the highly mobile fishes. Estuaries perform crucial roles in the life cycles of many fish species as several fishes use them for egg-laying and nursery. The

abundance of nutrients in the estuary, as mainly inputs from land sources, favour the growth of juveniles of many marine fishes which later move into the sea, their main home to be (Abookire 1999; Jha *et al.,* 2008; Brinda *et al.,* 2010).

Tropical estuaries are a focus of human activity and are considered among the most exploited of ecosystems. World over, including in India, imbalances are happening at various estuarine trophic levels leading to loss of ecological services and biodiversity. Being the natural harbours supporting a number of commercial activities and highly rich in biodiversity they are exploited continuously for addressing the livelihood concerns especially for the traditional fishers. Both food security and the conservation and maintenance of biodiversity, based on estuaries, require knowledge of the ecology of estuarine fishes and the extent to which they are dependent on estuaries or adjacent habitats for survival (Blaber, 2002; Jha *et al.,* 2008)

1.1 Estuarine fish diversity: The Indian coastline is more than 7,300 km in length with an exclusive economic zone of 2.015 X 10^6 that accounts for 61% of the land area of the country. The total estuarine area is estimated at 3,000,000 ha (Jha *et al.,* 2008). Karnataka has over 4,000 ha of estuaries and backwaters (Manisseri and Rao, 2000). Several works have contributed to our knowledge on fish diversity in estuarine systems. Naaf river estuary Bangladesh is notable for 98 finfishes (Chowdhury *et al*., 2010). From Pravara-Sangam of Ahmednagar district 41 fish species were recorded by Shinde *et al*., (2009). From Vellar estuary of South east coast of India, 45 juvenile fishes were recorded, indicating its importance for fish spawning and nurturing of juveniles (Brinda *et al*., 2010). Altogether 200 resident and migratory fish and shellfish species were reported as existing in the estuaries of Kerala (Nandan, 2008). Jayachandran et al (2013) reported 63 fin fishes from 37 families from the Kodungallur-Azhikode estuary of Vembanad wetland system in Kerala. The average yield of estuarine fish production in India was estimated to vary from 45 to 75 kg ha (Jha *et al.,* 2008).

1.2 Habitat preferences of estuarine fishes: The estuary is an intermediate habitat where the ecological system is in a flux being subjected to tidal effects from the sea and flushing with fresh water in seasonally variable proportions from the river or rivers upstream joining the estuary. Fishes with varied ranges of salinity tolerance can be found in different parts of a

natural estuary making it rich in fish diversity. Moreover the high nutrient status due to the input of nutrients from the land and the sea and presence of mangroves, planktonic organisms and castings from a variety of birds visiting or resident in the estuary contribute to high diversity and abundance of fishery resources. Most fish in the estuary use it for feeding since it provides protection from predators (due to mangroves with dense network of aerial roots) and ensure high food availability (Rong Kuo *et al*., 2001)

Estuaries are dynamic ecosystems supporting high levels of biological diversity, as their physical, chemical, and biological characteristics are greatly influenced by freshwater runoff from land and water exchange with the ocean. Traditionally estuarine food web studies focused on characterizing the trophic structure of the system (Atwood, *et al*., 2012). Rochette (2010) highlighted the role of estuaries as essential nursery habitats for many marine species. Mangroves provide unique habitats for many economically important fin fishes (Shervette, 2007). Three distinct estuarine zones have been established based on the dynamics of river and marine waters mixing viz. a riverine zone (upper estuary) in the upper limit of tidal influence, a coastal zone (lower estuary) with the estuarine plume, and an intermediate mixing zone (middle estuary), whose features constantly change due to waters of different characteristics. Although some species may occupy all three zones at times, many different fish species tend to adapt to a particular estuarine zone, thereby forming or changing assemblage structure throughout the longitudinal estuarine extent according to the environmental conditions in each zone (Kjerfve 1987; Blaber, 2000; 2002; Neves *et al*., 2010).

Salinity exercises a strong influence over the distribution of fishes within estuaries. The intermediate and fluctuating salinities typical of estuaries help to keep the number of species down because they prevent stenohaline (with narrow ranges of salinity tolerance) marine and freshwater fishes from penetrating far into estuaries. Most estuarine fishes are capable of living in a wide range of salinities. Although estuary, along with the organisms inhabiting it are studied as a whole, seldom ever is any attempt made to differentiate various ecological niches within it created by ever fluctuating salinity levels or of the impacts of hydroelectric projects in the upstream of river that drain into the estuary- both these objectives are attempted to be achieved in the current study. Freshwater fishes may be sometimes found in the upper reaches of the estuary, while often exclusive marine species frequent the estuarine

mouth when the salinity conditions are favourable. Some species tolerate only intermediate levels of salinity while broadly adapted species can acclimate to any salinity ranging from fresh water to seawater. The ability of estuarine fishes to cope up with salinity fluctuation varies from species to species. Besides salinity, other environmental variables such as temperature, depth and turbidity can play important roles in determining fish assemblages (Blaber, 2000; 2002). Temperature, unlike in the temperate estuaries, is seldom a structuring factor in tropical areas, as it remains relatively stable during the whole year, whereas oxygen may restrict the distribution and movement of fishes (Arau´jo *et al*., 1998, 2002). Tropical estuaries generally have high turbidity (Blaber 2000), which is also considered an important characteristic of rearing grounds for juvenile fishes because visual predators are less effective in the lowered light levels (Blaber & Blaber 1980).

1.3 Importance of estuaries

- Estuary is place where fishes from the salty ocean and from upstream fresh water areas arrive during their respective favourable conditions and mingle with the resident ones.
- Estuaries are very rich in biodiversity being used by scores of species ranging from invertebrates to fish, reptiles, birds and mammals and plants from phytoplankton to mangrove forests.
- Fishes of groups like Mullets, Seabass, Sillago, Snappers, Cat fishes, Groupers etc. are often associated with mangroves.
- Many marine organisms, including many commercially-important fish, need estuaries at some point during their development. Marine fish species rely on the sheltered waters of estuaries as protected spawning places. Estuaries are said to be "nurseries of the sea," being the feeding grounds for the juveniles of several marine fish and prawns.
- Estuaries have important role in sheltering and feeding of migratory birds during winter and resident birds throughout the year.
- Livelihood support from estuaries through fishing, agriculture, water transportation, shell and sand mining, salt making etc. is of high order. All these services are almost free and without any notable inputs from humans.
- Other economic benefits include tourism and recreational activities, ports and harbors etc.

- Estuaries provide places for scientific study
- They store and recycle nutrients, trap sediment and form a buffer between coastal catchments and the marine environment. They absorb, trap and detoxify pollutants acting as a natural water filter. When all such processes remain functional an estuary is considered to be in healthy state
- Estuaries with healthy mangrove vegetation provide protection to life and property by acting as natural buffers to erosion from both the land and the sea and guarantee some safety from cyclones and tsunamis.

(For more details: Gibson, 1973; Desaunay *et al.,* 1981; Macintosh, 1982; Miller *et al.,* 1985; Beck *et al.,* 2001; Able, 2005; Jha *et al.,* 2008).

1.4 Role of estuary in fish breeding/nursery: Some of the studies related to fish breeding in estuaries are cited in the Table 1-1.

Table 1-1: The role estuaries in fish breeding

Estuary	Role in fish life cycle	Reference
Pak Phanang Estuary, Thailand	*Scatophagus argus* migrates into mangrove areas during breeding season; highest density of its larvae noticed in the mangrove plantation during high salinity period	Supichaya 2009
Ponnani estuary, Kerala	Breeding or nursery of Clupeids, milk fish, Cichlids, Gobids, Mullets, Flat fishes, *Lates calcarifer, Gerres filamentosus, Scatophagus argus* etc.	Bijukumar and Sushama 2000
Vellar estuary, Tamil Nadu	Early developmental stages of *Ambassis ambassi, Glossogobius* sp, *Lates calcarifer*, *Secutor insidiator, Sillago sihama, Terapon jarbua* etc.	Bensem, 1987; Brinda et al., 2010
	Seabass from fresh water moves into sea for gonadial maturity. Spawning takes place in the sea; but larvae enter the estuary for further development	Mathew, 2009
Nethravati-Gurpur Estuary, Mangalore	*Etroplus suratensis* (Pearlspot) spawns in the estuary during August to November and January-February	Keshava et al 1988
Zuari estuary, Goa, Dakshina	*Sillago sihama* (Kane, Indian Sand whiting) spawns more than once in a single spawning season June to	Shamsan and Ansari, 2010

Kannada estuaries	December.	
Dakshina Kannada estuaries	*Sillago sihama* (Kane, Indian Sand whiting) juveniles were abundant in Dakshina Kannada estuaries	Ramamurthy and Dhulkhed, 1957.
-do-	*Chanos chanos* (Milk fish) seeds available in Coondapur and Mulki estuaries during April-May	James *et al*., 1972.
-do-	Seed of *Lates calycifer, Mugil* sp. (Mullets), *Megalops cyprinoides, Ambassis gymnocephalus, Therapon* sp., *Gobius* sp. *Scatophagus argus*	-do-
	The juvenile and immature prawns mainly *Metapenaeus dobsoni, M. monoceros* and *Penaeus indicus* abundant. Also young of crab *Scylla serrata*.	-do-
Sharavathi estuary, Uttara Kannada	*Gerres filamentosus* spawning and juveniles observed	Golikatte & Bhat, 2011
	Peak spawning of *Lactarius lactarius* occurs during November–April along Karnataka coast. It spawns during February-April along the Waltair coast, during February-July along Andhra-Orissa coast; during December-March off Karwar coast. Along the northern part of Karnataka coast (Karwar) it spawns for a shorter duration (December-March), in the southern part (Dakshina Kannada) comparatively longer November-April	Zacharia et, al., 2007

1.5 Salinity tolerance ranges of estuarine fishes: Salinity has been considered a central parameter for estuarine studies, as it directly affects the distribution, abundance and composition of estuarine fauna. Salinity in turn is influenced by freshwater inflow and prevailing air temperature. (Pattillo *et al*., 1995; Brinda *et al*., 2010). Seasonal salinity fluctuations appeared to be the main factor that structured the fish assemblage in the entire estuarine system. (Barletta *et al*., 2005). In the Indian conditions, higher salinity was observed during summer months (April-May) due to seawater intrusion, low rainfall, lack of freshwater

inflow and high surface water evaporation due to solar radiation. Kumaran *et al*.,(2012) observed in Giriyampeta estuary Puducherry that during low salinity monsoon period the fish density was also lower. Salinity data in their study shows that low density of fish population during monsoon. Many such studies from the west coast show lowered estuarine salinity during monsoons, due to rains and runoff from the land entering the estuary. In the Kali estuary higher salinity values were recorded during high tides and lower salinity during low tides (Gunaga *et al*., 1987). In the Kodungallur-Azhikode Estuary of south Kerala salinity was found to be the consistently most important parameter explaining variation in assemblage, composition and abundance availability of fish for recruitment into an estuary (Jayachandran *et al.,*2013) depends primarily upon the distributional range of euryhaline marine and estuarine species.In the Pak Phanang estuary of Thailand highest density of *Scatophagus argus* larvae was found in a mangrove plantation during high salinity period (Supichaya, 2009). Paulraj and Kirons (1988) found *Liza parsia* gaining maximum weight at 15 ppt. salinity. In Kodungallur-Azhikode Estuary salinity was consistently the most important parameter explaining variation in assemblage, composition and abundance availability of fish for recruitment into the estuary (Jayachandran *et al*., 2013).

1.6 Threats to estuaries

- The greatest factor leading to loss of marine nursery habitats is through conversion of wetlands, including marshes and mangrove forests, for coastal development, uncontrolled building of shrimp ponds and other large-scale aquaculture / mariculture sites.
- Shell mining, overfishing, indiscriminate cutting of mangroves for timber and fuel and unregulated sand mining.
- Non-sustainable fishing activities
- Dam construction in the river leading to alterations in the water flow into the estuary
- Diversion/overuse of fresh water upstream in the river for agricultural and other purposes leading to scanty summer flow into the estuary.
- Water pollution due to various human activities – release of industrial effluents, sewage, agricultural runoff carrying pesticide and fertilizer residues etc.
- Port operations, dredging
- Industrial and domestic pollution

2.0 OBJECTIVES AND METHOD

The study was carried out as part of the Karnataka Biodiversity Board sponsored project on ***Integrated Ecological Carrying Capacity Study of Uttara Kannada District, Karnataka.*** The parameters of the project fully or partly addressed to under this project study are:

1. Providing inputs for preparing Holistic Net Present Value (HNPV) of the estuarine portions of the main rivers of Uttara Kannada.
2. Inputs for estimating worth of estuary-mangrove based fishery
3. To secure a scientifically prepared database relating to diversity of estuarine fishes, quantification of income from estuarine fishery and employment scenario of fishermen estuary-wise.
4. To estimate the impact of major developmental projects, mainly hydroelectric projects, in the rivers Kali and Sharavathi, on estuarine fish diversity and on fishery related livelihood security. A comparison with the estuarine fishery of Gangavali and Aghanashini rivers, unaffected by such project is attempted here. Such findings are expected to help in preparing **cost-benefit analysis of livelihood security versus benefits from power projects** in case of planning for implementation of such projects in rivers hitherto unaffected.
5. Preparation of a comprehensive database on estuarine fish diversity in relation to salinity gradients, characterizing fish species in relation to their primary and secondary habitats and to finally arrive at management prescriptions.
6. To provide guidelines for sustainable fishery management in estuarine areas.

Although fish diversity of the estuary has been studied to some extent there is no study thus far aimed at estuary-wise exhaustive surveys on fin fish diversity in relation to salinity gradients existing in any of the estuaries, seasonally and spatially. There is practically no database on how many fishermen are dependent on etuarine fishery, on the number of fishing days that any estuary generates, estuarine village-wise fishing income and how much approximately is the total fishing income realized by the estuarine fishing communities. We have attempted here a comparison of fishing income of major Uttara Kannada estuaries and tried to explain any major disparities from different estuaries. The studies have been used to put forth recommendations for better management of estuaries.

2.1 Materials and Methods

Study area: Studies on estuarine fisheries were carried out in the west coast estuaries of Uttara Kannada district (74°05'13" - 75°05'58" E and 13°55'26"-15°31'23" N), situated towards the centre of the Indian west coast, in the Karnataka State. Here the Western Ghats come too close to the Arabian Sea in many places, especially in the Karwar taluk. With over 70% of the district covered with forests the district is very rich terrestrial biodiversity. The rainfall in the district ranges from 2800-5000 mm towards the western parts to about 1150 mm towards the northeast bordering on the Deccan plains. Five notable rivers namely, from north towards south, Kali, Gangavali, Aghanashini, Sharavathi and Venktapur, draining the Western Ghats, after running their short courses through the narrow coastal terrain merge with the Arabian Sea to the west. Towards the coast of alluvial flatlands, winding between flatter and low elevated (<100 m) laterite hills are the estuaries of these rivers. Traditionally known for rich fisheries and also for rice fields and coconut groves, these estuarine banks have densely populated villages and small towns, namely Karwar on the shore of Kali estuary, Ankola to the immediate north of Gangavali estuary, the famous tourist and pilgrimage town of Gokarna lying in between Ganagavali and Aghanashini estuaries, Kumta to the south of Aghanashini estuary, Honavar on the southern bank of Sharavathi estuary and Bhatkal close to Venktapur. Of the five estuaries of the district we have chosen Kali, Gangavali, Aghanashini, and Sharavathi (Figure 2.1-2.4) for the current study.

i. **Kali River** originates in Diggi, a small village in the Joida taluk. This river has a total length of 184 kilometers to its estuarine mouth to the north of Karwar town. It is the lifeline for tens of thousands of people in its valley, including of fisherfolks, providing water for agriculture, fishing and drinking water, sand and shell mining etc. Historically the estuary extended from the river mouth to Kadra 30 km upstream (Kamath 1985). Because of construction of a chain of dams upstream for hydroelectricity, across Kali River for generation of electricity at Supa, Bommanhalli, Upper Kaneri, Kodasalli, Tattihalli and Kadra and continuous water releases from them after power generation, the limits of upstream salinity in the estuary do not often cross 18 km from sea from what was about 30 km earlier. The river is, however, richest in mangroves diversity in the entire district.

ii. **Gangavali River** (Bedthi) originates in the Western Ghats towards the south-west of Dharwad as Shalmali and flows westwards winding through the valleys to join the Arabian Sea, between the coastal villages of Nadumaskeri in Kumta taluk and Gangavali in Ankola taluk, just traversing a total length of 152 km. The estuary portion of the river extends for about 15 kms upstream from the mouth till Gundabale. Gangavali has some good habitats for mangroves covering small, muddy islands and fringing the river banks. The mangroves have suffered from human pressures. The Forest Department is engaged in restoring this vegetation.

iii. **Aghanashini River** (Tadri) has one branch originating at Manjguni about 25 km west of Sirsi and the second close to the town of Sirsi. The streams meet near Mutthalli about 16 km south of Sirsi and thereafter winding its way through Ghat areas course through the Ghat areas it merges with the sea about 10 km south of the Gangavali river, the river mouth bordered by villages Aghanashini in the south and Tadri in the north. Its estuarine part is from the river mouth to about 25 km upstream at Uppinapattana. The estuary of Aghanashini has several mudflats and small islands, and network of drainage canals called *kodis*. Farmers traditionally practiced cultivation of the salt tolerant Kagga rice, in the large expanses of the reclaimed backwaters, called *gaznis*, also known as *Kharlands or Khajans*.

iv. **Sharavathi River** originates at Ambutirtha in Tirthahalli taluk of Shimoga district. On entering Uttara Kannada it hurtles down into a deep gorge creating the magnificent Jog Falls. From thereon it flows westward through the gorge and valleys flanked with evergreen forests. From Gersoppa westwards its course is through landscapes dominated by spice gardens rice fields and laterite hills. About 8 kms from its mouth, the river widens into a lagoon about 3 km broad, containing a few islands. Sharavathi is dammed at Linganmakki in Shimoga district and Gersoppa in Honavar taluk for power generation, causing continuous input of stored freshwater into the river.

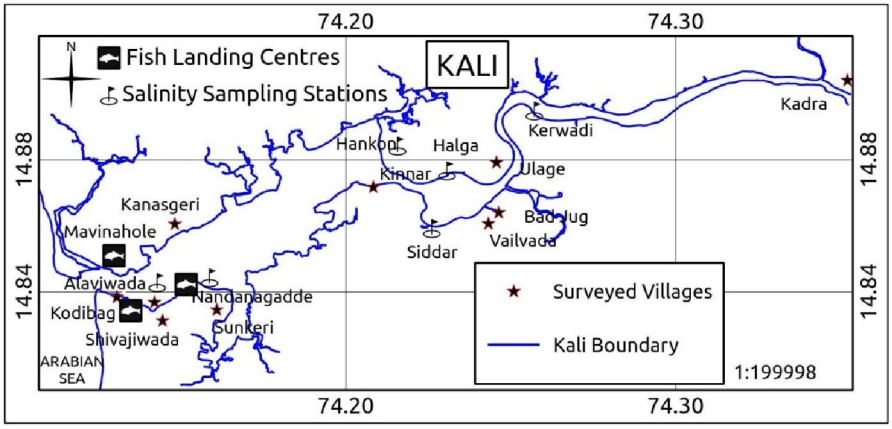

Figure 2.1. Kali estuary showing villages, fish landing centres and salinity monitoring stations

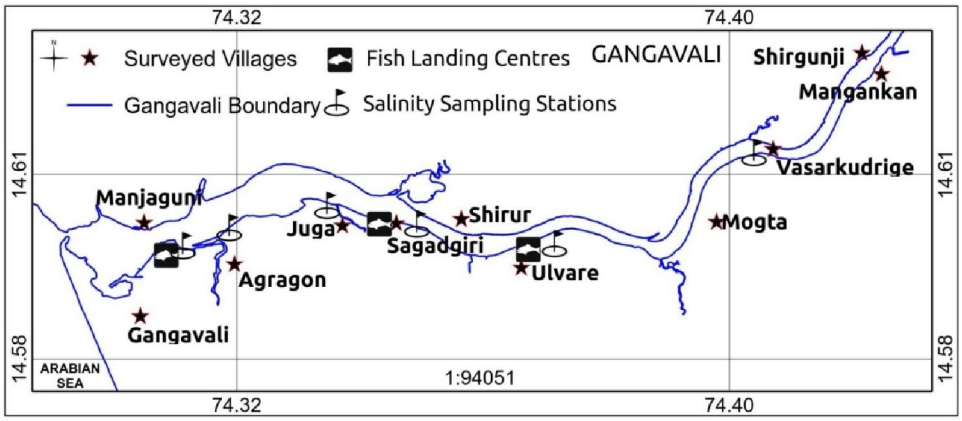

Figure 2.2. Gangavali estuary showing villages, fish landing centres and salinity monitoring stations

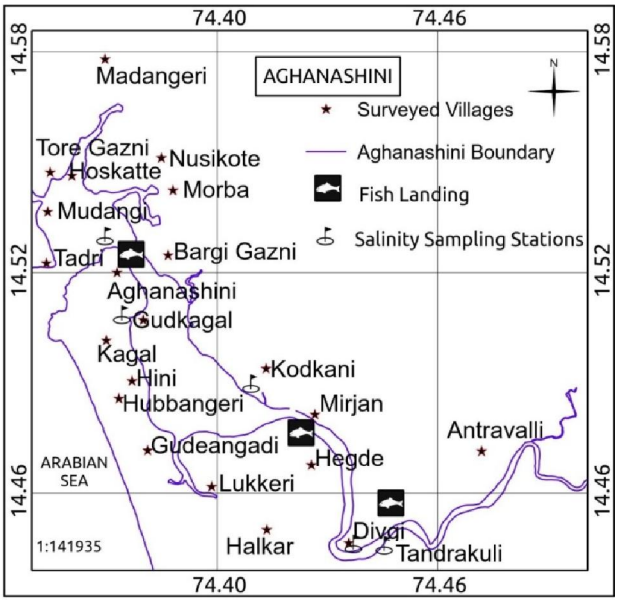

Figure 2.3. Aghanashini estuary showing villages, fish landing centres and salinity monitoring stations

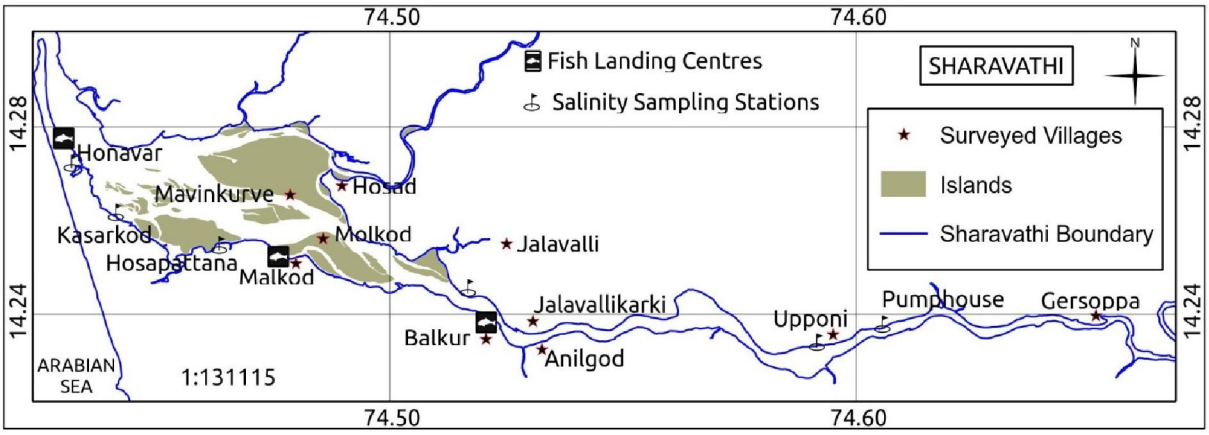

Figure 2.4. Sharavathi estuary showing villages, fish landing centres and salinity monitoring stations

Sampling methods

a. **Fin-fish diversity:** The fish diversity study was carried out during the period of 12 months from June 2011 to May 2012. Weekly samples were collected mainly from different fish landing centres of all the four estuaries (Figures 2.1-2.4). In addition, wherever fishing was going on, opportunistic collections were made so as to gain a

comprehensive picture of estuary-wise diversity. Questionnaire based interviews were conducted with the fishermen and field observations made additionally to understand the range of distribution of fish species within the estuaries and to ascertain the period of their availability. The fish samples collected for identification are preserved in 70% alcohol and deposited in the Kumta Field Station of the Centre for Ecological Sciences, Indian Institute of Science, Bangalore. For standard keys for identification, for their description, geographical distribution, habitats, feeding etc. literature provided by Day (1878), Talwar & Jhingran (1991), Munro (2000) and Fish Base website (www.fishbase.org) were used.

b. **Water salinity:** The water salinity plays an important role in the distribution, diversity and productivity of fishes within the estuary. A preliminary study was conducted during high tides at every two km intervals from the sea mouth to the farthest upstream limits of the estuary. Thereafter the estuary was broadly divided into three salinity zones viz. high salinity zone, closest to the sea (>20 ppt), medium salinity zone (10-20 ppt) and low salinity zone (< 10 ppt). The salinity condition of each zone was monitored, in one or more sampling stations, monthly once, at high tide time from the month of June 2011 to May 2012. At each station surface water was collected in a bottle and salinity measurement taken using salinity refractometer. In Sharavathi estuary only low salinity zone existed. The Fishes are categorized according to their primary habitats and salinity preferences viz. high, medium and low: i. Marine fishes in estuary; ii. Marine to estuarine fishes; iii. Entirely estuarine; iv. Estuarine to freshwater; v. Marine to freshwater & vice versa). Fish that can tolerate only narrow ranges of salinity are known as stenohaline species, while those which tolerating wide range of salinity at some phase or other in their life-cycle are termed euryhaline species. Similarities between the estuaries were quantified using Jaccard's index (Sneath et, al., 1973, Magurran et, al., 1988) based on a presence absence matrix of fish fauna within each estuary using the package past version 2.16.

2.2 Estimating population of estuarine fishermen and interviews on fishery based livelihoods: Estuarine maps are prepared along with villages/hamlets on their banks. The details regarding number of fishing households and fishing community population were obtained from the offices of the Gram Panchayats of respective estuaries. The numbers of

active fishermen (of estuaries) were obtained through surveys and interviews in the field. In every village 5-15 estuarine fishermen were interviewed about their fishery based livelihoods. As estuarine fishery is non-mechanized activity. Fishing efforts and income were estimated per village in terms of number of fishing days/month and average fishing income/fishing day. It needs to be clarified here that by fishing income is meant income obtained from all methods of fishing used in the estuary, excluding from private holdings in the estuary such as *gazni* fields and aquaculture farms. The fishing income estimated covers income from not only fin fishes but also from sale of all commonly marketable organisms used as food – such as crabs and prawns which are netted or snared from the estuary. Estuary-wise and village-wise sample surveys were used for extrapolation of income/day and per year. It was not practicable to obtain weights of fish catches from the estuaries the fishermen being averse to such kind of handling of the fishes. A total of 20 fishing villages were involved in the fishing activities at Aghanashini estuary, 11 villages in Gangavali estuary, and 10 fishing villages each were involved in Kali and Sharavathi estuaries.

3.0 ESTUARINE FISH DIVERSITY

During present investigation a total of 100 fish taxa were recorded from the four estuaries studied in Uttara Kannada district. Of these 83 fish taxa belonging to 64 genera and 49 families were actually observed and identified and remaining 17, known by only local names, are yet to be traced out. Of these unidentified 12 were from Sharavathi and 6 from Aghanashini, one (*Murgunda*) being common to both. Such information given by fishermen needs to be validated through observation of specimens **(Table 3.1** for estuary-wise fish data**).** Aghanashini ranked highest in fish diversity with 86 taxa from 64 genera and 47 families. Kali estuary had 61 taxa, from 50 genera and 40 families; Gangavali estuary had 55 taxa from 48 genera and 39 families and, surprisingly, only 43 taxa from 27 genera and 25 families could be recorded from Sharavathi; out of them 12, known only from local names, are yet to be traced out. Although Kali and Aghanashini estuaries have nearly equal sized water spread areas the former had only 61 taxa as compared to 86 in the latter. Further though Gangavali is a much smaller estuary compared to Sharavathi, it nevertheless had 55 taxa of fishes compared to 43 in the other.

Table 3.1. Inventory of fishes from four estuaries studied in Uttara Kannada (K= Kali; G=Gangavali); A=Aghanashini and S=Sharavathi)

Family	Scientific name	Common name	Local names (Kannada)	K	G	A	S
Marine							
Clupeidae	*Sardinella fimbriata*	Fringescale Sardinella	Pedi	+	+	+	+
Engraulidae	*Stolephorus indicus*	Indian anchovy	Belanji	+	+	+	+
Carangidae	*Carangoides Praeustus*	Brownback trevally	Haluguruku	+	+	+	-
Scombridae	*Rastrelliger kanagurta*	Mackerel	Bangade	+	+	+	-
Nemipteridae	*Nemipterus japonicus*	Japanees thread fin bream	Rane menu	+	+	+	-
Serranidae	*Cephalopholis boenak*	Blue lined coral cod	Gobrya, Kallumurge	+	+	+	_
Bothidae	*Crossorhombus azureus*	Blue spotted flounder	Masur leppe	+	-	+	-
Paralichthyidae	*Pseudorhombus javanicus*	Javan flounder	Nengu	+	-	+	-
Scombridae	*Scomberomorus commerson*	Narrow-barred Spanish mackerel	Iswana	_	_	+	-
Stromatidae	*Pampus argenteus*	Silver pomfret	Bili manji	-	-	+	-
			Total (10)	8	6	10	2
Marine - Estuarine							
Scatophagidae	*Scatophagus argus*	Spotted scat	Hulka	+	+	+	+
Carangidae	*Carangoids chrysophrys*	Longnose trevally	Kokkara	+	+	+	+
Ariidae	*Arius arius*	Threadfin sea catfish	Bilisady	+	+	+	+
Siganidae	*Siganus vermiculatus*	Vermiculated spinefoot	Baana, Padiyar	+	+	+	+
Tetraodontidae	*Arothron stellatus*	Starry blow fish	Chonja	+	+	+	+
Engraulidae	*Stolephorus commersonnii*	Commerson's Anchovy	Dodda danashi	+	+	+	+
Platycephalidae	*Grammoplites scaber*	Rough flathead	Vadati	+	+	+	+
Sillaginidae	*Sillago sihama*	Silver sillago	Nogla	+	+	+	+
Sciaenidae	*Otolithes ruber*	Tigertooth croaker	Banagu, Dodi	+	+	+	+
Sphyraenidae	*Sphyraena barracuda*	Great barracuda	Onakaandi	+	+	+	+
Lactariidae	*Lactarius lactarius*	False trevally	Samdale	+	+	+	-
Belonidae	*Strongylura leiura*	Banded needle fish	Burkaandi	+	+	+	_

Carangidae	*Megalaspis cordyla*	Torpedo trevally	Guruku	+	+	+	-
Carcharhinidae	*Scolidon sps*	Shark	Sora	+	+	+	-
Platacidae	*Drepane punctata*	Spotted sickle fish	Chandaka	+	+	+	-
Carangidae	*Caranx ignobilis*	Giant kingfish	Guruku	+	+	+	-
Dasyatidae	*Dasyatis bleekeri*	Bleekers whip ray	Hola	+	+	+	-
Clupeidae	*Opisthopterus tardoore*	Tardoore	Pachage	+	+	+	-
Leiognathidae	*Leiognathus splendens*	Blacktip ponyfih	Guruku	+	+	+	-
Lobotidae	*Lobotes surinamensis*	Tripletail	Pavade	+	+	+	-
Engraulidae	*Thryssa mystax*	Moustached thryssa	Vaintali	+	+	+	-
Rhinobatidae	*Glaucostegus halavi*	Halavi ray	Balagende Torke	+	+	+	-
Leiognathidae	*Secutor insidiator*	Pugnose ponyfish	Guruku	+	+	+	-
Soleidae	*Synaptura commersonnii*	Commerson's sole	Leppe	+	+	+	-
Trichiuridae	*Trichiurus lepturus*	Largehead hairtail	Barik hamle	+	+	+	-
Sciaenidae	*Johnius belangeri*	Belanger's croaker	Banagu	+	+	+	_
Triacanthidae	*Tricanthus biaculeatus*	Short-nosed tripod fish	Kuduremeenu, kadbale	+	+	+	-
Sphyraenidae	*Sphyraena obtusata*	Obtuse bararcuda	Hallin kaandi	+	+	+	-
Cynoglossidae	*Paraplagusia biliniata*	Double lined tongue sole	Leppe	+	-	+	-
Cynoglossidae	*Cynoglossus macrostomus*	Malabar sole	Leppe	+	-	+	-
Platacidae	*Platax orbicularis*	Orbicular bat fish	Manji	+	-	+	-
Siganidae	*Siganus argenteus*	Streamlined spine foot	Baana	+	_	+	-
Engraulidae	*Thryssa malabarica*	Malabar thryssa	Vaintali	+	-	+	-
Gobiidae	*Trypauchen vegina*	Burrowing goby	Bombale	+	-	+	-
Engraulidae	*Thryssa setirostris*	Long jaw thryssa	Vaintali	+	_	+	-
Carangidae	*Atule mate*	Yellowtail scad	Guruku	-	+	+	-
Pempheridae	*Pempheris moluca*	Mollucan sweeper	Ramachi	-	-	+	-
Pomadasyidae	*Pomadasys maculatus*	Saddle grunt	Guruku	-	-	+	-
Rhinobatidae	*Glaucostegus sps*	-----	Kari Balagende Torke	-	-	+	-
Ariidae	*Arius Caelatus*	Engraved sea catfish	Gonde Sady	_	-	+	_
Stromatidae	*Parastromateus*	Black pomfret	Kari manji	-	-	+	-

	niger						
Rhinobatidae	*Glaucostegus sps*	-----	Hullu Torke	-	-	+	-
Rhinobatidae	*Glaucostegus sps*	-----	Hakki torke	-	-	+	-
Rhinobatidae	*Glaucostegus sps*	-----	Het Torke	-	-	+	-
Sciaenidae	*Chrysochir aureus*	Reeve's croaker	Mooru hallin banagu	_	-	+	-
Sphyraenidae	*Sphyraena spp*	-----	Suji kaandi	-	-	+	-
Sphyraenidae	*Sphyraena spp*	-----	Bura kaandi	-	-	+	-
Belonidae	*Tylosurus strongylurus*			-	-	-	+
			Total (48)	35	29	47	11
Estuarine							
Lutjanidae	*Lutjanus johni*	John's snapper	Hottekemsa	+	+	+	+
Lutjanidae	*Lutjanus ruselli*	Russell's snapper	Kemsa	+	+	+	+
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper	Eri	+	+	+	+
			Total (3)	3	3	3	3
Estuarine - fresh							
Cichilidae	*Etroplus suretansis*	Pearl spot	Kagalse	+	+	+	+
Gobiidae	*Glossogobius giuris*	Tank goby	Bili Mandli	+	+	+	+
Synbranchidae	*Monopterus albus*	Asian swamp eel	Kolav	-	+	+	-
Gobiidae	*Glossogobius sps*	----	Kari Mandli	-	-	+	-
Cyprinidae	*Dawkinsia filamentosus*	Black spot barb	Pidtol	_	_	_	+
			Total (5)	2	3	4	3
Marine - Estuarine - freshwater							
Gerridae	*Gerries filamentosus*	Threadfin silverbiddy	Girbaingi	+	+	+	+
Gobiidae	*Periophthalmus koelreuteri*	Mudskipper		+	+	+	+
Mugilidae	*Mugil cephalus*	Flathead grey mullet	Madle	+	+	+	+
Mugilidae	*Liza parsia*	Goldspot mullet	Madle	+	+	+	+
Polynemidae	*Eleutheronema tetradactylum*	Four Finger Threadfin	Raws	+	+	+	+
Teraponidae	*Terapon jarbua*	Cresent pearch	Kumbari, Garge	+	+	+	+
Gerridae	*Gerres limbatus*	Saddleback silver biddy	Mundbaingi	+	+	+	+
Leiognathidae	*Secutor ruconius*	Deep pugnose ponyfish	Guruku	+	+	+	+

Latidae	*Lates calcarifer*	Barramundi, Seabass	Kurude	+	+	+	+
Batrachoididae	*Austrobatrachus dussumeri*	Flat toad fish	Gonke, Gorke	+	+	+	+
Ambassidae	*Ambassis ambassis*	Commersons glassy perchlet	Burante	+	+	+	+
Cynoglossidae	*Cynoglossus punticeps*	Spotted tongue sole	Leppe	+	+	+	-
Ophichthyidae	*Pisoodonophis cancrivorus*	Snake eel	Aragotka	+	+	+	-
Apogonidae	*Apogon hyalosoma*	Humpbacked cardinal fish	Burante	-	+	+	-
Ophichthidae	*Caecula polyopthalmus*	Ocellated sand-eel	Hemalga	-	-	+	–
Hemirhamphidae	*Hyporhampus xanthopterus*	Red tipped half beak	Soundkaandi	–	–	–	+
Hemiramphidae	*Hemirhampus lutkeii*	Black barred half beak	Toli	-	-	+	-
			Total (17)	13	14	16	12
Fishes to be traced out							
			Malati pedi	-	-	+	–
			Hembale	–	–	+	–
			Soge	–	–	+	–
			Adaga	–	–	+	–
			Baalya	–	–	+	–
			Murugundu	–	–	+	+
			Avalumeenu	–	–	–	+
			Ante	–	–	–	+
			Bale	–	–	–	+
			Hallmeenu	–	–	–	+
			Kadas	–	–	–	+
			Kelas menu	–	–	–	+
			Kukla	–	–	–	+
			Mogane	–	–	–	+
			Mumb	–	–	–	+
			Susila	–	–	–	+
			Vante	–	–	–	+
			Total (17)	0	0	6	12
	Total species of each estuary			**61**	**55**	**86**	**43**

The result of cluster analysis (Jaccard similarity index) based on fish diversity of different estuaries shown in **Figure 3.1.** Between Kali and Gangavali, estuaries in proximity, 80% similarity is seen. Kali-Gangavali cluster has 70% similarity with Aghanashini and this trio of estuaries is only about 40% similar to Sharavathi in fish composition.

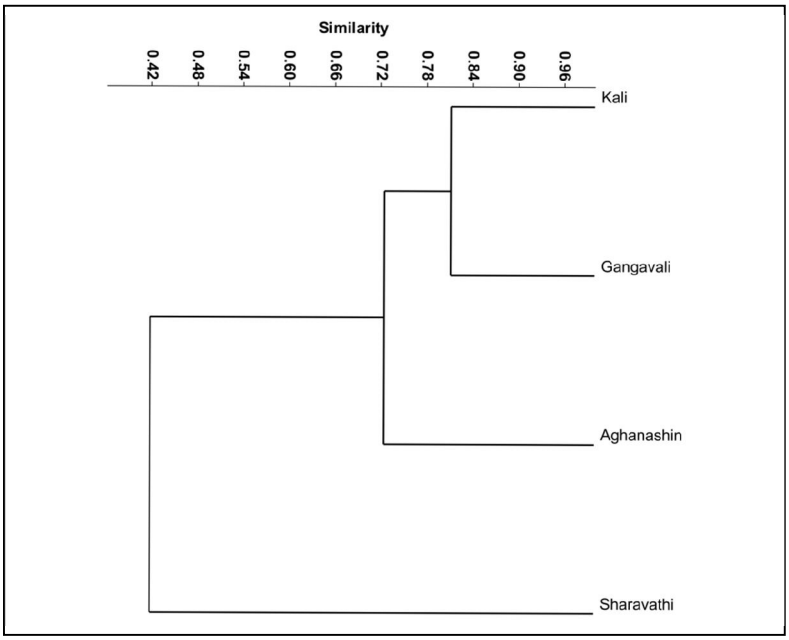

Figure 3.1. Jaccard similarity index for fish diversity in 4 estuaries of Uttara Kannada

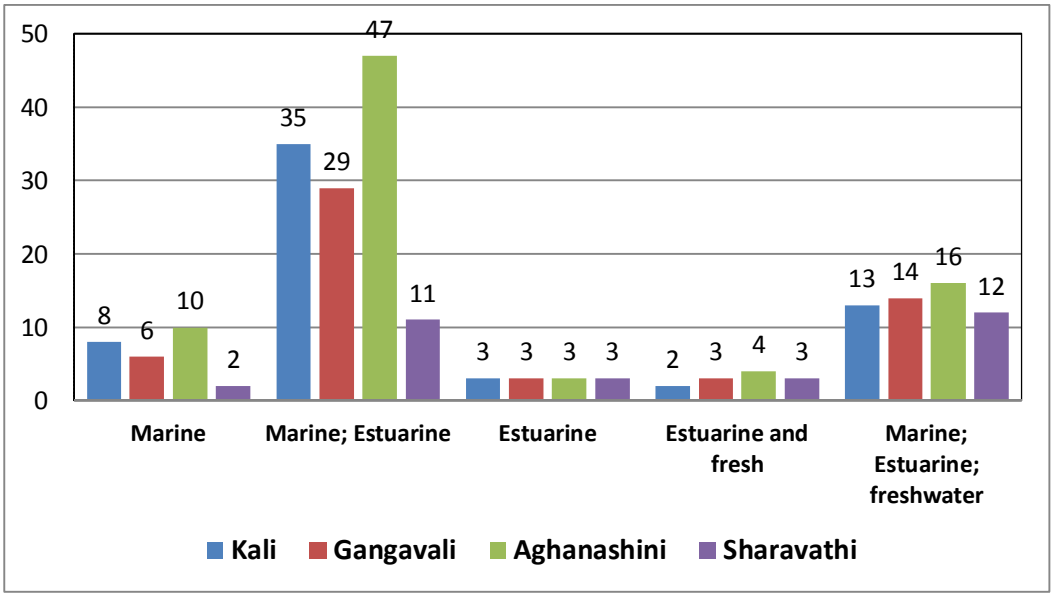

Figure 3.2. Habitat-wise number of fish species in the four estuaries of Uttara Kannada

Primarily marine fishes that visit especially downstream estuary are fewer in number. Highest of 10 such species occurred in Aghanashini, followed by Kali (8), Gangavali (6) and only 2 in Sharavathi. Marine to estuarine species were also highest in Aghanashini (47), followed by Kali (35), Gangavali (29) and only 11 in Sharavathi. All the four estuaries had just three species of fishes which can be called entirely estuarine. All of them were highly valued snappers (*Lutjanus* spp.) which command high market prices. Highly euryhaline fishes that move from sea to fresh water and vice versa passing through estuarine areas were found to be more comfortable with all the four estuaries (Figure 3.2).

4.0 ESTUARINE SALINITY AND FISHERIES

Among various hydrological factors, salinity is found to be the most fluctuating factor in the estuarine environment (Brinda et, al., 2010). Fish assemblages in the estuaries are largely structured by abiotic gradients, mainly salinity. Nandan (2012) attributed sudden changes in the salinity during the monsoon season as the major cause for sudden decline of marine fishes in the Kodungallur-Azhikode Estuary.

4.1 Temporal patterns of estuarine salinity: In the Kali estuary of Karwar salinity tends to fall with increasing distance from the river mouth. The salinity gradient mainly depends upon runoff from the land, rainfall and evaporation from the estuary itself. With the higher rainfall and greater runoff from the land during monsoon, the evaporation becomes insignificant (Bhat *et al*., 1988; Neelakantan *et al*., 1988). In the same estuary salinity fluctuation was comparatively more around full moon and new moon days. The range was minimum during the half moon day (Gunaga *et al.,* 1987).

In the current study salinity was measured month-wise, during high tide, in all the estuaries at different sampling stations at increasing distances from the river mouth. In the Kali estuary, Kodibag station closer to the sea had highest salinity of 34.5 ppt during May, (35-37 ppt being that of the Arabian Sea near the coast). Bhat (1984) and Gunaga (1989) had also made similar observations. At the same time Kerwadi's, (18 km upstream) salinity was 8.5 during May. Salinity dropped to less than 5 ppt in June and further down from 2.5 to 0 ppt in July, the peak of monsoon. The prevalence of very low to zero ppt salinity in the Kali estuary during peak monsoon was observed earlier also by Bhat (1984), Naik (1986), Gunaga (1989)

and Naik & Neelakantan (1991), and in the Mandovi and Zuari estuaries of Goa by Achuthankutty (1987). Throughout the main rainy months the salinity from June to September salinity scarcely reached 10 ppt anywhere in the estuary. Sunkeri and Kodibagh stations, closest to the sea recorded 25 ppt and more from August onwards to almost mid-June, until flood waters from the mountains and drainage from the land brought it down to lowest in July. High salinity preferring fishes and most other estuarine fishes tend to congregate in this downstream of estuary during rainy season.

The constant release into the river of fresh water after power generation from a series of hydroelectric dams in Kali River was found to have a telling impact on overall estuarine salinity, keeping it lower than other estuaries without dams. The mid estuary (Zone-II) and the upstream estuary (Zone-III) were most affected by reduced salinity conditions than the Zone-I. The impact of hydel projects in Sharavathi River resulted in serious upsets in esturine salinity, which happened to be lower than 0.5 ppt; the severity seems to be aggravated by a sand bar across the river mouth leaving only a narrow exit to the Arabian Sea, virtually converting the smaller estuary, in comparison to Kali also with dams, into a fresh water lake with tremendous upsets in estuarine fish diversity and fishery, and also eliminating most of the edible molluscs that existed earlier.

Gangavali and Aghanashini being normal estuaries without dams, salinity remained unaffected except by natural causes. In the peak period of rains during July to September almost fresh water conditions prevailed throughout in these estuaries, because of uninterrupted flows of huge volumes of land drainage. Gangavali had peak salinities of over 30 ppt during March to May in the stations Gangavali and Agragon closer to the mouth, whereas in the farthest upstream station of Sagadageri it was around 8 ppt during April-May. During July-August salinity was 0 ppt in all the stations of Aghanashini. In other months it was highest, between 30-35 ppt in Aghanashini station closer to the sea and of decreasing order in interior stations (Figure 4.1).

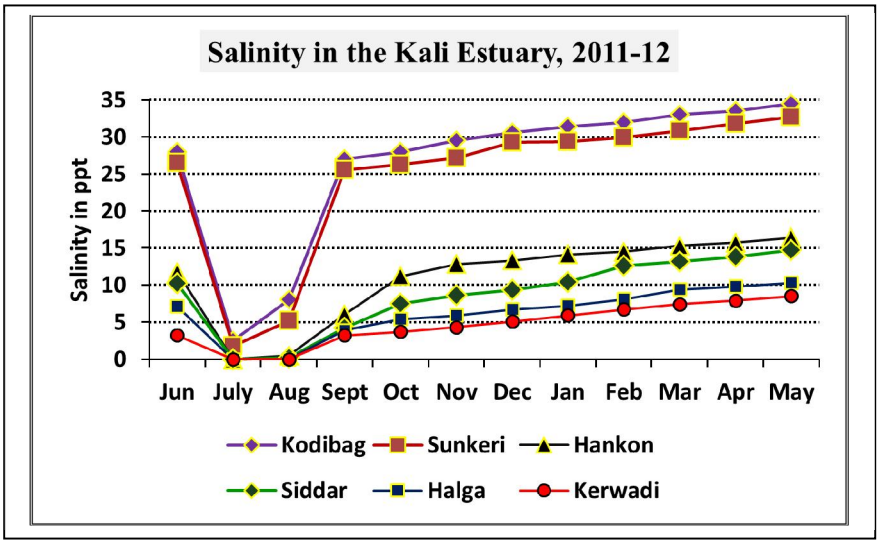

Figure 4.1. High tide salinity in Kali estuary

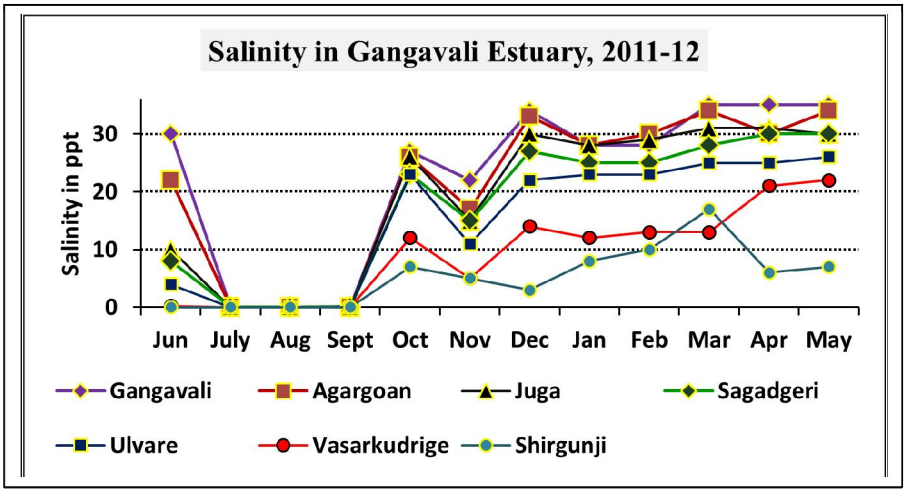

Figure 4.2. High tide salinity in Gangavali estuary

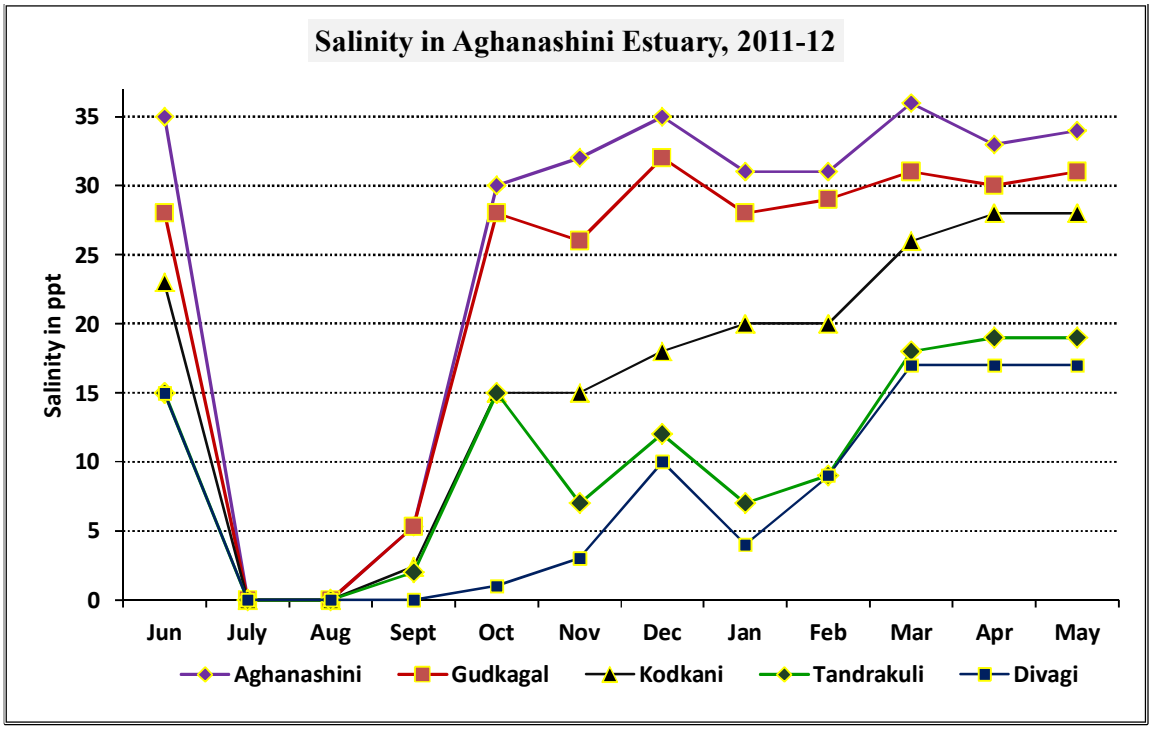

Figure 4.3. High tide salinity in Aghanashini estuary

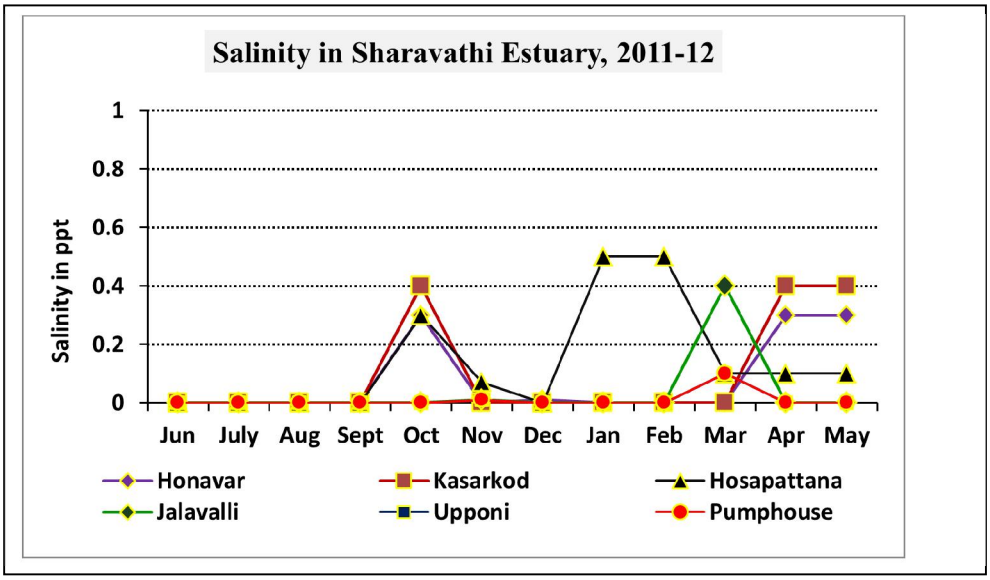

Figure 4.4. High tide salinity in Sharavathi estuary

4.2 Fish distribution in relation to salinity: Based on monthly measurements of salinity we have proposed here three gradients of salinity viz: Zone I (>20 ppt), Zone II (10-20 ppt) and Zone III (<10 ppt) and fish samplings carried out throughout the year have been related to

salinity zones. We have considered here only post-monsoon salinity regimes for such zoning within the estuaries. Zone-I is the fore-estuary closer to the sea, Zone-II is the mid estuary and Zone-III is the upstream estuary where the salinity declines and merges with the fresh water from the river. In all the estuaries (except Sharavathi which had neither Zone I nor Zone II). maximum fish diversity was from Zone-I. In Aghanashini all the 80 fishes identified occurred in Zone-I at one time time or the other. So was the case in Kali where all the 61 recorded taxa and all the 55 taxa of Gangavali occurred in Zone-I. Zone II of moderate salinity conditions, the mid-estuary zone, followed in fish taxa richness with 66 taxa in Aghanashini, 55 in Kali and 47 in Gangavali. The upstream low salinity zone, the Zone-III, of the estuaries (the entire estuary in the case of Sharavathi), had the least fish diversity – 27 each in Kali and Gangavali and 28 in Aghanashini, and all the fishes of Sharavathi.

An estuary in itself having lowest to highest (approaching nearly sea water salinity) salinity ranges tend to have maximum diversity of fishes, as fishes tolerant of varied salinity conditions find suitable niches in it in their respective salinity zones. Salinity zones are dynamic systems depending on amount of fresh water mixing with sea water which depends on tides and seasons. Rainy season finds most of the estuary having lowest salinity and during summer salinity turns highest in portion of estuary nearer to the sea, the Zone-I, declining in downward progression towards mid estuary (Zone-2) turning least upstream areas (Zone-3). In our study only 3 taxa were **exclusively estuarine**, and these (3 species of *Lutjanus*) occurred in all the four estuaries. Munro (2000) also considered these 3 species viz. *Lutjanus johni, L. ruselli* and *Lutjanus argentimaculatus* as exclusive estuarine fishes.

About 10 fish taxa, which are **basically of marine** habitat, occurred in the Zone-I of high salinity. Aghanashini was richest having all these 10, whereas Sharavathi was poorest with just 2 such taxa namely *Stoliphorus indicus* (Indian anchovy or *Belanji*) and *Saridinella fimbriata* (*Pedi*) which, of course, occurred in the three other estuaries also. **Marine to estuarine species** constituted the bulk of fish taxa (48) out of which 47 occurred in Aghanashini, followed by 35 in Kali, 29 in Gangavali and only 11 in Sharavathi. A small number of taxa (5) shared **fresh water to estuarine** areas. Of these *Dawkinsia filamentosa* was exclusive to Sharavathi estuary. This fish occurs in fresh water ponds as well. Altogether 17 taxa being adapted to wide range of salinity from **marine to fresh water** are truly euryhaline. Of these fishes, 12 were present in Sharvathi for understandable reasons and 16

occurred in Aghanashini, a natural estuary still, with all gradients of salinity. Wongchinawit *et, al.,* (2009) noted *Scatophagus argus* as tolerant of high to low salinity conditions.

Reasons for richness of Zone-I: Zone-1 closer to the sea, experiences rapidly rising salinity in the post monsoon months reaching peak levels, which almost equals marine salinity levels during pre-monsoon months of March to May. Peak salinity conditions favour otherwise exclusive marine fishes, which are stenohaline, living within narrow range of salinity, to frequent Zone-I and some others to Zone-II as well. Euryhaline fishes (marine to estuarine and marine to fresh water) also occur in this zone. Fresh water to brackish water find favourable situation in this Zone-I, when salinity drastically declines here from late June to August end. Altogether this Zone therefore accounts for highest diversity of fishes and is most important for estuarine fishery. Estuarine fishing communities have their densest settlements along the Zone-I, which also favours easy approach to marine areas. Some commercially important fishes like *Arius caelatus, Rhinobatus sps, Chrysochir aureus* and *Cybium commersoni* were exclusive to Zone1 in Aghanashini estuary.

4.3 Hydro-electric projects related salinity decline and decline in fish diversity: Kali and Sharavathi rivers have large hydroelectric projects, whereas Gangavali and Aghanashini are without these. The impact of dams on salinity conditions was clearly evident in Kali and Sharavathi estuaries. Whereas in Kali estuary, at Kodibagh and Sunkeri stations nearest to the confluence with the Arabian Sea, salinity reched 29-30 ppt during December, 2011, in Gangavali and Agragon stations, closer to the sea, of Gangavali estuary December salinity was 33-35 ppt. In Aghanashini and Gudkagal, stations closer to the sea in the Aghanashini estuary, salinity was 33-35 ppt during December. After a slight dip thereafter, in all these estuaries salinity rose towards the river mouth, in the Zone-1 during March-May period. It was 30-36 ppt in Aghanashini during this period and 30-35 ppt in Gangavali. In the dam affected Kali Kodibagh reached highest of 34 ppt only in May.

If we consider mid estuary salinity at Hankon and Siddar in Kali, it was below 15 ppt upto February 2012, where it reached 15 ppt. only in May. On the contrary in Gangavali, Sagadageri in the mid estuary witnessed over 25 ppt in December itself and reached 30 ppt in April-May. Kodkani in the mid-estuary of Aghanasshini (without dams) was 20 ppt during January-February, 2012 and 25-30 ppt during March-May. Salinity in Sharavathi was the

worst affected due to upstream hydel projects. Mainly because of the hydroelectric dam in the Sharavathi River, at Linganmakki, which has about 300 sq.km of water storage area and incessant release of fresh water after power generation, the estuarine salinity is most of the time less than 1 ppt. The execution of one more hydel power dam, smaller in size, at Gersoppa, also for power generation, might have aggravated the situation. The free mixing of river mouth water with the marine tides is once again impeded by a sandbar covering over three forth of the estuarine front virtually converting Sharavathi estuary almost into a fresh watr lake as salinity based zonation is absent all over. Incidentally most of the edible bivalves and molluscan fishery itself in the estuary collapsed, obviously because of salinity levels plummeting to low levels beyond their tolerance limits. A fishery collapse, therefore, has happened in the Sharavathi estuary. Some fresh water preferring fishes like *Tylosorus strongylurus, Dawkinsia filamentosa* and *Hyporhampus xanthopterus* seem to have entered the estuary because of the dam-related drop in salinity. Sharavathi is a classical case of how fish diversity decline can happen in an estuary without salinity zonation (Table 4.1). Although the estuary has a waterspread area (excluding private enclosures for fish farms) of 1336 ha, 2.39 times bigger to Gangavali estuary, the latter was richer in fishes with 55 taxa against 43 taxa of Sharavathi, of which about 12 are still elusive. Gangavali fishing income from estuary was almost 8.5 times more than that of Sharavathi although the latter has a water body about 2.4 times more than of Gangavali. Kali, despite the dams, had still all the three salinity zones- obviously due to the relatively larger size of the estuary. Higher salinity zone, however, is a narrow strip closer to the Arabian Sea. The salinity zonation was more pronounced in Gangavali and Aghanashini without dams. In the Kali River, also because of hydro-electric dams, the estuarine salinity has dropped substantially (Boominathan- personal communication). However, as the estuary being a bigger one, comparable in size with Aghanashini, it still retained much of its area under moderate salinity conditions, favouring bulk of the fish fauna, although the fishery income is far below that of Aghanashini as discussed in the next section of this report.

Table 4.1: Fish distribution in relation to salinity gradient

Estuary	Kali			Gangavali			Aghanashni			Sharavathi
Salinity zones and range (ppt)	Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3	Z3
	>20	10-20	< 10	>20	10-20	< 10	>20	10-20	< 10	< 10
Families	40	37	25	39	35	25	47	36	25	25
Genera	50	46	26	48	42	26	64	51	27	27
Taxa/sp	61	55	27	55	47	27	80	66	28	31
Fishes to be traced	0			0			6			12
Total taxa	**61**			**55**			**86**			**43**

5.0 ESUARINE FISHERY BASED LIVELIHOODS

Estuaries are very important sources of fish. If unaffected by humans estuaries can be very productive of fish supporting numerous livelihoods of fishing communities. Along the west coast they play crucial role in supporting fishermen during lean months of heavy rainfall, especially from June to end of August, when marine fishery using traditional crafts is risky. A ban during the recent years of monsoon fishing by mechanized boats, implemented by Governments of southern States, in the interests of conservation of breeding stock of fishes, has widespread livelihood implications on fishing communities. This has brought into the fore the importance of estuarine fishery, which provides subsistence for the fishing communities during the lean months of especially July and August. Estuarine fishes command high prices in the local markets, throughout the year, and supply the vital protein food for the coastal population when there is general scarcity of vegetables along the coast during especially July-August period. Estuarine fisheries broadly consists also capture of shrimps and crabs as well as collection of molluscs (the latter, pertaining to edible bivalves has been dealt with separately in another report). The fishermen being referred to here broadly include persons involved in capture fisheries (of fish, shrimps and crabs outside acquaculture areas). Details of waterspread area and total number of dependent fishermen/ha are given in **Figure-5.1.**

Kali estuary had an estimated 1,775 fishermen from 1,082 fishing families from 10 villages. 615 families exclusively did estuarine fishing of which maximum 1200 fishermen belonging to 400 families were from Kansageri village also, which also had the highest fishing income worth Rs. 86,400,000/- year. Alaviwada-Boribag generated income worth Rs.945,000 and had much less number of fishermen. Total number of fishing days per year for Kali estuary was estimated to be 307,320. Estuarine fishing generated Rs.108,738,000 income per year at about Rs.384/fishing day/person. Average fishing income/year/ head in Kali was Rs.61,260 **(Table 5.1 & Figures 5.1-5.3).**

Gangavali estuary had 996 fishermen from 357 families from 11 villages. Of the 11 fishing villages Belambar had highest number of 100 fishing families. The remaining had 10 to 50 fishing families each. The estuary generated an annual income of Rs.108,828,000/year from 246,060 days at about Rs.442/person/fishing day per year. Average fishing income/year/head in Gangavali was highest at Rs.109,265 (**Table 5.2 & Figures 5.1-5.3).**

Aghanashini estuary supported largest number (6139) fishermen from an estimated 2011 fishing families. The estuary generated employment for 1,497,200 fishing-days. Kagal-Hini had the highest density (375) of fishing families with 1125 estuarine fishermen. Aghanashini village, at the estuarine mouth had highest number of fishing days and generated fishing income of about Rs.12 crore. Village Antravalli, located farthest upstream in the estuary, in Zone-I, had far less fishermen who earned an income of about Rs.7 lakh per annum. Altogether the total income of Aghanashini estuary was estimated at Rs.435,072,000/year at Rs.291/person/fishing day. Average fishing income/year/head was Rs 70,870 (**Table 5.3 & Figures 5.1-5.3**).

Sharavathi estuary had the least of 283 estuarine fishermen from 103 fishing families. The estuary generated 41,420 man-days of employment/year with a total income generation of merely Rs.1,28,52,500/year at Rs.310/person/fishing day. The average fishing income/year/head from Sharavathi estuary was lowest at Rs.45,415. The estuary obviously witnessed fishing collapse as is evident from the less number of estuarine fishermen (283 only), despite average availability of 4.72 ha/head of fishing waters. As compared to Gangavali providing livelihood to 996 fishermen although estuarine water-spread area of Sharavathi is 2.46 times more than that of Gangavali. Main factor seems to be the loss of salinity in Sharavathi from which most of the basically sea fishes and many shifting between sea and estuary have vanished. (**Table 5.4 & figures 5.1-5.3**).

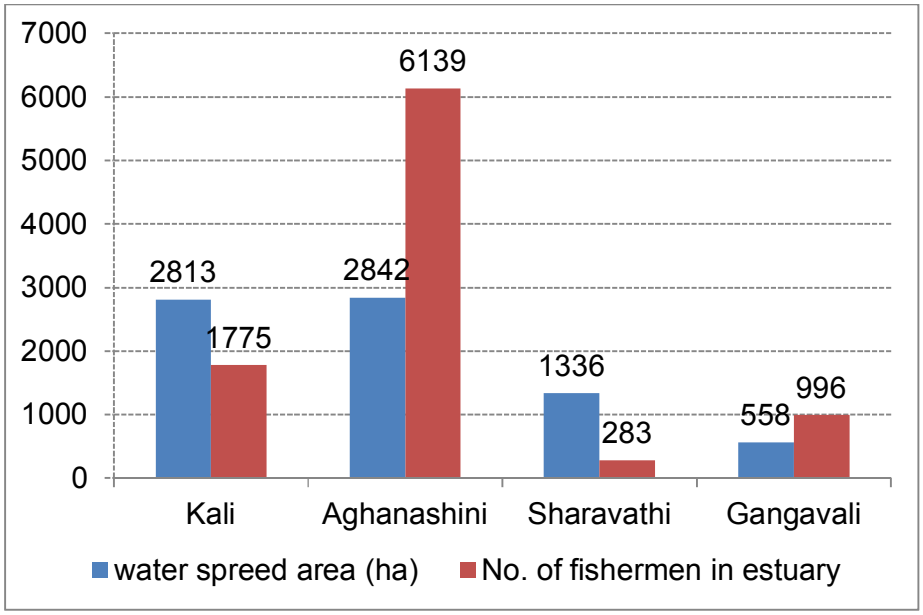

Figure 5.1. Estuary-wise waterspread area and dependent fishermen

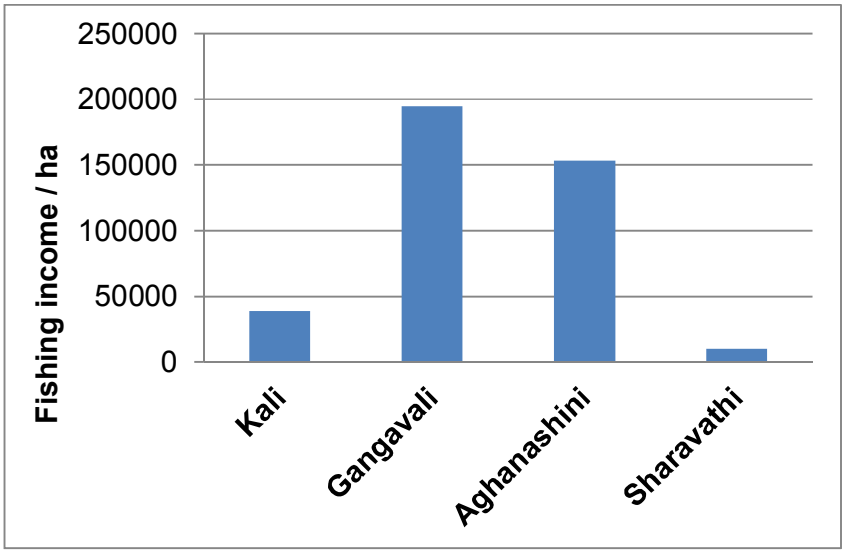

Figure 5.2. Fishing income/ha from Uttara Kannada estuaries

5.1 Need for sustainable management of fisheries: Already dam related salinity reduction, fishery depletion and reduction in fishermen's employment potential have happened in Sharavathi and Kali estuaries. This is despite availability over one ha of fishing water/head in Kali and 4.72 ha/head in Sharavathi. Bulk of fishermen, especially from the banks of these estuaries seeks alternative employment in other places, both in fishing and non-fishing sectors. The two rivers without dams, Aghanashini and Gangavali are exploited to the brim

for fish harvests. The fishermen in these estuarine areas roughly get about half ha per head of open estuary as fishing waters. The income being too low they too seek alternative employments. The common kinds of alternative employment are sand mining, shell mining, in aquaculture farms, in agriculture and as migrant labour in other places. Being good estuaries with better ecological conditions fishing per unit area is more in these two estuaries. That is the reason for high fishing pressure to the tune of 527 days/ha in Aghanashini, 441 days/ha in Gangavali, 305 in Sharavathi and only 109 in Kali. There is in Gangavali and Aghanashini urgent need to reduce fishing pressures by creating more productive alternative employment in eco-tourism, cottage industry based fish processing, apiculture etc. Women dominated employment in edible bivalve gathering from estuaries has gone extinct in Sharavathi due to dam related salinity decline and disappearance of most edible bivalves. Salinity reduction also has adversely affected bivalve production in Kali estuary. Sand mining in all the rivers and shell mining particularly in Aghanashini and Kali have adverse effects on edible bivalves as the estuarine bottoms and mudflats where these filter feeders live are subjected to mining operations for sand and shells.

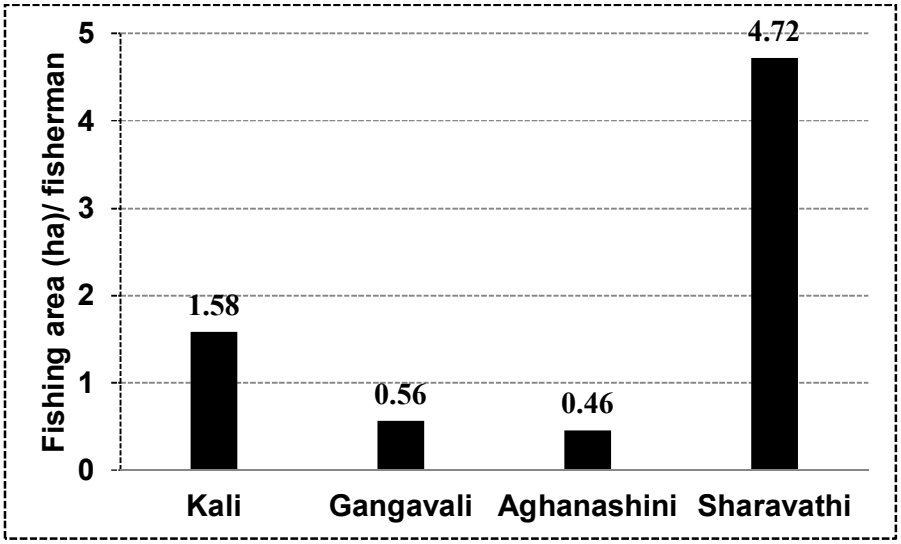

Figure 5.3. Estuarine fishing area/fisherman in Uttara Kannada

Table 5.1. Fishery based employment and income: Kali estuary

Villages	Fishing community houses	Houses with estuarine fishermen	No. of houses visited	Active fishermen/house	Tot. Estuarine fishermen	Avg. fishing days/head/yr	Tot. fishing days/yr	Avg income/ day/person Rs	Avg. income/yr/head Rs	Total Income/yr Rs
Nandangadda & Nagnathwada	150	60	20	3	180	150	27000	250	37,500	6,750,000
Alaviwada	65	35	15	2	70	90	6,300	150	13,500	945,000
Ulga (Katanya)	30	25	10	3	75	180	13,500	200	36,000	2,700,000
Kanasageri	700	400	20	3	1200	180	216,000	400	72,000	86,400,000
Vailwada	27	15	5	3	45	210	9,450	200	42,000	1,890,000
Kadra	15	8	5	3	24	180	4,320	400	72,000	1,728,000
Badjuga	30	20	7	2	40	120	4,800	150	18,000	720,000
Boribag (Kinner)	5	5	2	3	15	210	3,150	300	63,000	945,000
Shivajiwada	40	32	12	3	96	200	19,200	300	60,000	5,760,000
Sunkeri (Katinkon)	20	15	6	2	30	120	3,600	250	30,000	900,000
Total	**1082**	**615**	**102**	**----**	**1,775**	**----**	**307,320**	**----**	**61,260**	**108,738,000**

Table 5.2. Fishery based employment and income: Gangavali estuary

Villages	Fishing community houses	Houses with estuarine fishermen	No. of houses visited	Active fishermen/house	Tot. Estuarine fishermen	Avg. fishing days/head/yr	Tot. fishing days/yr	Avg income/ day/person Rs	Avg. income/yr/head Rs	Total Income/yr Rs
Gangavali	89	50	21	3	150	300	45,000	500	150,000	22,500,000
Juga	39	20	10	2	40	180	7,200	200	36,000	1,440,000
Agargoan	26	15	10	2	30	120	3,600	250	30,000	900,000
Sagadgeri	34	15	10	2	30	190	5,700	300	57,000	1,710,000
Uluvare	37	20	10	3	60	240	14,400	250	60,000	3,600,000
Mogta & Mangankaan	30	15	6	2	30	150	4,500	200	30,000	900,000
Shirgunji	16	12	8	3	36	210	7,560	300	63,000	2,268,000
Vasare	10	10	5	2	20	120	2,400	150	18,000	360,000
Belamber	495	100	25	3	300	240	72,000	500	120,000	36,000,000
Manjuguni	195	70	18	3	210	270	56,700	500	135,000	28,350,000
Shiroor	69	30	15	3	90	300	27,000	400	120,000	10,800,000
Total	**1,040**	**357**	**138**	**----**	**996**	**----**	**246,060**	**----**	**109,265**	**108,828,000**

Table 5.3: Fishery based employment and income: Aghanashini estuary

Villages	Fishing community houses	Houses with estuarine fishermen	No. of houses visited	Active fishermen/house	Tot. estuarine fishermen	Avg. fishing days/head/yr	Tot. fishing days/yr	Avg income/ day/personRs	Avg. income/yr/head Rs	Total Income/yr (Rs.)
Madangeri	200	125	30	2	250	120	30,000	250	30,000	7,500,000
Nushikote	148	75	18	2	150	240	36,000	200	48,000	7,200,000
Toregajani	100	75	20	2	150	120	18,000	250	30,000	4,500,000
Morba	139	80	25	3	240	240	57,600	350	84,000	20,160,000
Tadadi	82	50	32	4	200	365	73,000	400	146,000	29,200,000
Hosakatta	450	250	23	4	1,000	300	300,000	300	90,000	90,000,000
Moodangi	105	90	24	3	270	180	48,600	200	36,000	9,720,000
Bargi-gajani	50	30	16	2	60	180	10,800	150	27,000	1,620,000
Aghanashini	242	242	35	4	968	365	353,320	350	127,750	123,662,000
Gudkagal	65	50	19	4	200	300	60,000	250	75,000	15,000,000
Kagal & Hni	430	375	40	3	1125	180	202,500	250	45,000	50,625,000
Hubbana-geri	270	200	24	2	400	120	48,000	300	36,000	14,400,000
Kodkani	72	65	22	3	195	300	58,500	200	60,000	11,700,000
Mirjan	78	78	20	4	312	300	93,600	350	105,000	32,760,000
Halkar	64	45	17	3	135	120	16,200	150	18,000	2,430,000
Gude-angadi	65	45	10	3	135	120	16,200	150	18,000	2,430,000
Hegde	77	77	23	3	231	180	41,580	250	10,519	2,430,000
Lukkeri	33	30	18	2	60	365	21,900	350	12,775	7,665,000
Divagi	25	25	5	2	50	180	9,000	150	27,000	1,350,000
Antravalli	8	4	2	2	8	300	2,400	300	90,000	720,000
Total	**2,703**	**2,011**	**423**	**----**	**6,139**	**---**	**1,497,200**	**---**	**70,870**	**435,072,000**

Table 5.1. Fishery based employment and income: Sharavathi estuary

Villages	Fishing community houses	Houses with estuarine fishermen	No. of houses visited	Active fishermen/house	Tot. Estuarine fishermen	Avg. fishing days/head/yr	Tot. fishing days/yr	Avg income/ day/personRs	Avg. income/yr/head Rs	Total Income/yr Rs
Jalavalkarki and Jalavalli	74	6	3	2	12	200	2,400	300	60,000	720,000
Gersoppa	81	15	5	3	45	120	5,400	400	48,000	2,160,000
Kavur	7	5	2	3	15	150	2,250	200	30,000	450,000
Mavinkurva and Hosad	60	25	5	3	75	190	14,250	250	47,500	3,562,500
Upponi	17	10	3	2	20	120	2,400	300	36,000	720,000
Toppalkeri	100	20	4	3	60	65	3,900	350	22,750	1,365,000
Malkod	4	4	2	2	8	70	560	250	17,500	140,000
Molkod	55	6	4	3	18	70	1,260	250	17,500	315,000
Balkur	79	6	5	2	12	300	3,600	200	60,000	720,000
Anilgod	6	6	2	3	18	300	5,400	500	150,000	2700,000
Total	**483**	**103**	**35**	**----**	**283**	**----**	**41,420**	**----**	**45,415**	**12,852,500**

5.2 Estuarine fishery – yield (production per hectare): Only sketchy details are available on quantification of estuarine production from capture fisheries in India, making it very difficult to quantify the production per hectare. Decades ago, the total estimated landing of prawns alone from the Cochin backwaters in 1972 and 1973 were 898 t and 1541 t, respectively (CMFRI, 1972 & 73). At Thevara in Cochin backwaters during 1996-99, the total landing of penaeid prawns by stake net during 1996-97 was 292 t, with a catch per unit

effort of 3.8 kg. The total estimated landing of penaeid prawns at same site was 212.7 t in 1997-98 and in 1998-99 it was 280.8 t, with a catch per unit effort of 4.29 kg (Manisseri and Rao, 2000). The average annual production of both prawns and fish in the aquaculture farms of Karnataka coast was estimated to be about 338 kg per ha, out of which prawns accounted for 86.58% (Shastri, 1996). The fish production of various estuaries of the country has been estimated to be in the range of 43-75 kg/ha (Jha et al., 2008). The fish production (including prawns and bivalves (?) in the Kerala estuaries was estimated at 14,000 to17,000 tons/year (ibid.). Jayachandran et al (2012) reported a downfall from earlier annual average fish production (including bivalves and prawns) from 2,747 tons in the Kodungalloor-Azhikode estuary (700 ha) of Kerala to 908.6 tons during 2009-2010. The catch consisted of 632.57 tons of fin fish, 213.25 tons of prawns and 62.78 tons of bivalves (including oysters).

5.3 Estimating estuary-wise fish production based on income from fisheries: There was no easy way to quantify estuary-wise fish production in Uttara Kannada, due to the shortage of time and manpower. As the total annual income from fishing, earned by fishermen, has been estimated estuary-wise, we used the estuarine fish pricing in Uttara Kannada to indirectly arrive at fish production quantities. Fish prices range anyway from Rs.120/- kg to well over Rs.600/-kg, especially for some of the much favoured ones produced in smaller quantities. Average current market price for fish is approximately about Rs.175/- kg, for relatively widely available fishes. Total income from estuarine fishery in Kali being Rs.108,738,000/- the quantity from capture fishery (consisting of fin fishes, prawns and crabs- bivalves collected excluded-) could be placed at 621 tons from 2,813 ha of fishing waters, excluding portions of estuary under private ownership and aquaculture. This works out to 0.22 tons/ha. Likewise for Gangavali it was 622 tons from just 558 ha at 1.114 tons/ha. The stark difference between the estuaries has been attributed to lowered salinity in Kali caused by damming of the river and water discharges after power generation. Aghanashini, without any dams, had estimated production of 2,486 tons at 0.875 tons/ha. Sharavathi, the worst affected estuary due to hydroelectric dams related salinity decline, produced merely 73 tons from 1,336 ha at 0.055 t/ha.

6.0 ACKNOWLEDGEMENTS

We are grateful to the Karnataka Biodiversity Board, The Ministry of Environment and Forests, Government of India and Indian Institute of Science for the financial and infrastructure support. Our thanks are due to Dr. V.N. Nayak, Dr. Kusuma Neelakantan (Rtd. Professor) Dept. of Marine Biology, Karwar, Dr. Geeta Sasikumar & Mr. Prashant of CMFRI, Mangalore for their helping in the identification of fishes and for valuable suggestions. Mr. Sumesh Dudani is thanked for reviewing the manuscript. Technical inputs and valuable suggestions from Mr. Balachandran, Mr. Boominathan and assistance rendered in the field by Messers Shrikanth Naik, Vishnu D.M and Mableshwar Naik are gratefully acknowledged. Our special thanks are to Dr. Roshmon T. for sketches on fish morphology. We thank the estuarine fisher folks of Uttara Kannada for giving precious information on various fishes and on their fishery based livelihoods and economics and the staff of the Panchayats bordering the Kali, Gangavali, Aghanashini and Sharavathi estuaries for providing official statistics on fishing communities.

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Annexure1: ESTUARINE FISHES OF UTTARA KANNADA

Abbreviations used: **D**-Dorsal fin, **P**-Pectoral fin, **V**-Ventral fin, **A**-Anal fin

Ambassis ambassis **(Kan: Burante)**

Family : Ambassidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D VII+I 8-9; P I 12-14; V I 5.

Description : Body elongate and fairly broad. Head rather massive, with a prominent chin. Supra-orbital ridge smooth, terminating posteriorly in a spine; Scales large, lateral line complete, with 27 to 30 scales. Transperent, delicate amber to yellowish with a bright silvery mid-lateral stripe.

Geographical Distribution : Indo-west Pacific, India, Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food habit : Benthos, Crustaceans, Fishes. (Fishbase.org)

Apogon hyalosoma **(Kan: Burante)**

Family : Apogonidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Description : Body shape is robust and rhomboid with large scales on the flanks. Its forehead is slightly concave and its mouth and eyes are large. There are two dorsal fins of roughly equal size, the tail and other fins are mainly white to translucent, except for the leading edge of the first dorsal fin which is dark red to blackish.

Geographical Distribution : Japan south to Indonesia, Karnataka estuaries (Gangavali, Aghanashini).

Salinity : High to low

Food Habit : Benthos, Crabs, Prawns (Kulbicki *et, al*, 2005)

***Arius arius* (Kan: Sady)**

Family : Ariidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D I 7; A v-vi 14-16; P I 10; V I 5

Description : Body elongate and robust. Head depressed; Barbels 3 pairs; maxillary barbells reaching to anterior –third of pectoral fin, mouth sub-terminal and narrow. Tip of dorsal spine prolonged into filament.Life bluish to silvery steel along back, Dorsal and pectoral fin margins posteriorly dusky; adipose fin with a well-defined black spot.

Geographical Distribution : Pakistan, Bangladesh, Burma and India,Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

***Arius caelatus* (Kan: Gonde Sady)**

Family : Ariidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D I 7, A 16-30.

Description : Head profile concave at nape. Head shield strongly rugose and granulated; supra-occipital process short, about as long as broad, with median keel, hind end concave. Dorsal and pectoral fins with very strong, thick, and coarsely granulated spine; tip of dorsal spine produced into a long filament; adipose fin rather large. Body with metallic blue luster. Tip of dorsal fin blackish,

Geographical Distributio : Indo-Pacific: east and west coast of India, Sri Lanka, Pakistan, Bangladesh, Myanmar, Thailand. Karnataka estuaries (Aghanashini).

Salinity: High to medium

***Austrobatrachus dussumeri* (Kan: Gonke/Gorke)**

Family : Batrachoididae

Class : Actinopterygii

Distinguishing characters : D III, 20, A-16

Geographical Distribution : Western coast of India from Cochin north atleast to the Malabar area. Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High to low

***Strongylura leiura* (Kan: Burkaandi)**

Family : Belonidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D 17-21; A 23-25; P 10-11; V 6

Description : Body elongate laterally compressed, almost rectangular in cross-section. Upper and lower jaws greatly elongated, studded with a sharp teeth. Anterior parts of dorsal and anal fins forming distinct lobes. Top of head and back greenish; a silvery stripe along sides, lower flanks and ventral surface white. Tips of dorsal and anal fin lobes yellowish; pectoral fin with a distal spot

Geographical Distribution : Indo- west pacific.Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High to medium

***Tylosurus strongylurus* (Kan: Kaandi)**

Family : Belonidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D-12-15, A-15-18.

Description : Caudal fin rounded or truncate. Predorsal scales few and relatively large, 100-130. Caudal fin light with a prominent round black spot near its base. Dorsal fin lobe and distal margin of caudal fin yellow in live adults, anterior margin of anal fin orange.

Geographical Distribution : Indo-West Pacific: Persian Gulf eastward along the coasts of Pakistan, India, and Sri Lanka, Karnataka estuaries (Sharavathi).

Salinity : Low

***Crossorhombus azureus* (Kan: Masur leppe)**

Family : Acanthuridae

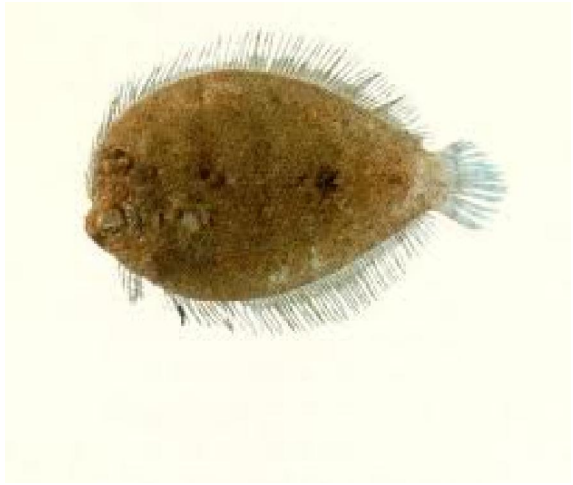
Class : Actinopterygii

Habitat : Marine

Description : Ground colour on eyed side brownish grey, with darker spots and blotches. dorsal and anal fins with small dark spots, caudal fin with 2 distinct dark bands. Males with small dark spots in anterior part of interorbital region.Blind side whitish in females. Males with distinct bluish black pyriform colour pattern on blind side. Snout shorter than eye, both eyes on left side of head.

Geographical Distribution : Indo-West Pacific: Bay of Bengal, northwestern South China Sea, China, Taiwan, Japan,Karnataka estuaries (Kali,Aghanashini).

Salinity : High



Carangoides praeustus **(Kan: Guruku)**

Family : Carangidae

Class : Actinopterygii

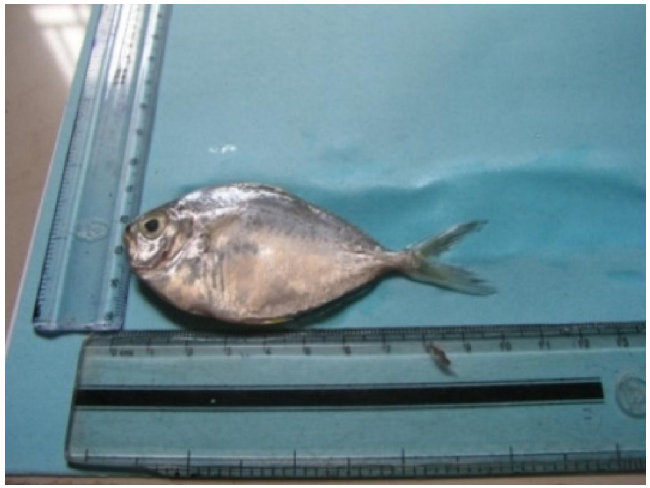
Habitat : Marine

Distinguishing characters : D I, VIII; I, 23-24. A II, I,19-20.

Description : Body torpedo-shaped. Adipose eyelids well-developed and extend into pupil, leaving eye as a small slit. Teeth feeble on both jaws, in upper jaw in a band and in lower jaw in a single row. Dorsal and anal fins with 8 or 9 semi detached fin-lets behind. Scales on body small; breast naked, lateral line with 53-58 large scutes.

Geographical Distribution : Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High to low



Carangoids chrysophrys **(Kan: Kokkara)**

Family : Carangidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D I,VIII;I, 18-20.A II, I, 16-17.

Description : Naked breast, pectoral much longer than head. Soft dorsal and anal slightly falcate, but low. Fine teeth in bands in both jaws.

Geographical Distribution : Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food habit : Crustaceans, Crabs, Worms (Salini *et, al.,* 1994)

***Caranx ignobilis* (Kan: Guruku)**

Family : Carangidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D IX, 17-22; AIII, 15-17.

Description: Head and body dusky golden dorsally, silver ventrally; fins usually pigmented grey to black. Opercular spot absent.26-38 strong scutes. Breast without scales ventrally; Pectoral fins falcate; anal fin with 2 detached spines.

Geographical Distribution : Indo-Pacific: Red Sea and east coast of Africa to the Hawaiian, north to southern Japan. Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

***Atule mate* (Kan: Guruku)**

Family : Carangidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D –IX, 22-25, A III,18-21.

Description : Body color olive dorsally, shading to white ventrally; black spot on opercle; dorsal and caudal fins dusky greenish yellow in color. The adipose eyelid completely covering the eye except for a vertical slit centered on pupil.

Geographical Distribution : Indo-Pacific: Red Sea and the east coast of Africa to the Hawaiian Islands and Samoa, north to Japan south to the Arafura Sea and northern Australia. Karnataka estuaries (Gangavali, Aghanashini).

Salinity : High

Megalaspis cordyla **(Kan: Guruku)**

Family : Carangidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D –IX 18-20, A III, 16-17.

Description : Color bluish grey to green dorsally; silvery below; dark fins. Opercle with a large black spot.51-59 strong, very large scutes. Anal fin with 2 detached spines, numerous dorsal and anal finlets are distinct.

Geographical Distribution : Indo-West Pacific: East Africa to Japan and Australia. Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

Food Habit : Fishes (Fischer *et, al.,* 1990)

Etroplus suretansis **(Kan: Kagalsi)**

Family : Cichilidae

Class : Actinopterygii

Habitat : Fresh, Brackish

Distinguishing characters : D XVIII-XIX; 14-15.A XII-XIII, 11-12

Description : Most of the scales above the lateral line with central pearly spot. Some irregular black spots on abdomen. Pectoral yellowish with black base. Other fins dark leaden colour. Yong fish have a white edged black ocellus from 4^{th} to 10^{th}dorsal ray. Light green with 8 transverse bands.

Geographical Distribution : India, Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi), Srilanka

Salinity : High to low

Food habit : Filamentous algae, decayed organic matter, diatoms, digested matter, sand grains, items including fish eggs, Copepods, fish miscellaneous scales, insects, worms (Vidhya *et. al.,* 2012).

Sardinella fimbriata **(Kan: Pedi)**

Family : Clupeidae

Class : Actinopterygii

Habitat : Marine

Distinguishing characters : D 0, 13-21, A 0, 12-23

Description : Body somewhat compressed; Vertical striae on scales not meeting at center, hind part of scales with a few perforations and somewhat produced posteriorly. A dark spot at dorsal fin origin.

Geographical Distribution : southern India and Bay of Bengal to the Philippines, Guinea. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Opisthopterus tardoore **(Kan: Pachage)**

Family : Clupeidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D ii-iii 11-14; A iii 48-60; P i 11-13.

Description : Body elongate and strongly compressed, Mouth pointing obliquely upward. Dorsal fin small, well behind midpoint of body. Anal fin long, its origin well before dorsal fin. Back blue-green, flanks and belly silvery.

Geographical Distribution : Western and Southern coast of India, Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi), Sri Lanka, Burma & Indonesia.

Salinity : High

Food Habit : Planktons, Crustaceans (*Fishbase.org*)

Paraplagusia biliniata **(Kan: Leppe)**

Family : Cynoglossidae

Class : Actinopterygii

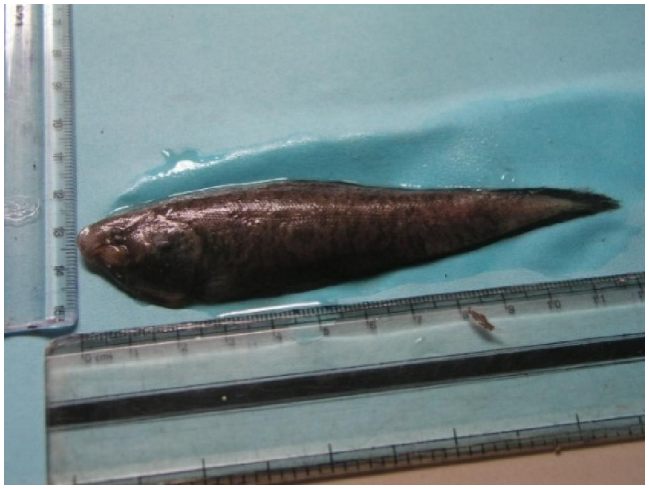
Habitat : Marine, Brackish

Distinguishing characters : D 100-114; A 72-89; V 4;C 10

Description : Body tongue shaped. Snout fairly rounded; rostral hook reaches past lower eye. Ctenoid scales on both sides of the body. Two lateral lines.Upper side of the body tan, marbeled with dark wavy anastomosing lines enclosing pale patches; blind side yellowish.

Geographical Distribution : Indo- west pacific.Karnataka estuaries (Kali, Aghanashini).

Salinity : High to low



Cynoglossus macrostomus **(Kan: Leppe)**

Family : Cynoglossidae

Class : Actinopterygii

Habitat : Marine, Brackish

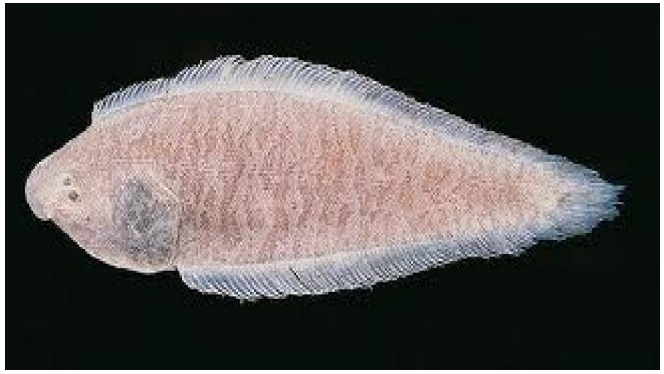
Distinguishing characters : D 100-106; A 78-84; V 4;C 10

Description : Body tongue- shaped. Snout obtusely pointed; angle of mouth reaching well beyond lower eye. Eyes nearly contiguous. Two lateral line on ocular side, separated by 14-16 rows of scales, no lateral line on blind side. Scales ctenoid on both sides of body , in life, ocular side light brown with dark brown mottling forming diffuse irregular cross bands; blind side whitish.

Geographical Distribution : India Karnataka estuaries (Kali, Aghanashini).

Salinity : High to low

Food Habit : Zoobenthos, annelids (Menon, 1984)



***Cynoglossus punticeps* (Kan: Leppe)**

Family : Cynoglossidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D-90-100, A-72-78

Description : Ocular side yellow-brown. Dorsal and anal fins joined to caudal. Eyes both on the left side of the body, a narrow space separating them; asymmetrical mouth; rostral hook below mouth. Ocular side with 2 lateral lines. Only the left ventral fin present.

Geographical Distribution : Indo-West Pacific: India eastward to the Malay Archipelago and the South China Sea, southward to the Philippines and northwest Australia, Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

***Dawkinsia filamentosa* (Kan: Pidtol)**

Family : Barbinae

Class : Actinopterygii

Habitat : Fresh, Brackish

Description : Adults differ from all other South Asian *Puntius* by a combination of the following characters: branched dorsal-fin rays prolonged into filament-like extensions in adult males only; a black band about as wide as the eye near tip of each caudal-fin lobe; lower lip continuous; no distinct markings on body in advance of anal-fin origin.

Geographical Distribution : Asia: India Karnataka estuaries (Sharavathi).

Salinity : Low

Food Habit : Insects, Plants, Detritus (Fishbase.org)

***Dasyatis bleekeri* (Kan: Hola)**

Family : Dasyatidae

Class : Elasmobranchii

Habitat : Marine, Brackish

Description : Two long finger like processes on floor of mouth. Tail long, whiplike. Large round tubercle in middle of back and usually 3 smaller ones before and three more behind. Others along upper surface of tail to caudal spine. No cutaneous fold. Uniform dark brown above.

Distribution : Indo-Pacific: from Pakistan to the Malay Peninsula. Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

***Stolephorus indicus* (Kan: Belanji)**

Family : Engraulidae

Class : Actinopterygii

Habitat : Marine

Distinguishing characters : D iii 12-14; A iii 16--18; P i 13-15;V i 6

Description : Body slender, elongate sub-cylindrical in cross section; belly rounded with 3-5 small needle like scutes between pectoral and pelvic fin bases. Snot prominent, rather pointed; Posterior border of pre operculum evenly rounded near maxilla tip; maxilla tip pointed reaching to or only just beyond anterior border of pre-opercle.

Geographical Distribution : Indo-west pacific, Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High

Food Habit : Zooplankton, Invertebrate (Whitehead *et, al.,* 1988)

Stolephorus commersonnii **(Kan: Dodda danashi)**

Family : Engraulidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D iii 12-14; A iii 18-19; P i 13-14; V i 6

Description : Body slender and somewhat compressed; belly slightly rounded, with one to four small needles like scutes. posterior border of pre operculum evenly rounded near maxilla tip; maxilla tip pointed reaching to a little beyond hind border of pre-operculum; Back with a two pigmented areas behind head and a double pigment line before dorsal fin origin.

Geographical Distribution : Southeast Asia and further to Samoa. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Plankton, Prawn larvae, (Robins *et, al.,* 1991)

Thryssa mystax **(Kan: Vaintali)**

Family : Engraulidae

Class : Actinopterygii

Habitat : Marine, Brackish

Description : Belly with 24 to 32 keeled scutes from isthmus to anus. Tip of snout on a level with eye center. Maxilla long, reaching to or almost to base of first pectoral fin ray; first supra-maxilla oval, minute. Lower gill rakers with serrae on the inner edge even and not clumped.

Geographical Distribution : Indo-West Pacific: western coast of India to Myanmar and south to Java, Indonesia. Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

Food Habit : Plankton, Fish egg, Larvae (Fishbase.org)

***Thryssa malabarica* (Kan: Vaintali)**

Family : Engraulidae

Class : Actinopterygii

Habitat : Marine, Brackish

Description : Belly with 23 to 26 keeled scutes. Maxilla moderate; first supra-maxilla small, oval; jaw teeth small. A dark blotch behind upper part of gill opening; small spots on cheek, gill cover, maxilla and paired fins; gill arches pinky orange, inside of gill cover yellow and gold; inner part of anal fin deep yellow, margin whitish.

Geographical Distribution : Indian Ocean: India, perhaps reaching to Pakistan, Karnataka estuaries (Kali, Aghanashini).

Salinity : High

***Thryssa setirostris* (Kan: Vaintali)**

Family : Engraulidae

Class : Actinopterygii

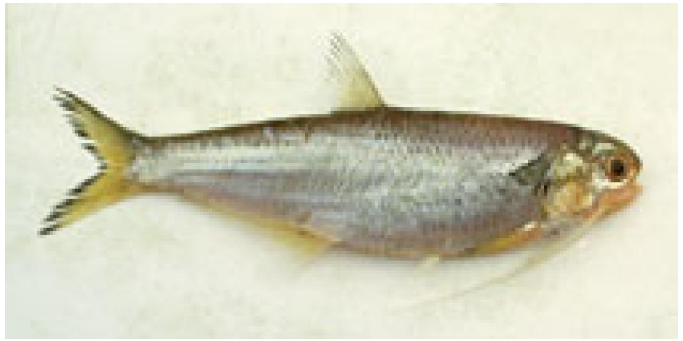
Habitat : Marine, Brackish

Description : Belly with 25 to 28 keeled scutes. Distinguished from all other *Thryssa* species and anchovies by the very long maxilla, usually to pelvic fin base or even to anal fin origin; also unique is the high coronoid process of the lower jaw, the jaw rising steeply in the mouth. Head with gold tints; anal and caudal fins deep yellow; dark spot behind gills.

Geographical Distribution : Indo-Pacific: Gulf of Oman south to Port Alfred, India. Karnataka estuaries (Kali, Aghanashini).

Salinity : High

Food Habit : Benthos, Crustaceans (Fishbase.org)



***Gerries filamentosus* (Kan: Girbaingi)**

Family : Gerridae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D IX10-11; A III 7; P i 14; V I 5.

Description : Body deep and compressed, Pre-dorsal distance equal to or less than depth of body. Second dorsal spine laterally compressed, produced into filament whose tips extend past level of first anal spine. Pectoral, pelvic, anal, caudal fins dusky, end of filamentous spine is black.

Geographical Distribution : Indo-west pacific. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : **C**rustaceans, polychaetes (Woodland, 2001)

***Gerres limbatus* (Kan: Mundbaingi)**

Family : Gerridae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D-IX,10, A-III, 7

Description : Dorsal fin faint yellowish, with a dark patch on tip of spinous portion above a line running from middle of second dorsal spine to tip of 6th dorsal spine. Caudal fin pale yellow. Anal fin with anterior half yellow or dull orange, posterior whitish hyaline. Pectoral fins yellowish color.

Geographical Distribution : Indo-West Pacific: India and Sri Lanka to southeast Asia and the South China Sea. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Glossogobius giuris **(Kan: Bili Mandli)**

Family : Gobiidae

Class : Actinopterygii

Habitat : Fresh, Brackish

Distinguishing characters : D VI+I 8-9; A I 7-8; P i 16-21

Description : Body elongate and somewhat compressed. Eyes small, Yellowish brown with 5 dark blotches on flank; sides of head is irregular violet spots. Dorsal, pectoral and caudal fins mottled with dark spots, spots darkest along spine of second dorsal fin.

Geographical Distribution : Indo-west pacific. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Copepods, cladocerans, post larvae and juveniles of shrimp, insect larvae, polycheates, fish-fry (Rainboth, 1996)

Trypauchen vegina **(Kan: Bombale)**

Family : Gobiidae

Class : Actinopterygii

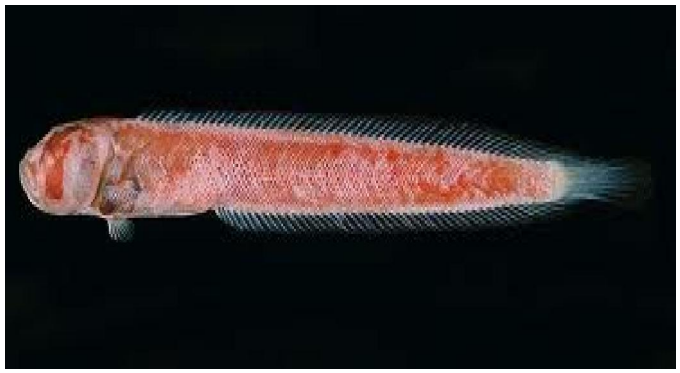
Habitat : Marine, Brackish

Description : Elongated body about 20 to 22 cm in length. It is reddish-pink in color and possesses distinctive pouches in the upper edges of its gill covers. It lives in burrows in the silty and muddy bottoms of its marine and brackish habitats. It has reduced eyes that are entirely covered with skin and the anterior portion of its head is protected by thick flesh.

Geographical Distribution : Indian ocean, Persian Gulf, Western Pacific Ocean Karnataka estuaries (Kali, Aghanashini).

Salinity : High to medium

Food Habit : Zoobenthos, Crustaceans (Rainboth, 1996)



***Hyporhampus xanthopterus* (Kan: Sound kaandi)**

Family : Hemiramphidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D 14-15, A 16-17

Description : Caudal forked, lower lob longer. Anal originates opposite dorsal. No scales on dorsal and anal fins. Upper jaw longer than wide. End of the beak coral red.

Geographical Distribution : Western Indian Ocean: Kerala, India Karnataka estuaries (Sharavathi).

Salinity : Low

***Lactarius lactarius* (Kan: Samdale)**

Family : Lactariidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D VII-VIII; I 20-22 A III, 25-28

Description : Black spot on operculum. Dorsal and caudal with dusky border. Other fins yellowish, lateral line parallel to dorsal profile and without shields or scutes. Silvery grayish above.

Geographical Distribution : Western Indonesia.Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High to medium

Food Habit : Early stage of fish, Zooplanktons, Invertibrates (Fischer *et, al.,* 1990).

Lates calcarifer **(Kan: Kurude)**

Family : Latidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D-VII-IX,10-11,A-III,7-8

Description: Body elongate; mouth large, slightly oblique, upper jaw extending behind the eye. Lower edge of preopercle serrated, with strong spine at its angle; opercle with a small spine and with a serrated flap above the origin of the lateral line. Caudal fin rounded.

Geographical Distribution : Indo-West Pacific: Persian Gulf to China, Taiwan and southern Japan.Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High to low

Food Habit : Crustaceans and Fishes (Hora & Pillay 1962)

Secutor insidator **(Kan: Guruku)**

Family : Leiognathidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D VIII 16; A III 14; P I 17; V I 5

Description : Body oval and compressed, its depth 2 to 2.6 times in standard length. Mouth small, pointing upward when protracted; teeth minute, in one or two rows on jaws. Scales on body small; suborbital region naked; lateral line reaching backward to below end of dorsal fin.In life, silvery; upper half with pearly blue spots. Margins of spinous dorsal fin black; other fins hyaline.

Geographical distribution : Indo west pacific.Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High to low

Secutor ruconius **(Kan: Guruku)**

Family : Leiognathidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D VII-16, A-III,14,

Description: Body silvery. Head naked; with nuchal spine.Protracted mouth pointing upward; tip of maxilla reaching to about level of lower margin of eye.Lateral line ending about middle of soft dorsal fin.

Geographical distribution : Indo-West Pacific: tropical Indian Ocean and southeast Asia, north to Taiwan and China, south to northern Australia.Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to medium

Food Habit : Crustaceans (Fischer *et, al.,* 1990).

Leiognathus splendens **(Kan: Guruku)**

Family : Leiognathidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D VII-VIII;16-17.A-III 14.

Description : Ventrals with large axillary scale.Silvery. End of snout dotted with black.Pectoral axilla black.Spinous dorsal membrane between 2nd to 6th spines black.

Geographical distribution : Indo-West Pacific: from India to Papua New Guinea;Karnataka estuaries (Kali, Gangavali, Aghanashini).

***Lutjanus johni* (Kan: Hottekemsa)**

Family : Lutjanidae

Class : Actinopterygii

Habitat : Brackish

Distinguishing characters : D X 13-14; A III 8; P i 16; V I 5

Description : A fairly deep bodied species with head profile straight or slightly convex. In life, silvery green or bronze / red, with a distinct spot on each scale forming a length- wise series of dark streaks; a large black blotch often present above lateral line at junction of spinous and soft parts of dorsal fin.

Geographical Distribution: India, Sri Lanka, through the East Indies, to the Western Central Pacific. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Fishes, Crab, Shrimps (Lee & Sadovy 1998)

***Lutjanus ruselli* (Kan: Kemsa)**

Family : Lutjanidae

Class : Actinopterygii

Habitat : Brackish

Distinguishing characters : D X 14-15; A III 8.

Description : A dark oval blotch on lateral line, mostly above it and opposite anterior part of soft dorsal. Fins yellowish, borders of dorsal and caudal sometimes dusky. Young specimens with 3 dark longitudinal bands, which are replaced by about 6 golden longitudinal bands in adults.Golden olive, darker above, silvery below.

Geographical Distribution : Indo-West Pacific: East Africa to Fiji, north to southern JapanKarnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

***Lutjanus argentimaculatus* (Kan: Eri)**

Family : Lutjanidae

Class : Actinopterygii

Habitat : Brackish

Distinguishing characters : D X 13-14; A III 8-9; P I 15-16; V I 5.

Description: Body elongate, with head profile straight or slightly convex. Pre-opercle unnotched Longitudinal rows of scales above lateral line parallel to dorsal profile anteriorly, In life red- brown, somewhat paler on belly; often a silvery patch in centre of each scale.

Geographical Distribution : Indo-west pacific.Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Fishes, Crustaceans (Anderson, W.D. Jr., 1986)

***Mugil cephalus* (Kan: Madle)**

Family : Mugilidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D_1 IV D_2 I 8; A III 8; P 15; V I 5

Description : Body robust; head broad and much flattened dorsally, Lips thin, Scales cycloid in young, becoming feebly ctenoid with growth. Olive-green on back, Silvery on flanks, shading to white below; six or seven indistinct brown bands down flanks, a dark purple blotch at base of pectoral fin. Dorsal and caudal fins with dusky margins.

Geographical Distribution : Worldwide, in temperate and tropical waters.Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity: High to low

Food Habit : Algae, Diatoms, Plant materials, Crustaceans, Bivalves, Fishes (Soyinka *et, al*., 2008).

***Liza parsia* (Kan: Madle)**

Family : Mugilidae

Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

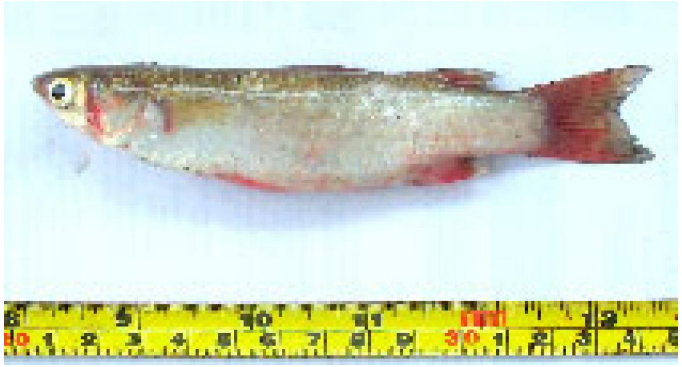
Distinguishing characters : D1 IV D2 I 8; A III 9; P 14; V I 5

Description: Body slender head moderately wide, dorsally flattened, Teeth labial; two rows of short teeth on upper lip, but lower lip toothless. First dorsal fin inserted nearer to snout tip than to caudal fin base; Pectoral axillary scale rudimentary or absent. Greenish brown above, white to silvery below; a golden spot on upper operculum.

Geographical distribution : Pakistan, India, and Sri Lanka. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Algae, Diatom (Breder, Rosen, 1966)



***Pisodonophis cancrivorus* (Kan: Aragotka)**

Family : Ophichthyidae

Class : Actinopterygii

Habitat : Marine

Distinguishing characters : D 0, A O.

Description : Teeth molariform, multiserial on jaws, intermaxillary and vomer; dorsal fin with broad dark edge. Dorsal fin beginning above pectoral fin.Body snake-like, cylindrical, anterior nostril tubular, posterior nostril along lower edge of lip; lateral line inconspicuous. Variable from grey to black or brown.

Geographical distribution : Indo-Pacific: Red Sea and East Africa to French Polynesia, north to the Ogasawara Islands, south to Australia.Karnataka estuaries (Kali, Gangavali, Aghanashini).

Food Habit : Macrofauna (Masuda *et, al*., 1993)

Nemipterus japonicus **(Kan: Rane meenu)**

Family : Nemipteridae

Class : Actinopterygii

Distinguishing characters : D X; 9 A III, 6-8

Description : Yellowish red with longitudinal yellowish or longitudinal red lines along each scale row, usually numbering 8. Dorsal and anal fins with yellowish streak along centres.

Geographical distribution : Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

Food Habit : Small fishes, crustaceans, mollusks (Russell, 1990).

Pseudorhombus javanicus **(Kan: Nengu)**

Family : Paralichthyidae

Class : Actinopterygii

Distinguishing characters:D-67-76, A-51-56

Description : Body brownish, a distinct, large dark blotch at junction of straight and curved parts of lateral line and a smaller blotch on middle of straight section of lateral line, many dark rings scattered on body. Scales on eyed side ctenoid on anterior part and dorsal and ventral margins of body on eyed side, cycloid on remaining areas.

Distributio : Indo-West Pacific: Persian Gulf and off India Karnataka estuaries (Kali, Aghanashini).

Food habit `: Zoo benthos and invertibrates (Nielsen, J.G., 1984)

***Pempheris moluca* (Kan: Ramachi)**

Family : Pempheridae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D-VI,9 A-III,41

Description : Rostro-dorsal profile barely convex, Upper rim of eye nearly level with it. Distance from snout to dorsal origin only slightly less than body depth. Silvery brownish on back and coppery on flanks. Base of pectorals with brown or black patch. Vertical fins reddish.

Geographical distribution : Indo-West Pacific: southwest Sumatra to Bali Strait, and Malaysia Karnataka estuaries (Aghanashini).

***Platax orbicularis* (Kan: Manji)**

Family : Platacidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D V; 34-38, A III, 6-8.

Description : The central cusp of teeth much longer and stronger than lateral cusps. Soft anal and dorsal less produced and barely falcate in young and becoming obtuse and rounded in older fish. Pectorals rounded. The first 2 cross bars tend to be broader and the third more diffuse.

Geographical distribution : Indo-Pacific: Red Sea and East Africa to the Tuamoto Islands, north to southern Japan Karnataka estuaries (Kali, Aghanashini).

Food habit : Algae, Invertibrates, Small fishes (Myers, 1991)

Grammoplites scaber **(Kan: Vadati)**

Family : Platycephalidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : DI/VIII+12; A 12; P20-21; V I 5.

Description : Body robust and sub-cylindrical. Pre-opercular spine short does not extend to gill- opening. Lateral line spiny along its entire length. Dark brown, whitish below; black regular dots along lateral line, head and body. First dorsal fin dark; soft dorsal and anal fin rays with rows of black dots.

Geographical distribution : Indo-west pacific, Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Pomadasys maculatus **(Kan: Guruku)**

Family : Pomadasyidae

Class : Actinopterygii

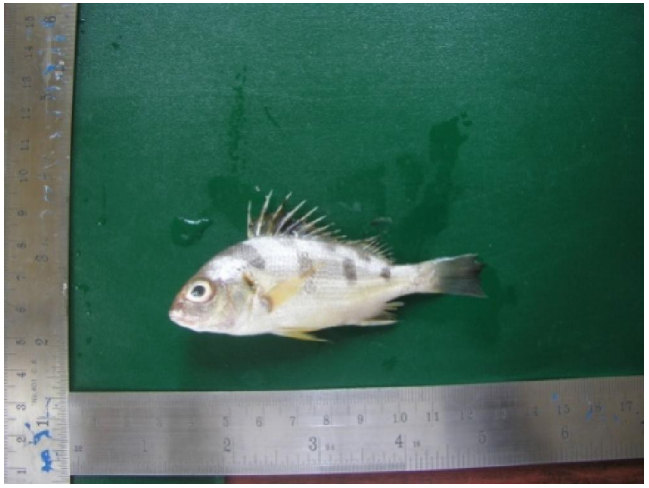
Habitat : Marine, Brackish

Distinguishing characters : D. XII-XIII; 12-14. A.III 7-8

Description : The second anal spine much longer and stronger than third. Silvery grey with purplish head. The nape being most prominent. Spinous dorsal with large black blotch. Dorsal and caudal edged with black, otherwise fins yellowish.

Geographical distribution : Indo-West Pacific: throughout the Indian Ocean. Karnataka estuaries (Aghanashini).

Food habit : Crustaceans and fishes (Fischer, 1990)



***Glaucostegus halavi* (Kan: Balagende Torke)**

Family : Rhinobatidae

Class : Elasmobranchii

Habitat : Marine, Brackish

Description : Disc and snout triangularly pointed. Length of nostril equal to internarial space and twice width of mouth. Brown above, coarsely tuberculate, rough to touch. Each side of rostral cartilages buff. Dorsal and caudal grayish attains 6 feet.

Geographical distribution : Indo-West Pacific: Red Sea to Gulf of Oman. Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity: High

Food habit : Mollusks, Bony fishes (Michael, 1993)

***Scatophagus argus* (Kan: Hulka)**

Family : Scatophagidae

Class : Actinopterygii

Habitat : Marine, Brackish

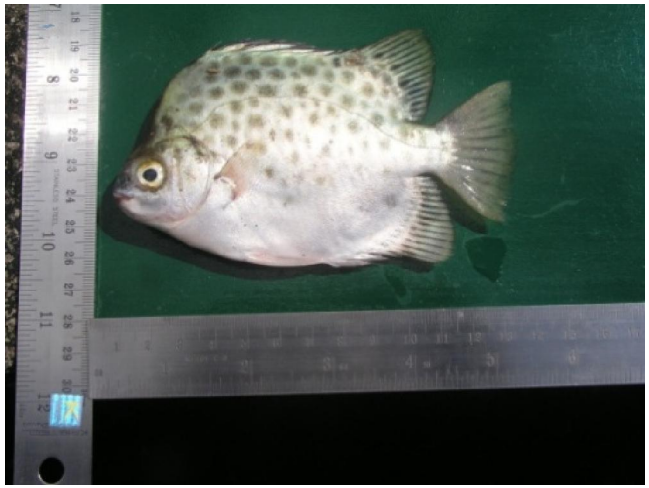
Distinguishing characters : D XI; 16-18 A IV, 14-15 P 16-17; VI 5

Description : Body quadrangular, strongly compressed. Head profile rising steeply to nape; snout and interorbital space rounded. Mouth small, Dorsal fin deeply notched, scales very small. Young fishes about 2 cm are usually quite dark in colour. uniform greenish silvery, bluish silver or coffee – brown with a delicate golden sheen, especially on back;

Geographical distribution : India, Sri Lanka, through the East Indies to Australia, Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Diatoms, nematodes,rotifers, polycheates, insects and protozoa (Gisha *et, al.,* 2011)



Otolithes ruber **(Kan: Banagu)**

Family : Sciaenidae

Class : Actinopterygii

Distinguishing characters : D X;I 28-31. A II 7.

Description : Operculum with 2 flat spines. Lateral line tubules branched. Anal originates behind middle of soft dorsal. Caudal wedge shaped in young but round to truncate in older fish. Brownish red shot with silver and sometimes golden below. Spinous dorsal with black edge. Soft dorsal and anal with grey margins, other fins yellow.

Geographical distribution : Indo-West Pacific: East Africa, including Madagascar Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity: High to low

Food Habit : Zoobenthos, Crustaceans, Prawns (Nasir, 2011)

Chrysochir aureus (**Kan: Mooru hallin banagu)**

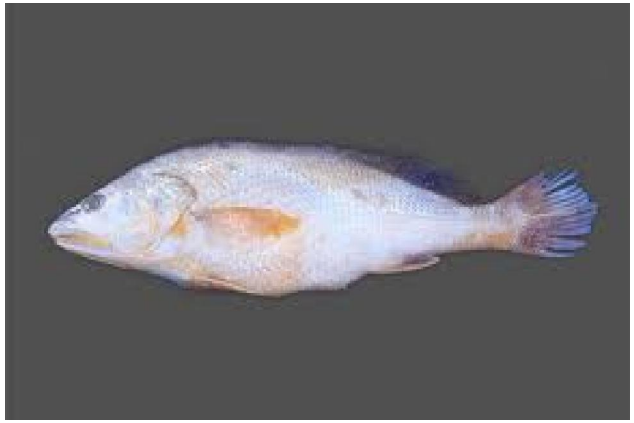
Family : Sciaenidae

Class : Actinopterygii

Distinguishing characters : D XI,25-28, A II,6-7

Geographical distribution : Indo-Pacific: southeast India and Sri Lanka to southern China. Karnataka estuaries (Aghanashini).

Food Habit : Zoobenthos, Crustaceans(Sasaki 2001)



***Johnius belangeri* (Kan: Banagu)**

Family : Sciaenidae

Class : Actinopterygii

Distinguishing characters : D-X-XI,27-31,AII,7

Geographical distribution : Indo-West Pacific: Pakistan, India, Sri Lanka,Karnataka estuaries (Kali, Gangavali, Aghanashini).

***Rastrilliger kanagurta* (Kan: Bangade)**

Family : Scombridae

Class : Actinopterygii

Habitat : Marine

Distinguishing characters : D X 12;5 A 12; 5.P2 17

Description : A single series of very small teeth in jaws, almost obsolete in adults.. About 35-38 gill rakers on lower arm of first arch, longest equal to distance from pupil to snout, Back green, silvery below. Dorsals yellow with black tips. Caudal and pectoral also yellow but anal and ventrals dusky.

Geographical distribution : Indo-West Pacific: Red Sea and East Africa to Indonesia, China, south to Australia, Melanesia Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

Food Habit : Crustaceans, Phytoplankton, Diatoms (Rao *et, al.,* 1962)

***Scomberomorus commerson* (Kan: Iswana)**

Family : Scombridae

Class : Actinopterygii

Habitat : Marine

Distinguishing characters : D-XV-XVIII, 15-20, A-16-21,

Description : Swim bladder absent. Vertical bars on trunk sometimes break up into spots ventrally which number 40-50 in adults, and less than 20 in juveniles. Juveniles with large oval dark spots on body; middle third of first dorsal fin white, rest of fin black

Geographical distribution : Indo-West Pacific: Red Sea and South Africa to Southeast Asia, north to China and Japan and south to southeast Australia, Karnataka estuaries (Aghanashini).

Salinity : High

Food Habit : Small fishes (Collette, 1986)

***Cephalophalis boenak* (Kan: Gobrya, Kallumurge)**

Family : Serranidae

Class : Actinopterygii

Habitat : Marine

Distinguishing characters : **D-IX, 15-17, A-III, 8**

Description : Brownish to greenish grey with dusky vertical bands over the body. White margins and black sub-margins on the median fins. Pre-opercle rounded, very finely serrate; no enlarged spines at angle, lower edge fleshy.

Geographical distribution : Indo-West Pacific: Kenya to southern Mozambique eastward to the western Pacific.

Karnataka estuaries (Kali, Gangavali, Aghanashini).

***Siganus argenteus* (Kan: Baana)**

Family : Siganidae

Class : Actinopterygii

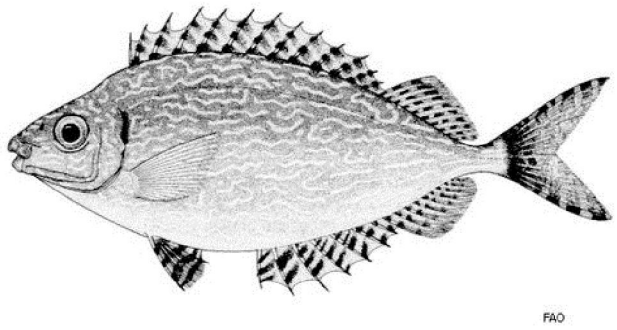
Habitat : Marine, Brackish

Distinguishing characters : **D-XIII 10-17, A-VII, 9**

Description : Body blue above, silvery below; variations in markings (spots, curved lines) occur. Silvery-yellow iris. When frightened or asleep, entire fish becomes mottled with very light and dark browns, with dark ones predominating in 7 diagonal zones across the sides.

Geographical distribution : Indo-Pacific: Red Sea and East Africa Karnataka estuaries (Kali, Aghanashini).

Food Habit : Benthic algae weeds (Sano *et, al.,* 1984)



Siganus vermiculatus (Kan: Baana)

Family : Siganidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D XIII; 10 A.VII 9

Description : Light brown with back bluish-green and abdomen white. Head body and lips vermiculated with very sinous bluish lines. Caudal with brown lines.

Geographical distribution : Indo-West Pacific: India, Sri Lanka, Andaman Islands, Thailand, Malaysia, Singapore, Indonesia, Philippines, Guam, New Guinea, Solomon Islands, Fiji,Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity: High to low

Food Habit : Plants, Detritus (Woodland, 1990)

. ***Sillago sihama*** **(Kan: Nogla)**

Family : Sillaginidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : DX-XI;I 20-23.AII, 21-24

Description : Scales on cheek cycloid. Olivaceous or grey above, silvery below with a diffuse silver band along body.

Geographical distribution : Indo-West Pacific: Red Sea and Knysna, South Africa to Japan and south to Australia.Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

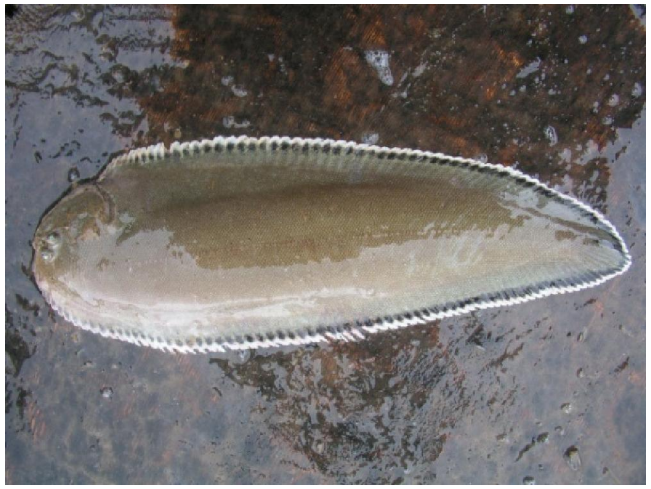
Food Habit : Sea weeds, Crustaceans, Fishes (Radhakrishnan, N. 1957)

. ***Synaptura commersoniana*** **(Kan: Leppe)**

Family : Soleidae

Class : Actinopterygii

Geographical distribution : Indo-West Pacific: Red Sea to the Persian Gulf, west coast of India and Sri Lanka; also off Mauritius and Seychelles.Karnataka estuaries (Kali, Gangavali, Aghanashini).



***Sphyraena barracuda* (Kan: Onakaandi)**

Family : Sphyraenidae

Class : Actinopterygii

Distinguishing characters : D-VI,9, AI,10

Description : Double emarginated tail fin with pale tips on each lobe, and (usually) the presence of a few scattered black blotches on the lower sides.

Geographical distribution : Indo-Pacific: Red Sea and east coast of Africa to Hawaii and the Marquesan and Tuamoto islands. Western Atlantic.Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Zoobenthos and Mollusks (Randall, 1967)

***Sphyraena obtusata* (Kan: Hallin kaandi)**

Family : Sphyraenidae

Class : Actinopterygii

Distinguishing characters : D V;I 9. A II-III8-9

Description: Angle of pre operculum rectangular.Operculum without spines. Dorsal originates before tip of lower jaw. Green- grey above with indistinct darker bars, white below.Pectorals grey, other fins yellow.

Geographical distribution : Indo-Pacific: Red Sea and East Africa to Samoa, north to the Ryukyu Islands, south to Lord Howe Island.Karnataka estuaries (Kali, Gangavali, Aghanashini).

Salinity : High

Food Habit : Nektons, Fin fish, Bony fish (Senou, 2001)

***Pampus argenteus* (Kan: Bili manji)**

Family : Stromatidae

Class : Actinopterygii

Habitat: Marine

Distinguishing characters : *D IX; I 37-43.A I 38-43 P 23-26*

Description : Eye with feeble edipose lid.Narrow row of villiform teeth in jaws. Origin of anal behind that of dorsal.Anal lobe longer than dorsal lobe. Caudal deeply forked. Upper surfaces neutral grey with purplish sheen. Sides of head and body silvery, fading to white on abdomen. Everywhere covered in small black dots. Dark spot on upper part of opercle.

Geographical distribution : Indo-West Pacific: Persian Gulf to Indonesia, Japan. Karnataka estuaries (Aghanashini).

Salinity : High

Food Habit : Zooplankton, Jellyfish (Haedrich, 1984)

***Parastromateus niger* (Kan: Kari manji)**

Family : Stromatidae

Class : Actinopterygii

Habitat: Marine

Distinguishing characters : D IV; I 41-46.A II, 35-40 P23-24.

Description : Eye with narrow adipose lid. Maxillary reaches to front border of eye. Teeth almost absent in adults, in young are needle like Ventrals well developed in young absent in adults. Caudal deeply forked. Deep brown or grey with blue reflections; cheeks opercles and abdomen paler. Dorsal and anal grey brown with black margins.

Geographical distribution : Indo-West Pacific: East Africa to southern Japan and Australia, Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High

Food Habit : Plants, Algae, Weeds (Mohsin *et, al.,* 1986)

Monopterus albus **(Kan: Kolav)**

Family : Synbranchidae

Class : Actinopterygii

Habitat : Fresh, Brackish

Description : Body eel like and robust, not whip-like. Head small, Teeth small and conical; Gill opening triangular, without lateral folds, and internally attached to isthmus; gills greatly reduced. Body naked. Branchiostegal rays 6 in life, light greenish, with or without dark spots.

Geographical distribution : India: northeastern region, Bangladesh, Burma, Indo – Malayan archipelago; China; and Japan; Karnataka estuaries (Gangavali, Aghanashini).

Food Habit : Zoobenthos, Worms, other annelids (Yang, 1997)

Terapon jarbua **(Kan: Kumbari, Garge)**

Family : Teraponidae

Class : Actinopterygii

Distinguishing characters : D-XI-XII,9-11, A-III,7-10.

Description : Lower opercular spine extending well beyond the opercular flap. Post temporal bone exposed posteriorly and serrate. Body color is fawn above, cream below, nape dark; head, body and fins with and iridescent sheen. Three or four curved dark brown bands run from the nape to the hind part of the body,

Geographical distribution : Indo-Pacific: Red Sea and East Africa to Samoa, north to southern Japan. Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

Food Habit : Crustaceans, Polychaetes, Fish, Bivalves,Gastropods, Zooplanktons, Phytoplanktons, Sand grains (Manoharan *et, al.,* 2012)

***Arothron stellatus* (Kan: Chonja)**

Family : Tetraodontidae

Class : Actinopterygii

Distinguishing characters : D-10-12, A10-11,

Description: Juveniles with dark stripes on belly, becoming spots with growth; adults with or without spots on fin

Geographical distribution : Indo-Pacific: Red Sea and East Africa Karnataka estuaries (Kali, Gangavali, Aghanashini, Sharavathi).

Salinity : High to low

***Tricanthus lepturus* (Kan: Kuduremeenu, kadbale)**

Family : Tricanthidae

Class : Actinopterygii

Distinguishing characters : D V, 22-25 A-16-19

Description : First dorsal spine as long as or longer than head. Second dorsal spine very short, not much longer than third. Scales minute. Spinous dorsal with or without a black spot when present restricted to membrane between 1st and 2nd spines.

Geographical distribution : Karnataka estuaries (Kali, Gangavali, Aghanashini).

***Trichiurus haumela* (Kan: Barik hamle)**

Family : Trichiuridae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : DIII-130- 135, A 100-105.

Description : Body extremely elongate, compressed and tapering to a point. Mouth large. Dorsal fin relatively high; anal fin reduced to minute spinules usually embedded in the skin or slightly breaking through; Pelvic and caudal fins absent. Lateral line beginning at the upper margin of the gill cover, Fresh specimens steely blue with silvery reflections,

Geographical distribution : Karnataka estuaries (Kali, Gangavali, Aghanashini).

***Caecula polyothalmus* (Kan: Hemalga)**

Family : Ophichthidae

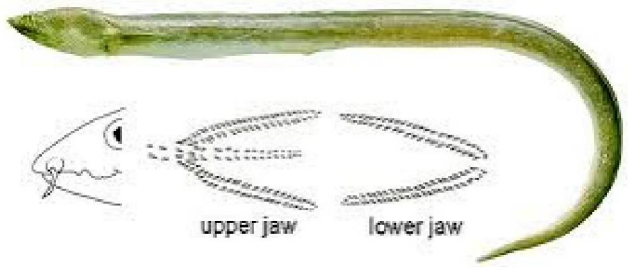
Class : Actinopterygii

Habitat : Marine, Fresh, Brackish

Distinguishing characters : D -0, A-0.

Description: Body elongate, more or less cylindrical, slightly compressed, with a hard tail tip; sharply conical head; large mouth, reaching well behind eyes; teeth on jaws small, sharp and recurved; vomerine teeth larger; gill-openings strongly oblique, small, beneath the throat with an extra fold of skin alongside.

Geographical distribution : Indo-West Pacific: Sri Lanka and the East Indies. Karnataka estuaries(Aghanashini).



. ***Drepane punctata*** **(Kan: Chandaka)**

Family : Drepaneidae

Class : Actinopterygii

Habitat : Marine, Brackish

Distinguishing characters : D VIII-IX, 20-22, A-III,17-19,

Description : Color generally silvery with greenish tinge above. Pectoral fins long and pointed. Similar to *D. longimana* but differs in having 4 - 11 vertical gray spots on the upper half of the sides, and generally 8 dorsal spines.

Distribution : Indo-West Pacific: temperate and tropical waters from India to northern Australia, New Guinea, Indonesia, Philippines, Taiwan and Japan. Karnataka estuaries (Kali, Gangavali, Aghanashini).

Food Habit : Benthic fishes, invertebrates (Fischer *et, al.,* 1990)

ANNEXURE-2: ESTUARINE FISHES: MORPHOLOGY AND IDENTIFICATION

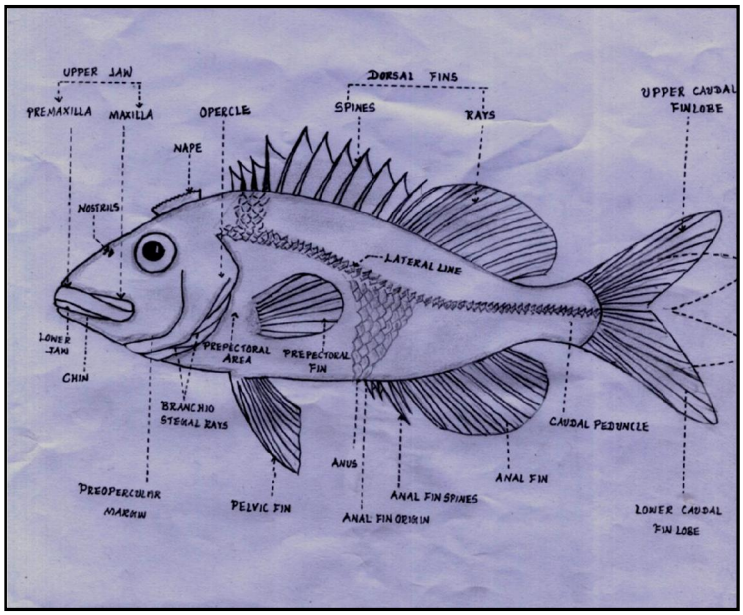
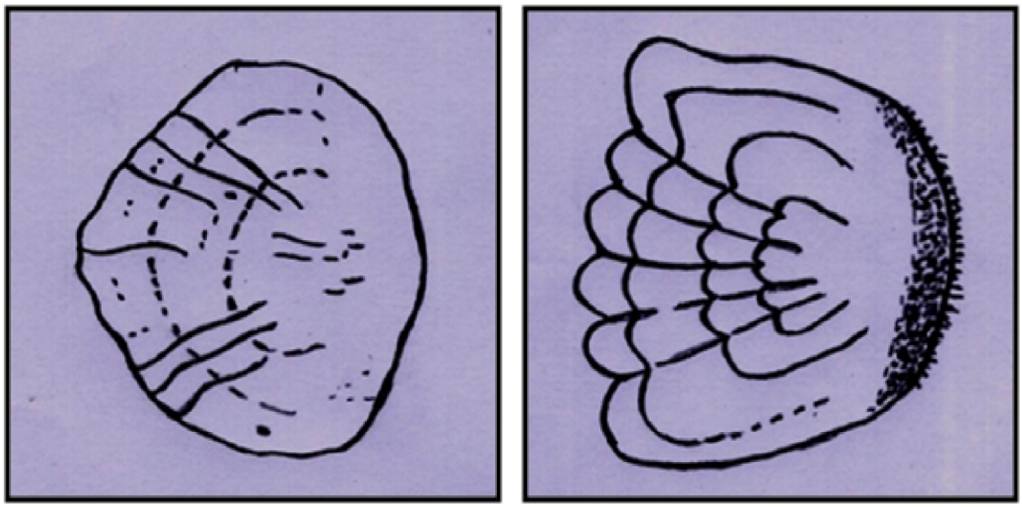


Fig. Parts of a typical fish

- **Lateral line**: Sense organ used to detect movement and vibration in the surrounding water.
- **Dorsal fins:**Fins located on back. A fish can have up to three of them.They prevent the fish from rolling, and assist in sudden turns and stops.
- **Pectoral fins:** Paired fins on the sides, usually just behind the operculum. Creating a dynamic lifting force for the fish. Well developed pectorals help the flying fish in its short flights
- **Pelvic fins:** The paired pelvic or ventral fins, located ventrally below the pectoral fins, assist in going up or down through the water, turning sharply and stopping quickly.
- **Caudal fin:** Alsoknown as tail fin, it helps in propulsion during forward movements.
- **Anal fin:**Located on the ventral side behind the anus; gives stability during swimming.
- **Gills**: These are fleshy organs used for breathing located on the sides of the head. When water "inhaled" through the mouth passes over the gills rich in blood vessels, oxygen is absorbed and carbon dioxide released passes out through the "exhaled" water from beneath the operculum.
- **Operculum** (gill cover): Is a flexible, bony plate that protects the sensitive gills.
- **Mouth:** Located at the front of the body; its shape is a good clue to what the fish eats.

- **Nostril:** Paired nostrils, or nares, in fish are used to detect odors in water and can be quite sensitive.
- **Eyes**: Sight organs located on the head.
- **Branchiostegal rays:** Numerous tiny thin bones arranged fanwise from the lower edge of the operculum to the ventral surface of the head and covered by the branchiostegal membrane.
- **Scales:** Most fishes have scales, and some fishes like cat fishes have no scales and are said to be naked. Scales are used for body protection. Fish scales composed of connective tissue covered with calcium. Typically, soft rayed fish have smooth cycloid scales and spiny-rayed fish have ctenoid scales. Scales can be used for estimating age of fish. **Cycloid scales** are small oval-shaped scales with growth rings **Ctenoid scales** are similar to the cycloid scales, with growth rings. They are distinguished by spines that cover one edge.



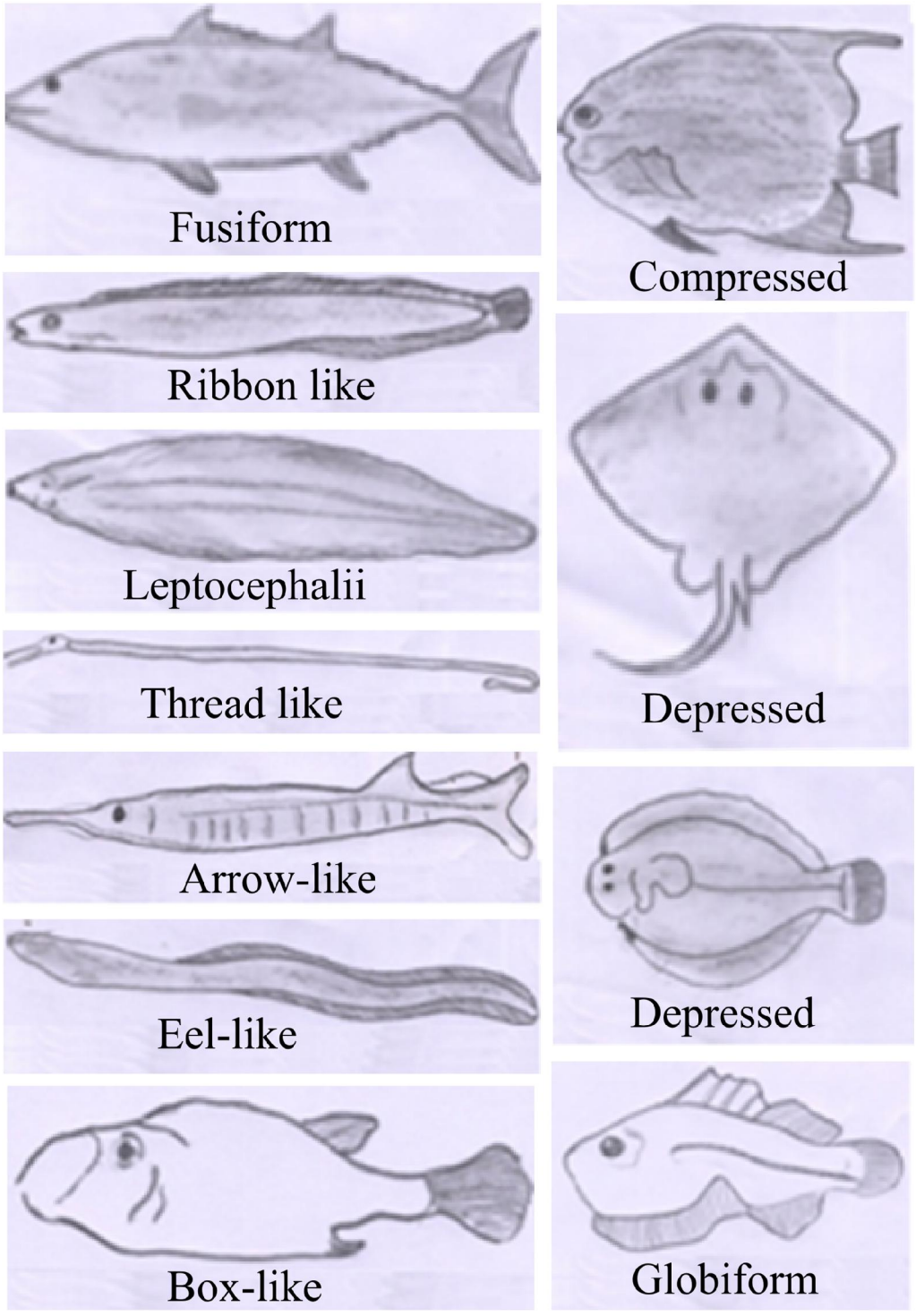
Cycloid Ctenoid

Senses: Fish have a number of sense organs

- **Sight:** Most fishes have well developed eyes which are located on the sides of the headallowing them to see in every direction.Fish that are colorful probably have colour vision. Nocturnal fish have large eyes that help them to see in the low light.
- **Smell and Taste:** Fish can smell things in the water with two blind sacs called nares, similar to our nostrils. But they cannot breathe through their nares. A fish can taste with taste buds in the lining of its mouth and gills. Some fish have feelers, like the "whiskers" on a catfish, called barbells which act as feelers.
- **Hearing:** Fish have ears but they are invisible. Their ears are inner and well developed to pick up sound waves in the water.
- **Lateral line:** The lateral line system helps the fish feel movements in the water. The line, actually a row of tiny holes in the skin, begins behind the gill cover and runs along the side of the body to the tail. Tiny hairs in the lateral line system are sensitive to vibrations. This system helps fish swim in schools, avoid predators and find food.
- **Electricity:** Some bony fish and sharks have special pores on the head that allow them to detect electrical currents. This sense aids them in navigating or finding prey in dark or muddy water.

Body shapes

Body shape of the fish varies greatly from dorsoventrally flattened, to streamlined, to shorter bodies. The body shape has much to do with the speed and way a fish swims. Fusiform or streamlined fishes are capable of swimming very fast; they usually live in open water. Fish that are laterally compressed found near to coral reefs, their shape allows them to move about in the cracks and crevices of the reef. This fish lies on its side on the bottom. Depressed fishes like sting rays live on the bottom. Eel-like fishes have snake like body shape. Many fishes like box fishes are slow swimmers with special protective mechanism.


Fusiform
Compressed
Ribbon like
Leptocephalii
Depressed
Thread like
Arrow-like
Depressed
Eel-like
Box-like
Globiform

Structure of mouth

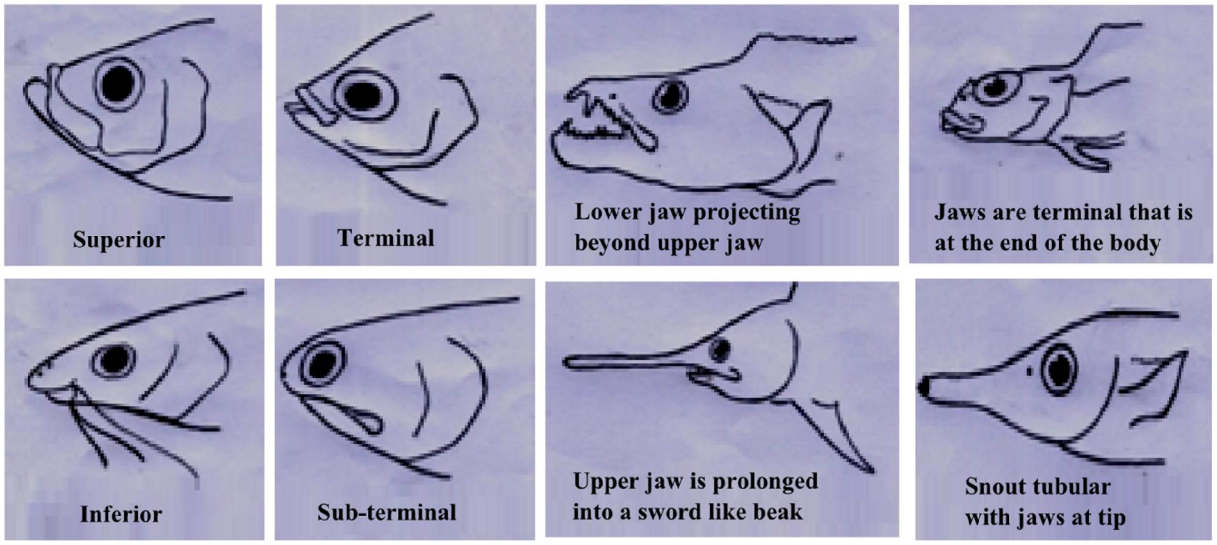
The mouth tells much about the habits of a fish by its position, shape and size. Bottom feeding fishes have sub-terminal mouths, while surface oriented fishes have upward pointing mouths. Size of the mouth is usually directly related to the size of the preferred food organisms as its shape. Thus fishes that feed on small invertebrates have small mouth surrounded by protractile lips.

The structure of fish mouth reveals its feeding habits. Fishes can be divided into 3 feeding groups: top, midwater and bottom-feeders.

- **Top swimmers mouth:** This type of fish has a straight dorsal surface and an up-turned scoop like mouth for gathering floating insects.

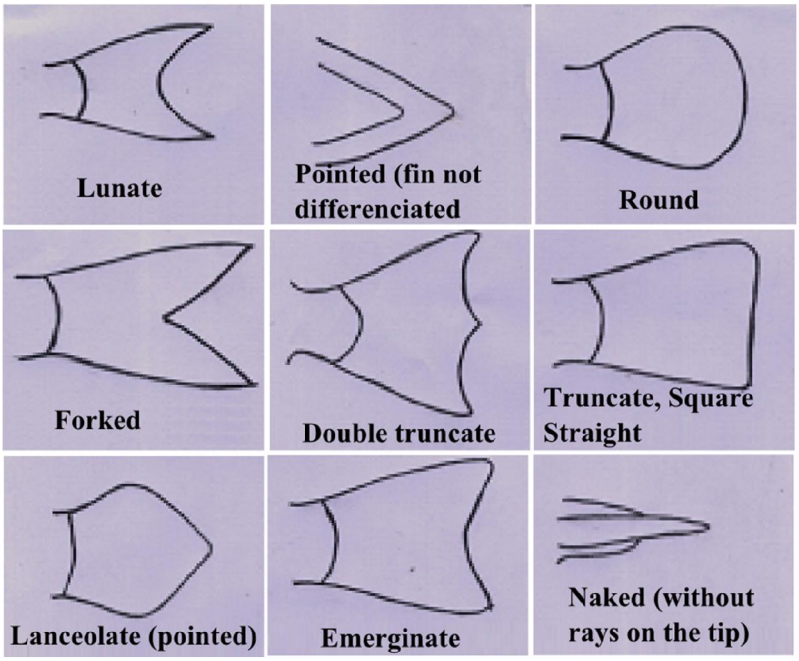
- **Mid water swimmers mouth:** Species that swim in mid water have mouths at the tip of their snouts, and generally snatch their food as it falls through the water.

- **Bottom dwellers mouth:** These fishes have under-slung mouths with flattened ventral surfaces which can be brought into close contact with riverbed where much of their food lies.

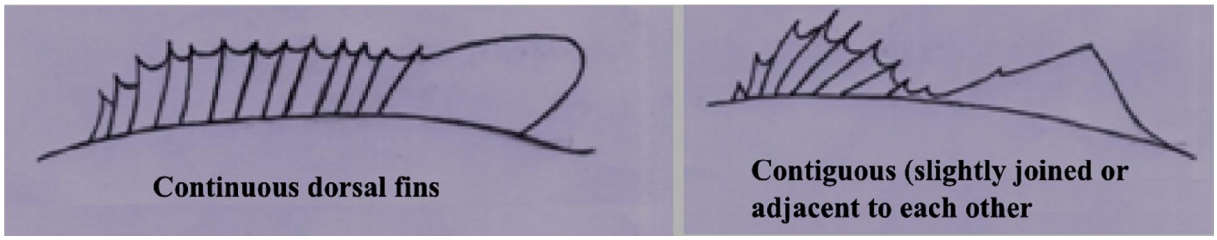


Tails

The shape of the tail can be an indicator of how fast a fish usually swims. Fish with forked tails swim faster. The deeper the fork, the faster the fish can swim. Fish with rounded or flattened tail are generally slow moving, but are capable of short, accurate bursts of speed.



Dorsal fins: These are fins located on the back of the fishes. Some have only one dorsal fin while others have two or even three. In many bony fishes the dorsal fin has stout spines in the front to help to give the fin support. It helps in swimming as well as in protecting itself against larger animals by becoming erect and making it difficult for other animals to eat the fish. Two types of dorsal fins found in the bony fishes are shown below:



Annexure

Identification Key

Part I
SHARKS SKATES AND RAYS
Cartilaginous fishes
Class: Elasmobranchs
Subclass: Selachii

Skeleton composed of cartilage which is sometimes partly calcified. Skin covered with small denticles instead of overlapping scales, but smooth in Electric rays and Eagle Rays. A single nostril on each side. Five separate gill openings and no bony operculum covering the gill – arches. Never more than one spine in each fin. Caudal fin asymmetrical, upper lobe longer than lower. Males with a pair of claspers alongside pelvic fins. In this group fertilisation is internal. Chrondrichthyes are primarily marine although a few elasmobranchs have adapted to life in fresh water.

1. Gill- openings on the sides; body cigar-shaped…….Lamniformes(Sharks)
   Gill-opening on lower surface; body flattened, descoid……2

2. Electric organs absent……. Rajiformes(Skates and Rays)
   Electric organs present……..... Torpediniformes (Electric rays)

Part II
Bony fish, Class :Teleostomi, Subclass :Actinopterygii

Skeleton composed of true bone. Skin normally covered with overlapping scales which is some families may be obsolete, and in others modified by calcification into a hard covering, ossified dermal plates or a complete bony casing. Gills covered by bony operculum and have only one external opening on each side. Caudal fin nearly symmetrical. Most bony fishes are oviparous

1. Body asymmetrical with eyes both on same side of head…….. Pleuronectiformes
   Body bilaterally symmetrical with eyes on opposite sides of head…….2

2. Ventral fins absent……....3
   Ventral fins present……..9

3. Body extreamly long, eel-like or ribbon- like……....4
   Body short, not eel-like or ribbon like……7

4. Body cylindrical; Caudal fin present……..5
   Body flattened and ribbon like; caudal fin absent……. Perciformes

5. Dorsal and anal fins without spines……...……6
   Dorsal and anal fins with spines…… Mastacembeliformes

6. Two gill-openings lateral in position……. Anguilliformes
   One gill-opening on ventral surface……. Symbranchiformes

7. Scales modified into minute sharp granules , needle like spines , calcareous plates or fused into a bony casing……Tetradontiformes
   Scales when present are normal overlapping type……8

8. Large sub-cylindrical fishes with upper jaw prolonged into a sword…….. perciformes.(SCOMBROIDEI)
   Small oval fishes with upper jaw not prolonged to into a sword……...
   ……perciformes. (STROMATEOIDEI)

9. Ventral fins abdominal……..…….10
   Ventral fins thoracic or jugular……...……20

10. Body naked or with bony plates or rings……..……..11
    Body with normal overlapping scales……...13

11. Snout produced into a tube; barbels absent……...……...…12
    Snout normal; several pairs of long barbels ……. ….Cypriniformes

12. Pelvics with 1- 3enlarged feeler-like rays …….. Pegasiformes
    Pelvics with 3-7 small normal rays…… Sygnathiformes

13. One spineless dorsal fin…….14
    Two distinct dorsal fins……..18

14. Gill-membranes broadly united with isthumus; jaws without teeth…….
    ……...Cypriniformes
    Gill- membranes free from isthmus; jaws usually with teeth……15

15. Lateral line when present situated in upper half of sides, never forming a raised ridge……..16
    Lateral line extreamly low on sides, forming araised ridge……..…17

16. Head scaly and depressed, ventrals moderately large……. Cyprinodontiformes

Head naked and compressed; ventrals small……Clupeiformes

17.Tail tapering to a point; ventrals with 9 rays ……Halosauriformes
Tail forked, truncate or rounded; ventrals with 6 rays…… Beloniformes

18.First dorsal with soft rays only; second dorsal adipose……. Scopeliformes
First dorsal with spines only; second dorsal with soft rays……..……19

19. Pectoral with lowermost rays detached and filamentous……. Polynemiformes
Pectoral fin entire, with no free rays……. Mugiliformes

20.Ventral fins with 1 spine and 5 rays……..……...30
Ventral fins with other than 1 spine and 5 rays……....21

21. Fins without true spines……..…..22
Fins with true spines……...……...…….25

22. Two dorsal fins first short usually with 1-2 ossified rays……..……...….23
Asingle dorsal fin with no ossified rays……...……..24

23. Free caudal fin present…….. Gadiformes
Tail tapers to sharp point without free caudal fin……. Macruriformes

24. Fresh water species with accessory air- breathing apparatus; depressed head covered with large plate like scales; ventrals when present , thoracic with 6 rays … ……Ophiocephaliformes
Marine species without accessory air- breathing apparatus; Head naked or with small scales only; Ventrals when present, jugular or mental with 1 or 2 rays ……. …… Perciformes (OPHIDIOIDEI)

25. Scales present…….……26

26.Scales large and strongly serrated or spinous; head with mucous cavities……27

27. Anal with 7 spines…….. Perciformes (SIGANOIDEI)
Anal with 2 or 3 spines .....Perciformes (Acanthuroidei)

28. Anterior dorsal spines modified as a movable lure equipped with a terminal organ……...…… Lophiformes
Anterior dorsal spines not modified……...…..29

29.First dorsal with 2-4 short stout spines……... Batrachoidiformes
First dorsal with more than 4 spines……
…….Perciformes (BLENNIOIDEI)

30.First dorsal fin modified to a sucking disc on upper surface of head……ECHENEIFORMES
Dorsal fins normal……..31

31.Pectorals very large and devided into 2 portions……...
……DACTYLOPTERIFORMES
Pectorals moderate and normal…….….32

32. A short anterior anal fin of 3 spines; first vertibra firmly attached to skull…….
……Zeiformes.
Anal spines not forming a separate anterior fin; first vertebra free from skull…….33

33.Dorsal anal fins followed by 5 or more detached finlets…
……Perciformes (SCOMBROIDEI).
Dorsal and anal fins without series of detached finlets……..34

34.Supra-branchial organ for a accessory air breathing……..
……..Perciformes (ANABANTOIDEI)
No accessory air breathing organ ……..35

35. Mouth much reduced; gill-openings reduced to small pore
……... Perciformes (CALLIONYMOIDEI)
Mouth with moderate to large gape; gill – openings normally wide……36

36. Males with a characteristic denticulated crest on the supraoccipital……
…….perciformes (KURTOIDEI)
No such crest in either sex…….37

37. Bony ridge across cheek, its end articulating with the front edge of the opercle ; head armoured with bony plates and many spiny projections ……
……Perciformes (COTTOIDEI)
Head not armoured in such fashion…….……..38

38. Ventral fins close together or united, forming a sucking disc……..
……Perciformes (GOBIOIDEI)
Ventral fin moderately far apart, never forming a sucking disc.
……Perciformes (PERCOIDEI).

Field Photographs

*Caecula polyopthalmus (*Kan: Hemalga) : A fish used in folk medicine

Eleutheronema tetradactulum (raws), Etroplus suretansis (Pearl spot, *Kagalsi*) etc.
ice preserved for marketing

Confirming fish identification in the field

Sorting the estuarine fish catch

Fish capture using bag net fixed to sluice gate (to the right of fishermen)

Identified fish specimens in CES Field Station, Kumta

Cast nest fishing in Kali estuary

Fisherman with cast net in Kali estuary

Fishing canoe in Kali estuary

Cast net fishing in Kali estuary

Aghanashini estuarine fishes

Stolephorus indicus from Aghanashini estuary

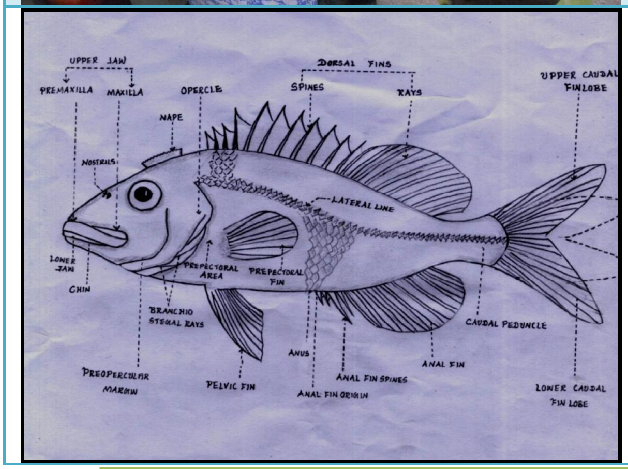
Estuarine crabs from Aghanashini estuary

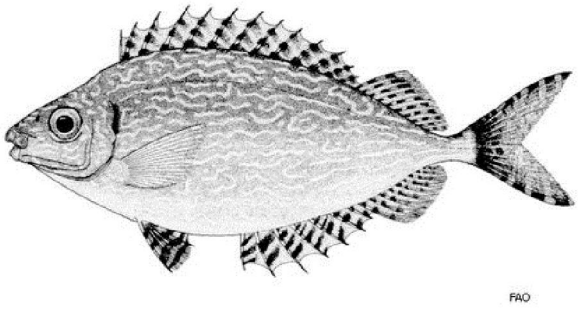
Fishermen getting ready gillnets for operation in Aghanashini estuary

Crab catcher in Aghanashini

Sand mining without setting sustainable limits

Fishing canoe kept for drying close to mangrove patch





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