Fish Distribution in Relation to Salinity in the AghanashiniEstuary Kumta,Karnataka

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Introduction

Fish is a major protein rich food source for humans around the world. Marine sources provide about 20% of the animal protein consumed by humans.There are to date around 25,000 known fish species of which15,000 are marine, that includes estuarine fishes, and nearly 10,000 are freshwater (Holmlund, 1999).

Over-fishing and its consequences: Decline of fisheries is feared to cause overall decline of biodiversity ultimately affecting the ecosystem functioning andhuman welfare. Consumption of organisms by fish, a salient feature that regulates trophic structure, influences the stability, resilience, and food web dynamics of aquatic ecosystems(Cecilia M. *et. al*.,1999, Clausen*et.al*., 2008).Fish that are consumed also transport nutrientstransgressing spatial boundaries and linking different ecosystems whether in water or on landFishing is not only for livelihood but also is a popular sport. Aquaculture, both inland and in coastal waters, has become a major source of protein rich food production throughout the world. Fish, from time immemorial, has been used in traditional medicine and is also increasingly used in the modernpharmaceutical industry.

Fishes live in various habitats and micro-habitats within their major aquatic domains,namely, freshwater, estuarine, and marine areas. The focus of thepresent article is on fishes in relation to salinity levels in the estuaries.Estuaryis a semi-enclosed coastal body of water having a free connection with the open sea and within which the sea water is measurably diluted with fresh water deriving from land drainage (Pritchard, 1967). Estuaries are located all over the globe and

are ranked among the most productive ecosystems of the world. They are also among the world's most beautiful andbiologically diverse habitats, and are very favored places for human settlements from time immemorial.The estuaries, meeting places of rivers with the sea, are high ranking among coastal natural habitatsbeing rich feeding grounds for shore birds and breeding grounds for fish and many marine organisms.

An estuary usually exhibits a gradual change in salinity throughout its length, as fresh water entering it from the land, through the river, mixes with the salt water brought in by the marine high tides. Salinity, highly variable within the estuary depending on seasons and distances from the sea, is a major factor decisive on the types of plants and animals that can live in it.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.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.

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 diminishesthe salinity rises in the estuary 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.Several fishesuse estuaries for laying eggs and developingtheir young ones. The abundance of nutrients in the estuary, as inputs from land sources, favour the growth of juveniles of many marine fishes which later move into the sea, their main home to be. *Otolithusruber*and*Latescalcarifer* are some examples of such fishes. Although there is some good data on individual fish species associated with estuary and its salinity, there is hardly any study yet from the Indian west coast on how the fish community, as such, collectively respond to wide salinity fluctuations in the estuary. In the current study our efforts are to understand year-

long fish diversity and distribution details in relation to fluctuations in salinity in the Aghanashini estuary of Uttara Kannada district, towards the centre of the Indian west coast.

Materials and Methods

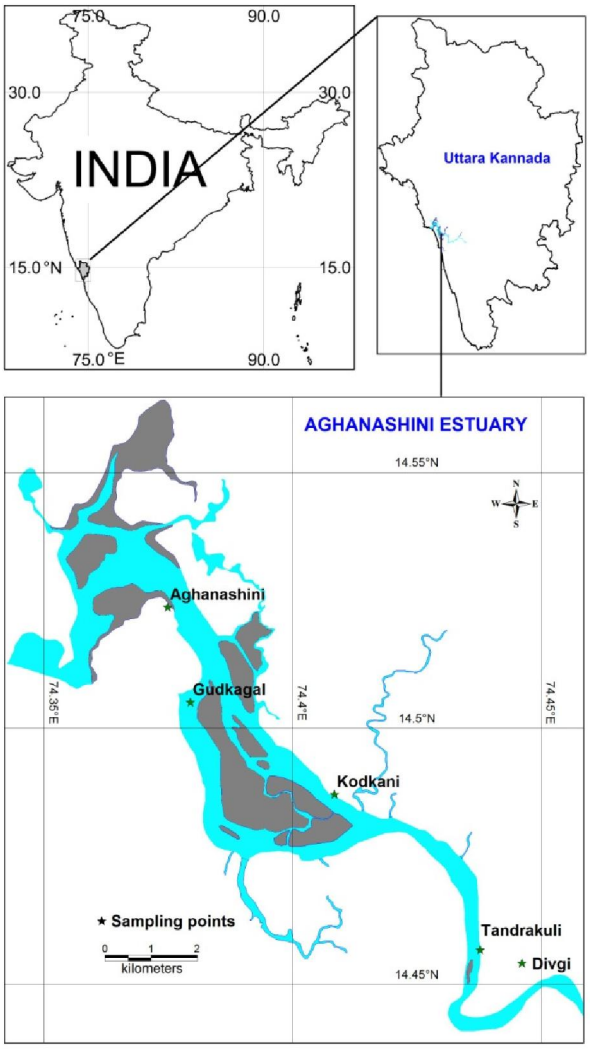


Figure 1: Location of Aghanashini estuary

Study area

The study was carried out in the estuary of AghanashiniRiver (Lat 14.391° to 14.585° N; Long 74.304° to 74.516° E) of Kumtataluk in the Uttara Kannada district of central west coast of India in the Karnataka State.The Aghanashinini River originates in the Western Ghats of Sirsitaluk in Uttara Kannada and winds its way through a rugged terrain for about 121 km before its confluence with the Arabian Sea. The estuary of the river is an expanse of about 48 sq. km between the famous temple town of Gokarna in the north and Kumta town in the south. The passage of the river through the forest clad Western Ghats and intermittently through agricultural landscapes has made it rich in biodiversity. Plenty of organic matter from the forests gets deposited in this estuary making it rich in nutrients. Mangroves that flourish in the estuary also provide ideal habitats for fish breeding and confer on them relative safety from predators and fishing by humans. In the recent years, due to the efforts of Karnataka Forest Department, good parts of the suitable habitats, almost six sq.kms, have been planted with mangroves; thereby creating very hopeful situation as far as the future of fisheries is concerned.

Measurement of salinity

Salinity is one of the critical factors that are decisive of fish diversity in any tropical estuary. In the estuary the high tides arrive from the sea twice in 24 hours bringing in a flush of salinity. In any estuary, the high tide contributes to increase in the salinity. Therefore, sampling of water for salinity was carried out during high tide timings only.Salinity was recorded on monthly basis using refractometer from five stations, two each from estuarine mouth and mid estuarine regions and the fifth one closer to the fresh water part of the river before it widens into the estuary. Salinity range was usedfor dividing the estuary into high, medium and low salinity zones. Salinity zones were established on the basis of mean salinities of the year(average of 12 months salinity) viz.,zone I:20.1 ppt or more mean salinity,zone II:10.1 to 20 pptand zone III: 0 to 10 ppt.

Fish diversity

The fish species of the estuary was inventorised from its mouth region closer to the Arabian Sea to its upstream region touching the fresh water portion of the river. The fishermen are active almost throughout the year, except when the river is in flood, in all the estuarine villages. The collected fishes were preserved in 10% formalin and identified using Day (1889), TalwarandJhingran (1991), and Munro (2000).Local names are also used as they are helpful guides for fish identification. Efforts are on to identify some of the fishes and juvenile forms that are yet to be identified.

Fish distribution

Fish samples for identification were obtained from different sections of the estuary from the fisher-folks. A questionnaire was preparedto obtain answers from the fisher folks about the occurrence of individual fish species in different parts of the estuary during different times of the year and the data tabulated. Through this questionnaire only commercially important fishes could be covered, as the fisher-folks do not keep clear track of fish species of negligible importance to them.Using the salinity data from the five sampling stations the fish species chosen were assigned to three classes of salinity namely high, medium and low and accordingly the fishes are called as narrow salinity range fishes, wide salinity range,Fresh water fishes entering estuary, Brackish and fresh water inhabiting,Estuarine exclusive fishes, Other rarer fishes and of indeterminate habitats.

Collection of miscellaneous information

In every fishing village/hamlet 5 to 15 persons were interviewed for fishes caught from different parts of the estuary and also on fishing efforts, local names,number of fishing days/month, market value, gears used, range of the fish etc.

Results and Discussion

Salinity zones

The salinity conditions in the Aghanashini estuary during study period in 2011as found to fluctuate greatly season wise. As the South-west Monsoon pounds on the coastal areas and the Western Ghats bringing in 2500 to 5000 mm of rainfall, a good part of it in just four months (June-September), the volume of fresh water onrush into the estuary is so high to keep down the salinity conditions to zero level for most of the rainy season. This time is not congenial for any stenohaline (fishes that live in narrow range of salinity) marine fishes. With the rainy season tapering off almost completely by October-November, the salinity starts rising and the mean winter period salinity ranges from almost 1 ppt in the upper reaches of the estuary to about 27 ppt in the lower reaches towards the sea. The intermediate portions exhibit salinity of about 17 ppt. The salinity continues to rise after winter so as to attain mean of 32 ppt towards the river mouth to the minimum of 15 ppt. in the upper reaches bordering the fresh water zone of the river. The mid estuary average was around 21pptduring this period.

Based on high tide salinity measurements in five stations it was possible to establish three salinity zones in the estuary (Figure 2). The sampling stations in high salinity zone (zone-1) were Aghanashini and Gudkagal; for medium salinity zone (zone-II) the station was at Kodkani and for the low salinity zone (zone-III) the stations were atTandarkuli and Divgi. Although salinity conditions were studied through monthly samples, for salinity zone establishment only the summer or pre-monsoon (March- April-May) salinities were considered,as during the rainy months from June to November it is difficult to get true picture of the estuarine salinity as it would be at its lowest most of the time due to heavy rains and periodical flooding. Fresh water input continues in substantial quantities even after the rainy period due to water flow from the mountain streams into the river. Nevertheless salinity keeps rising throughout from October to January period. From mid November to almost end of May could be totally rainless or with few spells of summer rains which hardly have any significant impact on estuarine salinity. Therefore salinity levels in the estuary continues to rise until May, when it touches 36ppt in Zone III at Aghanashini, and 31 at Gudkagal also in the same zone. Monthly salinity levels in all the five.stations covering the three zones are given in Figure 2 and Table 2. In all the three zones, salinity was measured during every month and the average values for seasons are shown in the Table 3.

Fish distribution in relation to salinity

During the present study about 80 species of fishes were documented from the estuary using both primary data and secondary information gathered from the fishermen. In fact ongoing efforts are likely to result in enlarging this list of fishes (Table 1). So far 59 fishes from the estuary were identified to generic or species levels. The remaining ones are from secondary data and the search is on for specimens, which are obviously rare, during future studies. However, most of the commercially important species have been assigned to species level.

Table1: Occurrence of fishes in relation to different salinity zones during the three seasons (Rainy (R); Winter (W) and Summer (S)

Sn	**Family**	**Scientific name**	**Local names (Kannada)**	**ZONE-I**			**ZONE-II**			**ZONE-III**			**REMARKS**
				R	W	S	R	W	S	R	W	S	
1	Ambassidae	*Ambassiscommersoni*	Burante 1	+	+	+	-	-	-	+	+	+	-
2	Apogonidae	*Apogonhyalosoma*	Burante 2	+	+	+	-	-	-	+	+	+	-
3	Ariidae	*Arius arius*	(Cat fish Bilisady)	+	+	+	+	+	+	-	-	-	-
4	Ariidae	*Arius spp.*	Cat fish (GondeSady)	+	+	+	+	+	+	-	-	-	-
5	Batrachoididae	*Austrobatrachusdussumeri*	Gonke/Gorke	+	+	+	+	+	+	+	+	+	Rare in zone II
6	Belonidae	*Strongyluraleiura*	Burkaandi	-	-	-	+	-	-	-	-	-	Rare
7	Carangidae	*CaranxPraeustus*	Guruku1	+	+	+	+	+	+	+	+	+	Mainly marine
8	Carangidae	*Carangoidschrysophrys*	Kokkara	+	+	+	+	+	+	+	+	+	Peakin winter in zone I
9	Carangidae	*Carangoidspreustus*	Haluguruku	-	-	-	-	+	+	+	-	-	-
10	Carangidae	*Carangoidessps*	Halukokkara	+	+	+	+	+	+	+	+	+	-

11	Cichilidae	*Etroplussuretansis*	Banded pearl spot(Kagalse/tonki)	+	+	+	+	+	+	+	+	+	Peak in zone I inrainy &zone II in winter, Brackish-fresh
12	Clupeidae	*Sardinellafimbriata*	Pedi	+	+	+	+	+	+	+	+	+	Marine
13	Pristigasteridae	*Opisthopterustardoore*	Pachage	+	+	+	-	-	-	-	-	-	-
14	Cynoglossidae	*Paraplagusiabiliniata*	Leppe 2	+	+	+	+	+	+	+	+	+	-
15	Cynoglossidae	*Cynoglossusmacrostomus*	Leppe 3	+	+	+	+	+	+	+	+	+	-
16	Engraulidae	*Stoliphorusindicus*	Indian anchovy(Belanji)	+	+	+	-	-	-	-	-	-	Marine; peak presence in summer
17	Engraulididae	*Stoliphoruscommersoni*	Commerson's Anchovy(Doddad anashi)	-	-	+	-	-	-	-	+	-	-
18	Gerridae	*Gerriesfilamentosus*	Girbaingi	+	+	+	-	-	-	+	-	-	Likely to be present throughout the estuary
19	Gerridae	*Gerreslimbatus*	*Mundbaingi*	+	+	+	-	-	-	-	-	-	-
20	Gobiidae	*Glossogobiusgiuris*	BiliMandli	+	+	+	-	-	-	-	-	-	Fresh to brackish
21	Lactariidae	*Lactariuslactarius*	Samdale	-	-	+	-	-	-	-	-	-	-
22	Latidae	*Latescalcarifer*	Seabass (Kurude)	+	+	+	+	+	+	+	+	+	Coastal & estuarine
23	Leiognathidae	*Secutorinsidator*	Guruku 2	+	+	+	+	+	+	+	+	+	-
24	Lutjanidae	*Lutjanusjohni*	Hottekemsa	-	-	-	+	+	+	-	-	-	estuarine
25	Lutjanidae	*Lutjanusruselli*	Russell's snapper	+	+	+	+	+	+	+	+	+	estuarine

			(Kemsa)										
26	Lutjanidae	*Lutjanusargentimaculatus*	Eri	+	+	+	+	+	+	+	+	+	estuarine
27	Mugilidae	*Mugilcephalus*	Madle	+	+	+	+	+	+	+	+	+	Peak in September
28	Mugilidae	*Liza parsia*	Madle	+	+	+	+	+	+	+	+	+	Peak in September
29	Nemipteridae	*Nemipterusjaponicus*	Rani menu	+	+	+	-	-	-	-	-	-	-
30	Paralichthyidae	*Pseudorhombusjavanicus*	Nengu	+	+	+	-	-	-	+	+	+	-
31	Platacidae	*Platax orbicularis*	Round bat fish	+	+	+	-	-	-	-	-	-	-
32	Platycepha-lidae	*Platycephalusscaber*	Vadati	+	+	+	+	+	+	+	+	+	-
33	Pomadasyidae	*Pomadasysmaculatus*											
34	Rhinobatidae	*Rhinobatushalavi*	BalagendeTorke	-	-	+	-	-	-	-	-	-	-
35	Rhinobatidae	*Rhinobatus spp.*	Kari BalagendeTorke	-	-	+	-	-	-	-	-	-	-
36	Rhinobatidae	*Rhinobatus spp.*	HulluTorke	-	-	+	-	-	-	-	-	-	-
37	Rhinobatidae	*Rhinobatus spp.*	Hakkitorke	-	-	+	-	-	-	-	-	-	-
38	Rhinobatidae	*Rhinobatus spp.*	Het Torke	-	-	-	-	-	+	-	-	-	-
39	Scatophagidae	*Scatophagusargus*	Spotted scat (Hulka)	+	+	+	-	+	+	-	+	+	Rare in Zone II &III Marine-enters estuary for feedingPeak in zone I during rainy.
40	Sciaenidae	*Otolithusruber*	Banagu, Dodi	+	+	+	+	+	+	+	+	+	*Peak in zone I*

													during rainy.
41	Scombridae	*Rastrilligerkanagurta*	Mackerel(Bangade)	-	-	+	-	-	-	-	-	-	Marine enters zone I in summer
42	Scombridae	*Cybiumcommersoni*	Iswana	-	-	+	-	-	-	-	-	-	Marine, rarelyenters
43	Serranidae	*Cephalophalisboenak*	Gobra(Kallumurge)	+	+	+	+	+	+	+	+	+	-
44	Siganidae	*Siganusvermiculatus*	Baana/Padiyar	+	+	+	+	+	+	+	+	+	-
45	Sillaginidae	*Sillagosihama*	Nogla	+	+	+	+	+	+	+	+	+	Peak in rainy season
46	Soleidae	*Synapturacommersoniana*	Commerson's sole (Leppe 2)	+	+	+	+	+	+	+	+	+	-
47	Sphyraenidae	*Sphyraenabaracuda*	Onakaandi	+	+	+	-	+	-	+	+	+	-
48	Sphyraenidae	*Sphyraenaobtusata*	Hallinkaandi	+	+	+	-	-	-	-	-	-	Rare
49	Sphyraenidae	*Sphyraenaspp*	Sujikaandi	+	+	+	+	+	+	-	-	-	Rare
50	Sphyraenidae	*Sphyraenaspp*	Burakaandi	+	+	+	+	+	+	-	-	-	Rare
51	Stromatidae	*Pampusargenteus*	Bilimanji	-	+	-	-	-	-	-	-	-	Marine visits the estuary in winter
52	Stromatidae	*Parastromateusniger*	Kari manji	-	+	-	-	-	-	-	-	-	Marine visits the estuary in winter
53	Synbranchidae	*Monopterusalbus*	Kolav	+	+	+	-	-	-	-	-	-	Rare
54	Teraponidae	*Teraponjarbua*	Kumbari(garge)	+	+	+	+	+	+	+	+	+	Goes to nearly fresh water
55	Triacanthidae	*Tricanthusbiaculeatus*	Kuduremeenu	+	+	+	-	-	-	-	-	-	-
56	Trichiuridae	*Trichiurushaumela*	Barikhamle	+	-	+	-	-	-	-	-	-	-
57		Eel	Aragotka	+	+	+	+	+	+	+	+	+	Marine to fresh

													water
58		Puffer fish	*Chonja*	+	+	+	+	+	+	+	+	+	-
59		*Scolidonspp* (Shark)	sora	-	-	-	+	+	+	+	-	-	Marine, present in zone II in winter

Unidentified fishes (often rare ones in the estuary) known by local names

60		Hemalga	-	+	+	+	+	+	+	+	+	+	-
61		Bombale	-	+	+	+	+	-	-	+	-	-	-
62		Ramachi	-	+	+	+	+	+	+	+	+	+	-
63		Karchi	-	-	-	-	+	+	+	+	+	+	-
64		Galse	-	+	+	+	+	+	+	+	+	+	-
65		Tenli	-	+	-	-	-	-	-	-	-	-	Rare
66		Keke	-	-	+	-	+	-	-	+	-	+	-
67		Hola	-	+	+	+	-	-	-	-	-	-	Rare
68		Mara Vadati	-	-	-	-	+	+	+	-	-	-	Rare
69		Haambi	-	-	-	-	+	+	+	-	-	-	Rare
70		Kolicheri	-	-	-	-	+	+	+	-	-	-	Rare
71		Vaintali	-	+	+	+	+	+	+	+	+	+	-
72		Mullante	-	+	+	+	+	+	+	+	+	+	-
73		Kari Mandli	-	+	+	+	-	-	-	-	-	-	-
74		Chanakala	-	-	-	+	-	+	-	-	-	-	-
75		Hembale	-	-	-	+	-	-	-	-	-	-	-
76		Soge	-	-	-	-	-	-	-	+	+	+	-
77		Adaga	-	+	-	-	+	-	-	+	-	-	-
78		Kandali	-	-	-	+	-	-	-	-	-	-	-
79		Baalya	-	+	+	+	-	-	-	-	-	-	Rare
80		Murugundu	-	+	+	+	-	-	-	-	-	-	Rare

Marine fishes of narrow salinity range entering the estuary

It was found that when the salinity reached the peak during summer (some of the primarily marine fishes, of commercial importance, especially the ray fishes (*Rhinobatusspp.*), mackerel, *Rastralligerkanargurta,*seer fish (*Cybiumcommersoni*), *Lactariuslactarius,* anchovies (*Stoliphoruscommersoni*) were found to enter the high salinity zone of the estuary. These are not obligately estuary dependent for their life cycles; they mainly use the lower reaches of the estuary (zone III) as feeding grounds opportunistically when the salinity conditions are within their osmotic tolerance ranges.

The **ray fishes,***Rhinobatusspp.*(Kan:Torke),preferring shallow coastal water, feed on benthic organisms, mainlymollusks and crustaceans.They have flat depressed bodies with elongated snouts. Rays are common along the Indian coast preferring sandy bottom. Rays even bask in the intertidal zone of the sea and are exposed for short spells when the waves recede. When there is any danger they wriggle into the sea on a sloping beach. *Rhinobatushalavi* is known to attain a length of nearly two meters, including its whip like tail (Day, 1889; Munro, 2000). The estuarine mouth of Aghanashini rich in molluskan beds (Boominathan*et.al*.,2008) are probably good feeding grounds for these ray fishes.

The **seer fish**, *Cybiumcommersoni* (Kan: Iswan), is a highly priced table fish; when full sized it could exceed one meter in length. It is steel blue along the back with silvery and white abdomen. The seer fishes usually feed on sardines and anchovies (*Wealth of India, IV, Suppl.*, 2003).

Mackerel, *Rastrelligerkanagurta*(Kan:Bangade),is a very popular marine fish caught in very large quantities in the Indian waters and constitute the major share of fisheries from the west coast.It grows up to 31 cm long, usually attains 20-25 cm and is laterally compressed. It has greenish back and metallic lusture on sides. It feeds on phytoplankton and zooplankton.Enormous shoals of mackerel appear during October-January period. Surplus catches of this fish was traditionally salted and dried. Of the genus *Rastrelliger*only

*kanagurta*enters the inshore waters, others are occurringin offshore regions only. The weakening of the South-west monsoon is associated with prolific productivity of plankton in the inshore waters that could be the main factor for the shoals of mackerel to appear along the west coast. Moreover the fish is known to lay eggs in coastal waters than in offshore areas during April to September period (*Wealth of India, IV, Suppl.*,2003).

It may be the favourable salinity conditions and the high production of planktonic food that attract mackerel into the zone I of the estuary. The catch of this fish from high salinity zone takes place particularly during the summer months. Bulk of the seasonal catch being in the inshore waters, within four km from the shore, mackerel fisheries is very important for the subsistence of the artisanal fisher folks.

The **White fish**, *Lactariuslactarius*(Kan: Samdale), is a very popular table fish, considered light diet for convalescing persons, unlike mackerel which is considered heavy. It has lead coloured dorsal side up to lateral line. It grows up to maximum length of 25 cm. It is spindle shaped and laterally compressed. It moves in shoals which come into coastal waters of Malabar during February to March. The white fish prefers the calm inshore waters and enters the estuary, especially in summer months when salinity conditions are suitable. It is a carnivorous fish feeding mainly on prawns, sardines, and other small fishes.Whereas the fish is caught in good quantity from the sea during June to December, the estuarine catches are mainly confined to summer months(*Wealth of India, IV, Suppl.*,2003).

The **White pomfret**, *Pampusargenteus*(Kan: Bilimanji), is a delicious and high value marine fish. It is oval shaped and flat, being laterally compressed. Its upper half is deep grayish to light brownish grey, silvery below with metallic reflections, and dotted brown all over. Zooplankton constitutes its main food. Shoals occur in shallow muddy inshore waters. The pomfrets show tendency to migrate into the estuaries whileyoung. They were reported to be abundant in March in Sundarbans and Mumbai. June to September was considered as good period for Malabar

Coast(*Wealth of India, IV, Suppl.,* 2003). In the Aghanashini estuary the fish occurs in zone-1 during the winter months.

The **Black pomfret,***Parastromateusniger(*Kan: Karimanji), is yet another valued marine fish that enters the zone I of the estuary during the winter months.It is flat and strongly compressed fish, which attains at maturity a length of about 2 ft.It feeds on fish egg, crustaceans and algae (Dadzie, 2003).It is blackish in colour with blue reflections and can be easily distinguished from the white pomfret.

Marine fishes of wider salinity ranges

Tiger toothed croaker,*Otolithusruber(*Kan:Banagu),belongs to the community of croackers or sciaenids which are associated with warm coastal waters and estuaries of the world. Many species use the estuary as nursery and feeding ground for the young. The genus is characterized by carrot shaped gas bladder with a pair of long tubular appendages with ramifications (Talwar and Jhingran, 1991).*O. ruber*is a sluggish carnivore,inhabiting mainlysandy and muddy areas. Their maturitysizes range between 220mm and 240mm. (Brash *et.al.,* 2005);thesciaenids attain maturity in the second year and breed in shallow coastal waters. The spawning season for majority of sciaenid species in the Indian waters is during the monsoon and post-monsoon months. During the protracted spawning period spanning over six months, the individual fish spawns twice(Mohanraj*et.al.,* 2003). In the Aghanashini estuary *O. ruber* occurs throughout the year in all the three salinity zones benefitting much the local fisheries. It occurs in greater abundance in the zone-I towards the river mouth during the rainy season.

Whipfin silver biddy, *Gerriesfilamentosus*(Kan:Girbaingi),is a flattened silvery fish with horizontal bluish spots along the upper half of the bodyand numerous fine dots on fin membrane. It has highly protrusiblemouth adapted for feeding on bottom biota.The fish attains 20cm length at maturity and has a depth 2 to 2.5 times its standard length. Of its dorsal fin the second spine is very long and directed backwards. It is omnivorous feeding mainly on crustaceans, bivalves,

polychaetes, gastropods, coelenterates, small fishesand miscellaneous items including plant material. It is found in the Indian to the Malay Archipelago and beyond attaining 8 inches or more length (Day,1889).A study in the nearbySharavathi estuary reveals a decline in its feeding during the peak rainy months of July to September which coincides with its spawning period (Golikatte*et.al*.,2011). Its occurrence in the Sharavathi estuary, which has very low salinity (< 2ppt throughout the year) could be taken as proof for its wide tolerance range of salinity from near fresh water conditions to marine waters. Its occurrence is more towards the zone-I in the Aghanashini estuary.

Double lined tonguesole,*Paraplagusiabilineata(*Kan:Leppe), is a sole fish with flat tongue-shaped body with fairly rounded snout and very small eyes on left side. Like fallen leaves these fishes lie on muddy to sandy bottom with their eyes on the upper part and mouth towards the lower left side of the indistinct head part. It is covered with microscopic scales. On the upper side are two lateral lines which converge towards the head and the tail.They inhabit the sandy to muddy bottoms of the continental shelf and enter shallow estuarine waters (Talwar and Jhingran, 1991;Sommer*et.al*., 1996).

Fresh water fishes entering estuary

Bar-eyed goby,*Glossogobiusgiuris*(Kan:Bili-mandli), is considered a fresh water fish of the plains of India that sometimes occurs in the brackish water also (***Wealth of India, IV, Suppl.,***2003). Rao*et.al*.,(2002) consider it as basically an estuarine fish that occurs quite frequently in fresh waters too, whereas Talwar and Jhingran (1991) consider it primarily as of both fresh and estuarine waters and could be found in the sea as well. These observations testify to the wide adaptability of the fish from practically no saline conditions to the sea water. However, in our study area the fish was predominantly associated with the zone-I in all the seasons, affirming the fact that it survives zero salinity of rainy months to high salinity of summer period. It has long tapering body, attaining almost 46 cm, and is easily identifiable due to its vertically compressed head. Males are usually brown, females yellowish with grey marblings and black spots. According to ‘Fishbase’ (www.fishbase.org) it attains a much larger

size in brackish water than in fresh water.Though it is tougher fish externally its meat is tastier and is priced reasonably high in the local markets, but it seldom occurs in abundance.

The fish is a burrower in the mud and sand for which habit its shovel like head is ideal;it also enters into the crevices and holes towards bases of mangrove trees. It is a carnivore feeding on copepods, cladocerans, post larvae and juveniles of shrimp, insect larvae, polycheates, juvenile fish etc. On the east coast it is reported to be occurring in the shrimp and fish culture ponds in considerable numbers, where it not only competes for food and space but also preys upon them, thereby causing severe losses to the culturists(Rao*et.al.*,2002).

Brackish and fresh water inhabiting

Pearl spot,*Etroplussuretansis*(Kan: Kangalsi),is distributed along the west and east coasts of India and coast of Sri Lanka. It tolerates wide range of salinity conditions. It is found in coastal fresh and saline waters, and is ideal for culturing in both brackish and fresh water conditions. It attains a length of 10-13 cm in one year, and in the fresh water conditions maximum length of 31 cm. was reported (*Wealth of India, IV, Suppl.,*2003).The fish caught from the sea are deep purple with 8 nearly black vertical bands and dead white spots; those from backwater and ponds are of lighter green with 8 transverse bands of darker colour. Fins are of lead colour, except pectoral which is yellow with jet-black base.

The fish is one of the most sought after table fish, especially in Kerala, despite its high thorniness. It breeds twice a year, during May-June and November-February, both in saline and fresh waters. Salinity has little effect on the growth of *E.suratensis*; its rate of growth is not very fast. The best catches are obtained in December, just before the breeding peak (*Wealth of India, IV, Suppl.,*2003).

Estuarine and marine

Mullets are important estuarine fishes of Uttara Kannada. These carnivorousand high value fishes inhabit coastal waters including estuaries and rivers. They have great adaptablility to changes in salinity. Though most mullets spawn at sea the young enter the estuaries, their main nursery area.They have remarkably uniform appearance and anatomy and can be distinguished by elongated, slightly compressed body, depressed head, short snout and eyes partly covered by fatty tissue. The small mouth, either toothless or with tiny teeth,is towards tip of snout or on its underside. Of the two species found in Aghanashini*Mugilcephalus* (Flat head mullet)is cosmopolitan, widelydistributed in coastal waters, lagoons, and estuaries. Ithas more robust body, up to 91 cm long, with broad head that is much flattened dorsally and has thin lips. Colour on back olive green, silvery on flanks, shading to white below. It has six or seven indistinct brown bands down flanks, a dark purple blotch at base of the pectoral fin. Dorsal and caudal fins have dusky margins itis capable of surviving in coastal ponds with high salinity(Talwar and Jhingran, 1991).This mullet is ideally suited for aquaculture(Hsu *et.al.,2007)* and is reported to flourish in the fresh water tanks of Chennai (*Wealth of India, IV, Suppl*., 2003).

Goldspot mullet,*Liza parsia*(Kan:Madle),has slender body with moderately wide head, dorsally flattened, two rows of short teeth on upper lip, but lower lip toothless. This mullet grows 15-19 cm in one year and spawns in the sea (Talwar and Jhingran, 1991). The live fish are greenish brown above,white to silvery below, with golden spots on the operculumanal and caudal fins, which are yellowish.Other fins off-white with dusky margins.Inhabits shallow coastal waters,estuaries and lagoons;entering tidal rivers.Itsmaximum length of 40 cm was attained in natural waters and 25cm in pond cultures. Spawning takes place at sea (Day,1889).Primarily a detritus feeder substituting its food with diatoms and filamentous algae theminimum size at first maturity was found to be 13.5 cm (Babu*et.al*., 1983).

Scats are small estuarine fishes found in harbours, estuaries and lower reaches of fresh water rivers. Body disc shaped, deep and strongly compressed. Head small; mouth is also small but not of protruding type. It is generally believed that these fishes spawn in the neighbourhood of coral

reefs but the young migrate into the river mouths and other estuarine areas until they grow large enough,ready to go back to the sea.

Spotted scat,*Scatophagusargus(*Kan: Hulka), also known as 'leopard pomfret', is frequent in the coastal waters of India. It inhabits harbours, natural embayments, estuaries and lower reaches of fresh water rivers, frequently occurring among mangroves. It attains 30cm length at maturity (TalwarandJhingran, 1991). Its quadrangular body is strongly compressed; the mouth is small and teeth are brush like, and scales are tiny. The dorsal fin is deeply notched. It is of variable colour, the young ones of about 2 cm are quite dark whereas in the 5-6 cm stage the adult colouration appears and characteristic markings appear. They are uniform greenish silvery, bluish-silver or coffee-brown with a delicate golden sheen,especially on back;numerous greenish-black spots are mainly confined to upper portion of sides. It makes a handsome aquarium fish. Although tasty and shaped like a pomfret though,it is not all that sought after, and the poorer people are the major consumers; it may be the prominent dots and the tougher skin that deter the richer consumers. The fish feeds mainly on multicellular algae and detritus. It feeds on the algae and detritus attached to the ships and boats. It is suitable for farming in brackish water (Day, 1889;TalwarandJhingran, 1991;Gandhi,2002).

It is euryhaline having wide ranging salinity tolerance; the young onesmove towards fresh water whereas the mature ones move towards the sea. It enters the estuaries mainly for feeding, the mangrove swamps being its favourite feeding grounds. They are also reported to be spawning in the mangrove areas of Thailand estuaryaccording to Wongchinawit*et.al.,*(2009). Detailedinvestigations of the stomach contents of the juveniles reveal that these fishes feed mainly on phytoplankton.The zooplankton, benthos, insect and detritus are found to lesser amounts. The pennate diatoms of the mangrove swamps constitute major share of their food. The sub terminal mouth that supports the feeding habit.The fish is reported to visit the mangrove areas for spawning.

In the Aghanashini estuary it occurs in all the three salinity zones. Whereas in the high salinity zone closer to the sea it is found throughout the year, it tends to avoid zone II and III during the rainy season when the salinity is practically nil. Nevertheless, according to the Wealth of India(2003) it is amenable to culture in brackish water and easily adapts to fresh waters.

Seabass,*Latescalcarifer* (Kan: Kurudi), possess elongated body, rather pointed head, with large, concave mouth, with the upper jaw reaching to behind eyes. *L. calcifer* inhabits coastal, estuarine and other brackish water areas. Much of its catch lands in winter. It enters estuaries and backwaters for food and shelter but always return to marine environments for spawning, mainly during June/July, when estuaries are flooded and salinity is at the lowest (Talwar and Jhingran, 1991).

The juveniles are olive-brown above with silvery flanks and belly; the adults are greenish above and silvery below; eyes are bright pink and glowing at night.This species adapts itself to the fresh waters,in tanks with ample fish and crustaceans, being a voracious carnivore. It also feeds on shrimps, worms and snails. It is therefore not suitable for mixed fish culture. It attains a length of 46 cm in one year.This species is esteemed as a food fish and is a good game fish (*Wealth of India, IV, Suppl.*,2003).It is euryhaline, tolerant of wide range of salinity. The young ones from the sea migrate into the estuaries, lagoons & brackish waters. The spawning season, breeding grounds and attainment of maturity of sea bass vary according to location. Fish generally spawns from January to August in India (James *et.al*., 1986).

Whitings constitute a diverse family of fishes associated with shallow sandy bottoms of shores of bays and creeks and estuaries (Shamsan, 2008).

A notable member of the group **Silver sillago,***Sillagosihama*(Kan: Nogla), like other Sillagos are characterised by elongated body with fairly small scales and small terminal mouth with minute

teethin bands.The sides and belly are whitish or silvery and the dorsal side brownish green to olive green. The caudal fins are dusky; the dorsal and other fins are pale. It attains maximum size of about 25-30 cm. (Talwarand Jhingran, 1991; *Wealth of India, IV, Suppl.,*2003).It is associated with shallow sandy bottoms of shores and bays, and also estuaries. This near shore species frequently moves into the estuaries for considerable distances upstream. Because of their habit of burrowing in the sand when alarmed these fishes are also called sand whitings. They are caught in nets, or on long lines baited with prawns or bristle worms. They are excellent and highly priced food and are considered particularly nourishing for nursing mothers(*Wealth of India, IV, Suppl.,*2003).*S. sihama* has heavy dependence on the estuaries and is found throughout the year in all three salinity zones of Aghanashini.In the Zuari estuary of Goa,Shamsan*et.al.,* (2010) recorded prolonged breeding season from June to December, with spawning activity peak during the period of September to November.

Estuarine exclusive fishes

Snappersconstitute apan tropical family of 17 generaof predominantly marine and coastal areas. Just one genus, *Lutjanus*has association with the estuaries. They are predacious marine fishes often brightly coloured and with compressed body and fairly large mouth. Spawning for most tropical snappers occurs over aconsiderable part of the year and may take place year round in some species. Spawning peaks generally coincide with periods of warm water temperature, but not necessarily the warmest time of the year. In the wild, many lutjanids spawn at night near open water. Similarly, in aquaculture situations, spawning in tanks occurs at night (Russell*et.al.*,2008).

River snapper,*Lutjanusargentimaculatus***(**Kan: Eri),is a coastal fish with dark rose or reddish brown colour, and dull cherry below. Body elongate, with head profile straight or slightly convex. Its lateral line has 48 scales. Fins are with dark edges and the tail rounded. Juveniles usually inhabit mangrove and shallow water areas,but adults are found to a depth of 80 m in the sea (TalwarandJhingran, 1991).It is highly valued fish in the local markets and is also a sought after game fish.

John's snapper,*Lutjanusjohni(Kan: Hottekemsa),*is a fairly deep bodied species with head profile straight or slightly convex. It is 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 the junction of spinous and soft part of the dorsal fin,surrounded by silvery ring in juveniles.Inhabits shallow water and mangrove areas (TalwarandJhingran, 1991).It shows a tendency to associate with corals in clear water. The fins are yellow dashed with red.It attains a maximum length up to 31cm. (*Wealth of India, IV, Suppl*., 2003).

Other rarer fishes and of indeterminate habitats

Commersons glassy perchlet,*Ambassiscommersoni*(Kan: Burante), is both marine and estuarine.Its elongate and fairly broad body attains 16 cm length. Head rather massive, with a prominent chin.It is a rather cheap but tasty fish and caters much to the protein needs of the poor (Talwar and Jhingran,1991).Though it was recorded from zone I and zone III only, it is likely to occur in the middle zone as well.

Humpbacked cardinal fish,*Apogonhyalosoma*(Kan:Burante), has bodyhigh below the 1st dorsal fin, a distinct black spot just in front of anal fin.It is euryhalineable to survive in marine, brackish and freshwater conditions.Adults inhabit mangrove estuaries, tidal creeks and lower reaches of freshwater streams, usually found in brackish water or freshwater of river mouths. Feeds on zoo benthos (Fishbase.org).In the present study area it occurred in zone I and III and is expected to occur in mid-estuary as well.

Threadfin sea catfish,*Arius arius(*Kan:Sady),is a robust bodied, long fish of 20 cm with depressed head furnished with three pairs of barbells (antennae); body colour is dark bluish to silvery steelalong back,lighter on flanks and below.Though the genus *Arius* is associated with seas,estuaries,tidal rivers, and brackish-water lakes, *A. arius*is almost exclusive to the brackish waters of estuaries and tidal rivers(Talwar and Jhingran, 1991).A notable food fish of

Aghanashini, it occurs both in zone I and zone II throughout the year and avoids zone III of lowest salinity.

Flat toadfish,*Austrobatrachusdussumeri*(Kan: Gonke), has resemblance to a frog in its anterior part due to large head and wide mouth. Anterior part of the body is depressed.Colour is pale brown with darker mottling tending to form irregular crossbars on the body.It prefers muddy bottom of coastal waters (FAO-1984).In the estuary though it is more towards high salinity zone its presence was recorded from zone II and zone III as well. The fish croaks almost like a frog and can remain alive for over an hour if taken out of water. It is considered of medicinal value locally and is specially given to asthma patients.

Kingfishesconstitutea group of 21 speciesof which few enter estuaries. They are all fast moving carnivorous fishes with more or less compressed bodies with thin small scales. Teeth tiny or absent. Two anal spines present separately from the fin. Tail fin is powerful.

Brown-backed travelly,*Carangoidespraeustus(*Kan:Haluguruku), hascompressed body,largest in mid-region, with spinous, moderately high dorsal fin.Body is bluish grey to brownish above and silvery whitebelow. Second dorsal fin lobe is abruptly black, caudal fin yellowish. This species is usually enters coastal waters (Talwar and Jhingran,1991).Present in all the III zones of Aghanashini estuary.

Longnose trevally,*Carangoidschrysophrys(*Kan:Kokkara), Body greenish above, silvery with yellow-green reflections below; a small black blotch on upper edge of opercle. Dorsal and anal fins ranging in colour from whitish to pale yellow to dusky;adults, up to 61 cm long are sometimes very dark; yellow streaks as eyebrows. Inhabits coastal waters to at least 60 cm depth. Juveniles occur in inshore areas, including estuaries. Marketed fresh or in dried and saltedstate (FAO-1984).Occurs in all the 3 zones of Aghanashini estuarythroughout the year.

Gar fishes are slender long fishes with narrow, long, stiff, beak like jaws. Chiefly marine and estuarine and are voracious carnivores.

Banded needle fish,*Strongyluraleiura(*Kan: Burakandi), haslaterally compressed elongated body, almost rectangular in cross section. Upper and lower jaw greatly elongated, studded with sharp teeth.Top of head and back greenish in colour; silvery stripe along side. Fish attains a size of 73 cm length (Talwar and Jhingran, 1991). It is an inshore and estuarine fish and was common in AghanashiniZone II during rainy season, may be due to abundance of food due to good mangrove vegetation.

Sardinesconstitute an important group of fishes abundantly caught in the Indian coastal waters.

FringescaleSardinella,*Sardinellafimbriata(*Kan:Pedi), has somewhat compressed but variable shaped body, from slender to moderately deep.This coastal species grows up to 10-15 cm. It is less valuable than the oil sardine as a source of fish oil. Catches usually obtained from September to January along the west coast.((*Wealth of India, IV, Suppl.*, 2003). It occurs throughout the estuary year round.

Ilishas, orPellonas,*Opisthopterustardoore(*Kan: Pachage*)*, has about 18 cm long and strongly compressed body; its belly has 29-35 scutes or serrations.Mouth pointing obliquely upward,very small dorsal fin and long anal fin. In life, back blue green, flanks and belly silvery. It is marine close to the shore and also enters the estuaries, reaching only zone I in Aghanashini. The fish has low fat content, but rich in calcium and is also suitable for use as fish meal or fertilizer (Talwar and Jhingran,1991).

Malabar sole,*Cynoglossusmacrostomus*(Kan:Leppe), Body tongue- shaped mouth reaching well beyond lower eye. Two lateral lines on upper side or ocular (eye) side, which is light brown and the undersideis whitish. Dorsal and anal fins grey-black.Inhabits shallow and sandy bottoms.Occurs in all the three zones of the study area.

Anchovies are typically marine occurring towards the coast in schools, some enter the brackish or even the fresh water to feed or breed. India has five genera of which four have association with estuaries. They have fusiform strongly compressed body. Snout projects beyond the lower jaw.

Indian anchovy,*Stoliphorusindicus(*Kan: Belanji), iswidespread along coastal waters and enters estuaries, and tidal rivers. Maximum length about 12 cm; body elongated and slender; subcylindrical in cross section. It is light transparent fleshy brown with silvery stripe down flanks;anal fin region below centre of dorsal fin base(Talwar and Jhingran, 1991).It does not tolerate low salinities and could be seen throughout the year in zone I of Aghanashini. The fish is in much demand for food, both fresh and dried.

Commersons anchovy,*Stolephoruscommersoni*(Kan: Danashi), is slenderbodies and somewhat compressed fish withslightly roundedbeely,with one to four small needle- like serrations between pectoral and pelvic fin bases.Posterior border of pre-operculum evenly rounded near maxilla tip; maxilla tip pointed, reaching to the hind border of pre-operculum.Pre-dorsal spine is absent.

Saddleback silver-biddy,*Gerreslimbatus*(Kan:Mundbaingi), ofIndiancoastal waters occurs in zone I of Aghanashini estuary. It is silvery with yellow fins; both dorsal and caudal fins have dark margins. A spot occurs on each spine and ray of the dorsal fin about its middle.

Pony fish/Silver belly has deep body, moderately to strongly compressed; upper surface has bony ridges; small mouth is protractile, it can extend forward forming a tube, making the face horse-like. Inhabits coastal waters and some enter the estuaries where they feed on the bottom.

Pugnose pony fish,*Secutorinsidiator*(Kan: Guruku), Inhabits shallow coastal waters and enters brackish waters.The body is oval and compressed withsmall mouth,pointing upward when protracted.It is silvery in colour upper half with the pearly blue spots(Talwar and Jhingran, 1991).It tolerates much variation in salinity and occurs throughout the estuaryduring all seasons. Though used as food it is not much cherished.

Threadfin-breamis small to moderate-sized, slightly compressed fish with terminal mouth having small teeth in bands.Dorsal fin single, with 10 spines and 9 soft rays, originating above pectoral fin bases, its first spine sometimes prolonged into a filament; pectoral fins with 14 to17 branched rays; pelvic fins with 1spine and 5 soft rays, their origin below or just behind the pectoral fin bases; first ray sometimes elongate.Colours variable; pattern of juveniles often differs from adult fish. Mostly found in shallow coastal waters, inhabits soft bottoms as well as frequenting coral reefs. Carnivorous, feeding on a wide variety of bottom-living invertebrates. Excellent food fishes (FAO1984).

Japanese threadfin bream,*Nemipterus japonicas(*Kan: Ranimeenu),is a demersal species,found also in coastal waters on muddy or sandy bottoms. This is valued food fish, (Kerdgari*et.al.*,2009).Body moderately deep with a convex dorsal profile and a moderately deep snout. Bottom-living, in depths to about 60 m. Males grow faster and to a larger size than females. Feeds on a wide range of bottom-living animals including worms, crustaceans, mussels, and cephalopods and Fishes. The diet changes little with size, but small fish prefer small crustaceans. (FAO 1984 species identification sheets volume 3).Located only in zone I ofAghanashini.

Left-eye floundersare flat fishes, called so because of eyes on left side of head. Mouth protractile; fins without spines. Dorsal fin originates from anterior to upper eye and reaches near caudal fin. Anal fin nearly similar but little less in size.Lateral line single and anus on the underside facing the bottom surface. Out of nine genera found in Indian waters only one is estuarine.

Javanese flounder,*Pseudorhombusjavanicus*(Kan: Nengu), Body oval and flat, eyed side brown, with darker spots and blotches. A large, blotch at anterior end of straight part of lateral line and a smaller blotch halfway to caudal fin base.Inhabits the shallower muddy and sandy bottoms.Feeds on bottom-living animals. Marketed mostly fresh(FAO-1984).Located inZones I & III of Aghanashini; likely to be present in Zone II.

Rock-cod groupers are long and robust bodied fishes of primarily marine waters; some also occur in the estuaries.

Blue-lined coral cod,*Cephalophalisboenak*(Kan: Gobra), has reddish brown body with or without darker vertical bars; body with indications of slightly irregular blackish-brown bars; head, with irregular, broad dark bands radiating from eye and a blackish spot between upper 2 opercular spines; soft portions of median fins with a narrow bluish-white margin. Found in coastal waters (FAO-1984,Munro, 2000). It occurs throughout the estuary and is expected to be widely tolerant of salinity changes.

Rabbit fish are oblong compressed fishes, covered with minute longitudinally elongate scales. Mouth is small, terminal not protractile.

Vermiculated spine foot,*Siganusvermiculatus*(Kan: Baana), is one of the largest of the rabbit fishes. It is a herbivorefound in the mangrove swamps.Its spawning cycle is linked to phases of moon; eggs are sticky and are laid at the bottomand the larvae are pelagic (surface dweller). Metamorphosis occurs between 23 and 27 days after hatching.The juveniles live in small schools in brackish to fresh water among mangrove roots. The young and adults are found mainly in shallow, muddy water of mangrove swamps where they move in and out with the tides. The adults also are reported from coral reef areas. The females can reach 45 cm and weigh 2.3 kg. The body of juveniles and adults is compressed and deep, the length 2.4 to 2.6 times the greatest body depth.Coloration consists of a vermiculated pattern of brown lines on a silvery bluish background over the entire head and body.Changes in color pattern occur during spawning. This pattern becomes more complex and intricate with size and age. (Gundermane*t.al.*,1983). It is found throughout the estuary, in all the salinity zones.

Batfish are deep compressed fishes, almost circular in outline and covered with small scales.

Round bat fish,*Plataxorbicularis*has strongly compressed deep body. Adults silvery grey with blackish vertical bars fading with age.(FAO-51). It is a coastal fish and was found only in zone I of the estuary.

Soles are flat fishes with both eyes on right side of the body. Eyes are small and close together. Mouth small and asymmetrical.Dorsal fin origin above or before eyes.Only one lateral line present. These are mostly marine; nine genera found in Indian waters of which two are found in estuaries.

Commersons sole,*Synapturacommersoniana(*Kan: Leppe), haselongate body and flat, broad anteriorly and tapering posteriorly. Eyes separated by a scaly space; anterior part of snout with a bony process; mouth curved, cleft reaching beyond middle of upper eye. Dorsal and anal fins

joined to caudal fin; grey/brown on eyed side of body; dorsal, anal and caudal fins dusky toward edges of both sides and with a conspicuous white margin; pectoral fin on eyed side dusky. These fishes that lie flat on bottom with their eyes on dorsal side are found in shallow sandy/muddy grounds. Marketed fresh(FAO-1984).Present throughout the estuary all round the year.

Barracudasare carnivorous marine fishes with elongate, sub-cylindrical body with long snout.

Great barracuda,*Sphyraena barracuda(Kan: Onakaandi),*is noted for elongate and slightly compressed body, large head, long pointed snout; the large mouth has strong and pointed lower jaw. It is deep green to steel grey above, sometimes with a purplish tinge, sides mostly silvery, becoming abruptly white on ventral surface. Small individuals with 18 to 22 oblique dark bars on back; seconddorsal, anal and caudal fins violet to blackish with whitish tips.Adults can be seenin the open sea or around reefs; the juveniles are common in mangrove swamps and estuaries.Feeds on other fishes.Marketed fresh, frozen or dried salted(FAO-1984).It was found in Zones I & III during all seasons and in zone II during winter only; probably it could present there throughout the year.

Obtuse barracuda,*Sphyraenaobtusata*(Kan: Hallinkaandi),has elongate and slightly compressed body.Head large with a long, pointed snout; mouth large.Body colour is grey/brown with greenish tinge above, sides silvery white without dark bars; inside of mouth bright yellow/orange. Second dorsal, anal and caudal fins yellowish.Feeds mainly on fishes(FAO-1984).It occurs in coastal sea and was found in zone I of the estuary.

Swampeels are elongated like eel. Dorsal and anal fins are usually absent; caudal fin also reduced or absent. Gill membranes united with a single ventral gill opening. These are of brackish and fresh water and the swampy parts of estuarine areas are favourable for the burrowing habit.

Rice swampeel,*Monopterusalbus*(Kan: Kolav), grows to about 45 cm length, is rather robust bodiedwith small naked, head; colour light greenish with or without dark spots, or else entire body nearly black. It inhabits streamlets, canals and estuaries. It is useful as a food although many do not eat due to snake like appearance.It is able to survive in the deep mud pockets in dry season if the water bodydriesup. It spawns during the summer months and builds a bubble nest in which the eggs floatat the surface. (Talwar and Jhingran, 1991). Observed in zone I; expected to be present in other zones also, being tolerant of fresh water conditions.

Gruntershavetypical fish shaped body; with small mouth and feeble teeth. Dorsal and anal fins strong. A pit occurs beneath the chin. These are of coastal seas and enter the estuaries.**Spotted grunter,***Pomadasysmaculatus* issilvery grey with purplish head; nape and back with series of incomplete cross-bars. Dorsal and caudal fins yellowish, edged with black. It was collected from Zone I of Aghanashini during summer season.

Tiger perches have oblong to ovate,somewhat compressed body.Operculum with 2 spines,lower spine longer and stronger,mouth moderate,protractile.Dorsal fin is single arched,notched with 11 to 13 spines and 8 to 14 soft rays,short anal fin with 3 spines.

Jarbuaterapon,*Teraponjarbua(*Kan: Kumbari/Garge),is a tiger perch with oblong & slightly compressed bodywith its dorsal profile more pronounced than ventral. Mouth slightly oblique; teeth conical and strong, found only in the young and lacking in the adults.It is silvery grayish-blue above, silvery white below, with 3 or 4 longitudinal downwardly curved black stripes which resemble the contours of mountain on a map; Inhabits inshore waters and moves considerable distances upstream into fresh waters. This is a very robust and hardy fish for brackish water aquaria. It attains a length of 25cm. (TalwarandJhingran, 1991). This species is also called ‘Target fish’ because of the colour markings on the body (black arcs on white ground).Colour bluish grey on the back,abdomen white;pelvic and anal fins yellowish in the middle; eye

yellowish red;length up to 33cm.This fish feeds on sea weeds, prawns,crabs,sand hoppers, Polychaetes and various insects including mosquitoes. Itis useful for malaria control (*Wealth of India, IV, Suppl.*, 2003).

Tripod fishes have deep and compressed body and moderately thick skin with numerous scales, mouth small and terminal, Dorsal fin spines 6 and fin rays 22; anal fin rays 15 or 16;pelvic fin with 1 large spine. Four genera; all in Indian area of which 1 occurs in the brackish water**.**

Short-nosed tripod fish,*Triacanthusbiaculeatus* (Kan: Kuduremeenu), has deep body and compressed, snout moderately acute, the upper profile straight to concave, second dorsal spine much less than half length of first dorsal spine; colour of the fish is dusky silver on upper side and creamy silver on lower side; pectoral fins permanently yellow; basal half of first dorsal spine blackish, becoming whiter towards the tip; dorsal fin membrane black(Talwar and Jhingran, 1991). Found in zone 1; the fish is not eaten locally.

Ribbonfishesare elongated bodied, ribbon-shaped and laterally compressed. Its body tapers towards the posterior end. There is no caudal fin. Lateral line single.All species belong to a single genus *Trichiurus.*

Large-headed ribbon fish,*Trichiurushaumela(*Kan: Barikhamle), Ribbon fishes constitute an important item among the marine fish catches in India seasonally. It is a carnivore fish (*Indian Journal of Fisheries, Vol. II)* with elongated, compressed body,ribbon like tapering to a point.Body scales less,Fresh specimens are steel blue with *silvery* reflection,semi-transparent pectoral fins, and thecolourbecomes uniform silvery grey some time after death. (FAO-1984).It is found in zone I only of the estuary during rainy weather & summer.

Table 2:Month-wise high tide salinity (ppt) from five sampling stations of Aghanashini estuary.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Aghanashini (Station 1)	31	31	36	33	34	0	0	0	8	30	32	35
Gudkagal (Station 2)	28	29	31	30	31	0	0	0	8	28	26	32
Kodkani (Station 3)	20	20	26	28	28	0	0	0	6	15	15	18
Tandrakuli (Station 4)	7	9	18	19	19	0	0	0	2	15	7	12
Divagi (Station 5)	4	9	17	17	17	0	0	0	0	1	3	10

Figure.2 Month-wise high tide salinity from five sampling stations of Aghanashini

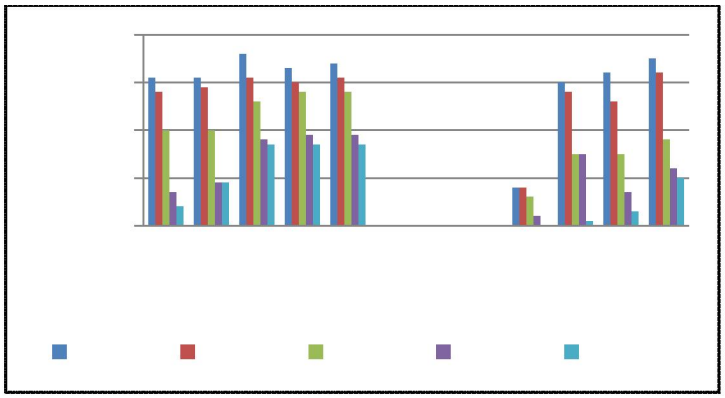


Table 3: Average high tide salinity (ppt), based on observations for 12 months, fromfivesampling sites in the Aghanashiniestuary

Sampling zones	Localities	Average salinity recorded	Highest recorded	Lowest recorded
Zone I	Aghanashini	22.5	36	0
	Gudkagal	20.2	32	0
Zone II	Kodkani	14.6	28	0
Zone III	Tandrakuli	9	19	0
	Divagi	6.5	17	0

Conclusion

Based on the occurrence of the fishes (Table 1) in different salinity zones of the estuary during different times of the yearit may be concluded that the estuarine fishes constitute a lot which have relatively wider tolerance of salinity fluctuations. The estuary formed towards the confluence of the river with the marine area is constantly subjected to fluctuations in salinity caused by rising and receding tides from the sea and the amount of fresh water input from the river. Estuary provides a dynamic system in relation to water salinity and the fishes which thrive there are expected to be tolerant of salinity fluctuations, sometimes of a violent nature, unlike exclusively marine or fresh water fishes. Such drastic changes in salinity happen during the rainy season of June to October period, when the waters rushing down the Western Ghats overwhelm the marine water and lowers the salinity to almost nil from mid-June to mid-September. The fishes living in the estuaries are therefore expected to adjust the solute concentrations in their cells to these dynamic changes in salinity which could range from almost zero ppt to in peak rainy season to 34 ppt in summer, almost as in the sea.

Though numerous kinds of fish are found in Aghanashini all fishes need not be tolerant of drastic changes in salinity. Several marine fishes likeray fishes,seer fish, mackerel, pomfrets just move into the lower reaches of the estuary (zone I) only during summer when the salinity reaches highest concentration, nearly reaching the level in the sea water.Those marine fishes like *Otolithusruber,Gerriesfilamentosus,Paraplagusiabilineata* etc., tolerant of more fluctuations in salinity, also move into zone II or even zone III of medium to low salinity. There is yet another class of fishes which moves from the estuary to almost the fresh water upstream in the river like *Etroplussuretansis* etc. Estuary is a habitat intermediate between the fresh water and the marine water and therefore the salinity conditions keep fluctuating here. It is difficult to find exclusively estuarine fishes except few like *Siganusvermiculatus.*

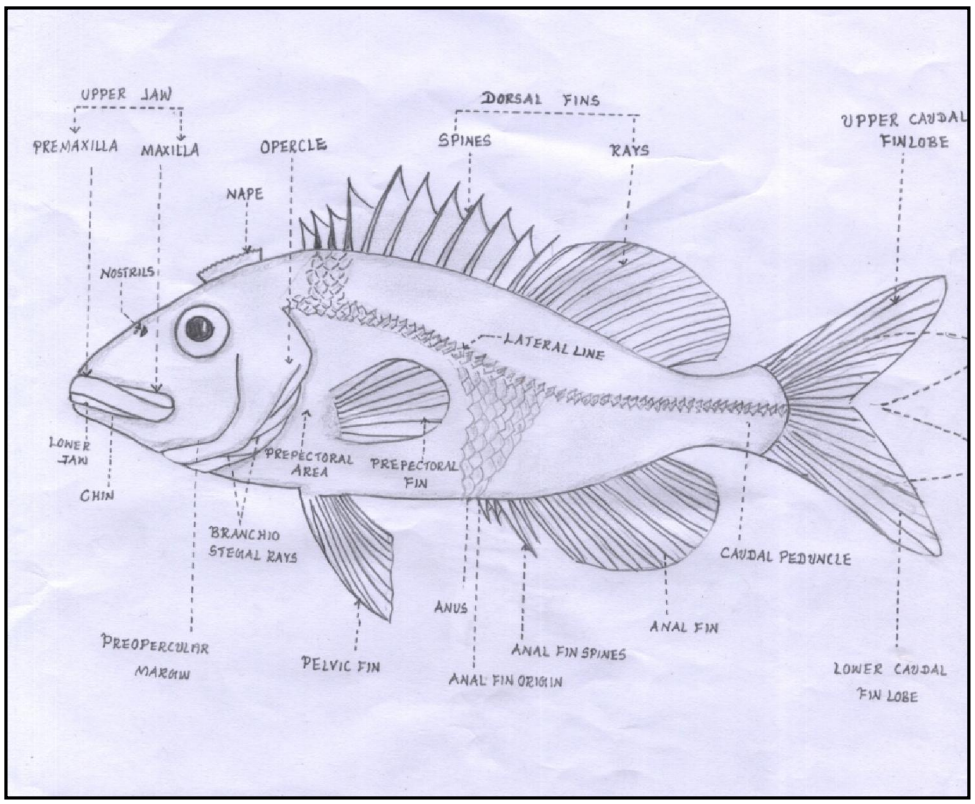
From the fisheries point of view the estuaries are considered highly productive systems not only for fishes but also for mollusks, shrimps, crabs etc. The intermediate conditions of the estuary, the presence of high nutrients, inputs coming from the forest clad hills and inflows from the rest of the drainage basin, the detritus fall from the mangroves, and the nutrients brought in by the marine tides make the estuary an exceptionally good centre of biodiversity and productivity. The entangled mass of aerial roots of mangroves rising from swampy substratum abundant in nutrients provides not only food to a variety of organisms but also shelter the juvenile fish from predators, nor can the fisherman cast his net into the swamp due to the obstruction by the root network.

It is therefore imperative that humans realize the importance of estuaries and desist from any drastic activities that alter these complex and very special ecosystems in the name of development. Building a dam across the river upstream can alter the fresh water input as well as nutrient flow from the mountains thereby challenging the estuarine salinity dynamism and food availability. Unregulated shell and sand mining in the estuaries that disturb the bottom violently can cause decline of fishes such as soles andcatfishes that are bottom dwelling and feeding. Mangrove cutting that was indiscriminately carried out during the past several decades for

meeting firewood needs, for creating rice fields and aquaculture ponds, have also affected estuarine productivity not only in terms of fish but also of other organisms like mollusks and shrimps, crabs and zooplankton, thereby fraying the food web seriously. However, realizing the importance of mangroves the Karnataka Forest Department, over a period of nearly one decade, has made great efforts to restore this important kind of vegetation in the backwaters of Aghanashini, literally greening the estuary, creating a hopeful situation for fish protection and production in the coming years.

Through a study of salinity conditions in the Aghanashini estuary in relation to fish distribution the present work highlights how the estuary provides a wide array of salinity conditions supporting different kinds of fish packed in a relatively small spread of water. The fish diversity and quantity harvested are decisive in maintaining the livelihood issues of scores of fisher folks in the densely populated estuarine villages. The estuary today is faced with various problems being eyed at for the execution of mega developmental projects such as thermal plant, port etc. that can affect its special characters and leading to the eventual collapse of the rich but fragile ecosystem. Studies of this kind attempted are therefore expected to widen our knowledge base of the estuarine ecosystem so that such unique habitats are preserved unharmed for posterity.

Morphology of typical fishand glossary



Lateral line: Sense organ used to detect movement and vibration in the surrounding water.

Dorsal fins: are located on back. A fish can have up to three of them, the dorsal fins serve to protect the fish against rolling, and assists sudden turns and stops.

Pectoral fins: The paired pectoral fins are located on each side, usually just behind the operculum. Pectoral fin is useful in creating a dynamic lifting force for some fish and also enables the flight for the flying fish.

Pelvic fins: The paired pelvic or ventral fins are located ventrally below the pectoral fins. This assists the fish in going up or down through the water, turning sharply and stopping quickly.

Caudal fin: Caudal fin is the tail fin, located at the end of the caudal peduncle and is used for propulsion to move the fish forward.

Anal fin: The anal fin is located on the ventral surface behind the anus. This fin is used to stabilize the fish while swimming.

Gills: The gills are fleshy organs that are used for breathing - they are located on the side of the head. When water “inhaled” through the mouth passes over the gills rich in blood vessels, oxygen is absorbed and carbon dioxide is released which passes out through the “exhaled” water from beneath the operculum.

Operculum (gill cover): Is a flexible, bony plate that protects the sensitive gills.

Mouth: The part of the body which the fish uses to catch food - it is located at the front of the body. The mouth’s shape is a good clue to what fish eat.

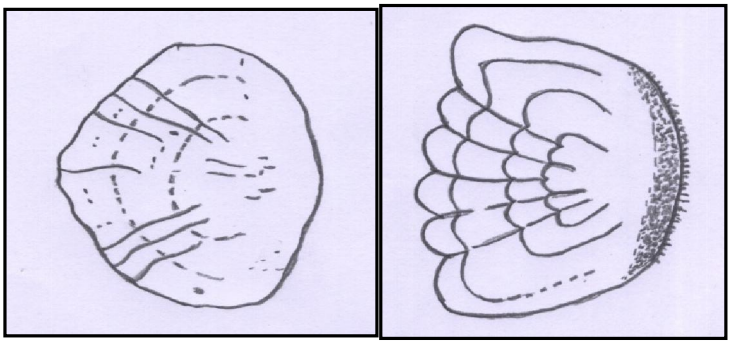
Nostril: Paired nostrils, or nares, in fish are used to detect odors in water and can be quite sensitive.

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 protection, much like our finger nails. Rather than protecting a just little part of the body, though scales protect a large part of the fishes body.It protects a fish’s skin from being cut by sharp object.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 scale **Ctenoid scale**



Senses: Fish have a number of senses that help them survive in their environments.

Sight: Most fish have well developed eyes which are located on the side of the head. This positioning allows the fish to see in every direction. Fish that are colorful probably have colour vision. Nocturnal fish have large eyes that help them see in the low light.

Smell and taste: Fish can smell things in the water with two blind sacs called nares. Nares are similar to our nostrils, except fish 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 barbels, which are covered with taste buds.

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.

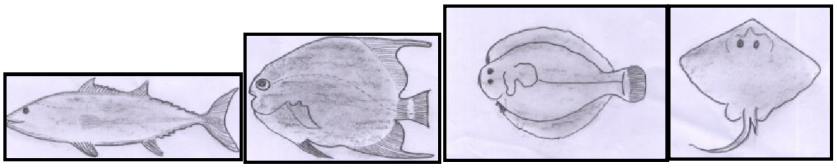
Different body shapes of fishes

Body shape plays a number of roles in the life of fishes. Body shape of the fish varies greatly from dorsoventrally flattened, to streamlined, to shorter bodies. The body shape of fish also has to do with the speed and way a fish swims; some fish swim extremely fast and need a shape that allows them to cut through the water at amazing speed.

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.

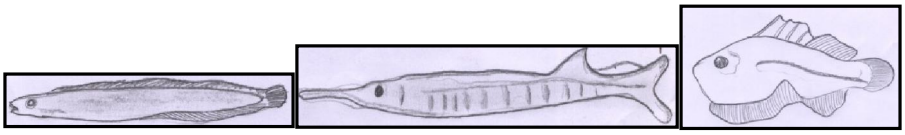
Depressed fishes like sting rays live on the bottom. Eel-like fishes have snake like body shape. Many fishes like box fishes are slow swimmers with special protective mechanism.

Fusiform Compreesed Depressed



LeptocephaliiEel-like Thread-like

Ribbon-like (Taeniform) Arrow-like Globiform



Box-like

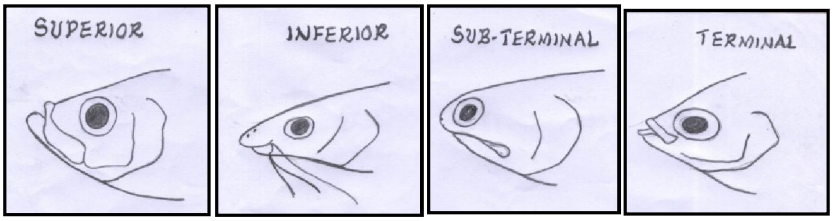
Structure of mouth: The mouth tells much about the habits of a fish by its position, shape and size. Bottom feeding fishes have sub-terminal mouths, while surface oriented fishes have upward pointing mouths. Size of the mouth is usually directly related to the size of the preferred food

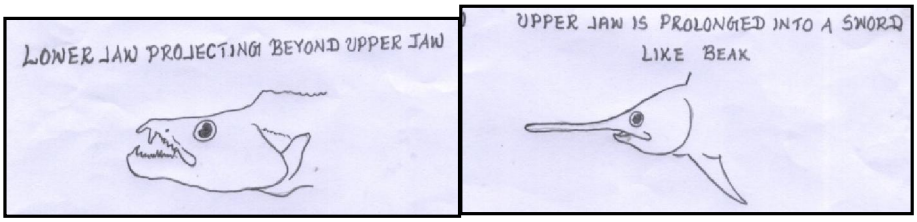
organisms as its shape. Thus fishes that feed on small invertibrates have small mouth surrounded by protractile lips. The structure of fish mouth reveals its feeding habits. Fishes can be divided into 3 feeding groups: top, mid-water and bottom-feeders.

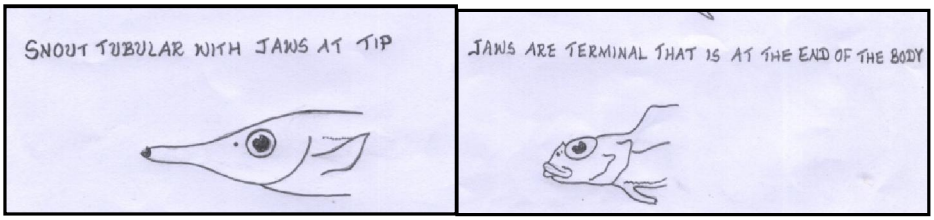
Top swimmers mouth: This type of fish hasa straight dorsal surface and an up-turned scoop like mouth for gathering floating insects.

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.

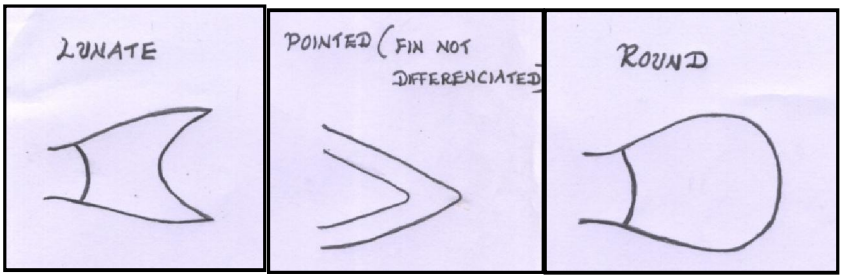
Bottom dwellers mouth: These fishes have under slung mouths with flattened ventral surfaces which can be brought into close contact with riverbed where much of their food lies.

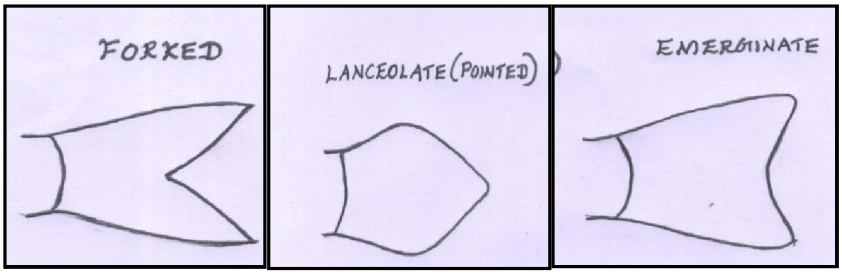


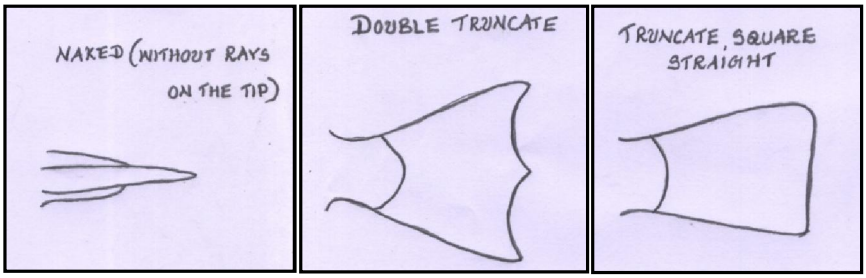




Tails: The shape of the tail can be an indicator of how fast a fish usually swims. Fish with forked tails are fast swimmers, though they may not swim all of the time. The deeper the fork, the faster the fish can swim. Fish with rounded or flattened tail are generally slow moving, but are capable of short, accurate bursts of speed.

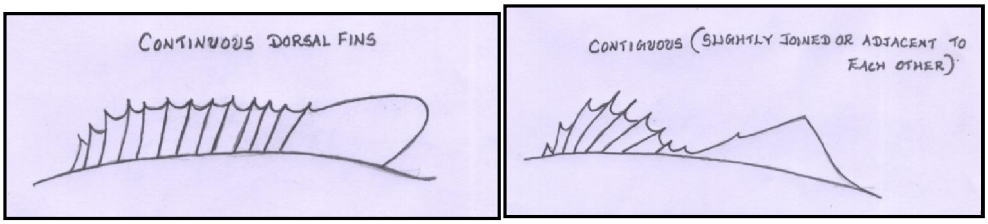






Dorsal fins: These are fins located on the back of the fishes.Some fishes may have only one dorsal fin while others may have two or even three.In many bony fishes the dorsal fin has stout spines in the front tohelp to give the fin support.Dorsal fin helps in fish swimming as well as in protecting itself.It can protect the fish 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:



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