

Resource selection and conservation of Smooth coated otter *Lutrogale perspicillata* in and around the Coringa Wildlife Sanctuary, Andhra Pradesh.

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By
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CERTIFICATE

This is to certify that **Shri N. Leela Prasad** has carried out original research work titled “**Resource selection and conservation of Smooth Coated Otter (*Lutrogale perspicillata*) in and around Coringa Wildlife Sanctuary, Andhra Pradesh**” for the partial fulfilment of his Master’s Degree in Wildlife Science from Saurashtra University, Rajkot. The study was carried out under our supervision from December 2014 to May 2015. We hereby certify that this work has not been submitted for any other degree to any other university.

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Summary

1. Resource selection of Smooth-coated Otter *Lutrogale perspicillata* was studied in the Coringa Wildlife Sanctuary, where a two dimensional interface of fishermen-otter present: fishermen fishing in the habitat of otter and otters feeding in the aquaculture farms of fishermen. This is resulting in conflict between Otters and Humans in the region. In this context, this study was carried out to understand the extent of this conflict by studying the food habit of otters and ecological factors that could affect the otter distribution in this mangrove ecosystem.
2. The study was carried out from December 2014 to April 2015 in and around the Coringa Wildlife Sanctuary, which is located at the mouth of the Godavari River, in Andhra Pradesh.
3. Food habit of otters was studied by analysing their spraints that were collected from different parts of the Sanctuary. Habitat and distribution of otters were studied using belt transects along creeks as otters mostly used banks of the creeks. Further, people perspectives towards otter and intensity of human-otter interface was studied using interview based questionnaire surveys.
4. It was found that the fishes cultured in the aquaculture farms were not present in the creeks of Coringa WLS.
5. Of these 93 species recorded inside the Coringa WLS during the study period, 11 species such as *Megalops cyprinoides*, *Pomadasys kakan*, *Terapon jarbua*, *Dendrophysa russeli*, *Liza tade*, *Oreochromis mossambicus*, *Gerres sps*, *Cynoglossus cynoglossus*, *Pacu*, *Mugil cephalus* and *Mystus gulio* were most common species of
6. *Mystus gulio* was found to be most abundant fishes of the sanctuary with relative abundance of 42.8% followed by *Oreochromis mossambicus* which is an invasive species commonly called as Tilapia at 22.9%, *Megalops cyprinoides* showed a relative abundance of 19.24%, *Dendrophysa russeli*, *Liza tade* and *Mugil cephalus* have a relative abundance of 17.51%, 10.90%, 9.57% respectively the Sanctuary.

7. The diet analysis of 81 spraints collected from December 2014 to March 2015 revealed that fish comprise of 99% of Smooth coated Otter diet. Of this major portion comprised of *Mystus gulio*, *Oreochromis mossambicus* and *Liza tade*. These species were also found in high abundance during the fish sampling from which relative abundance was calculated. This indicates that Otters in the sanctuary are opportunistic feeder rather than selective.
8. *Mystus gulio* (long whiskers catfish) found to be the major prey of otter in the Coringa WLS, constituting 17.8% of weight of all food items found in the spraints and this fish was also eaten by many otters (found in 13.4% of spraints). *M. gulio* was also the most common fishes of the Sanctuary. *M. gulio* followed by *Oreochromis mossambicus* (Tilapia) constituting 14.6% of weight of all food items found in the spraints.
9. Although, all five major aquaculture species of fish were found in the spraints of Otter but overall, the aqua farm fishes constituted only the 14.4% of weight of total foods items found in the spraints of otter. Of the total spraints collected, only 17.8% of spraints contained the aqua farm fishes and remaining 82.2 % otter spraints did not have aqua farms fishes and these otters were seems to be eaten only the wild fishes.
10. The high abundance of invasive tilapia was found in the Ramannapalem creek, which is a less saline creeks adjoining with aqua farms and villages. This fish was the second most preferred diet of otters in the area. This fish breeds in the grasses that are at the banks of creeks. Breeding tilapia was a easier target for otters and therefore, otters were seen close to aqua farms.
11. The factors essential for Otter survival in were found to be more towards land and decrease with increasing distance from land. An ordinal regression model with sign intensity in three ranks revealed that the factors that are play a significant role in Otter distribution are distance from sea had a positive effect on Otter distribution (estimate = 0.403, Standard error =0.225 and P value= 0.073), Width of channel also had a positive effect to an extent (estimate =0.509, Standard error =0.273 and P value = 0.062). Depth of the creek had a negative effect (estimate= -0.624, Standard error = 0.322 and P value=0.053).

12. As the factors that are positively influencing Otter distribution are near villages Otters signs were also found highest in creeks near villages. Thus it was concluded that the presence of Otters mostly towards villages is probably due to presence of suitable habitat near villages rather than fish from aquaculture farms.
13. Fishermen's Traditional Ecological Knowledge of Otters in and around the Coringa Wildlife Sanctuary had also confirmed that otters largely feed in the wild but visit aqua farms occasionally for food or to play. Further, about 79% of people in the region felt that Otters visit their farms at night that confirms the nocturnal behaviour of Otters around human habitation, which is supported by previous studies
14. Further, most of fishermen (75%) believed that otters are high threat to aquaculture when compared to fishing cat and jackals. This is due to group hunting behaviours of otters, whereas fishing cats and jackals visit aquaculture ponds solitarily
15. Interestingly, nearly 11% of fishermen felt that Otters have caused an income loss of 1-5% followed by 9% of respondents who claimed a loss of 10-30%. But, few farmers (2%) felt that Otters cause nearly 30-50% of loss, who were in the low income group and who can not offer even small loss in income.
16. Generalized Linear Model (GLM) with Poisson distribution revealed that both income and education of fishermen positively influenced their perspectives towards conservation importance of otters in the region.
17. Majority of fishermen (65%) believed that there was a decline in the sightings of otters and they have also believed that the population had been declined in the region. However, in contrast, about 13% of them felt that there was an increase in Otter population over years and most of these respondents who have also believed that high loss of income due to otters visits to their aqua farms.
18. Most of the aqua-farm owners admitted that they always scare and chase away otters when they visits their farms. Though only 11% of them opted for killing does not mean that people have a positive attitude towards Otter. Boxplot analysis to understand the relationship between people's action towards visiting otters to their farms and their income and education, has revealed that the farm owners who had less income have tried to kill the visiting otters due to their poverty.
19. This study found that fishermen with poverty could not bear even the meagre loss caused by otters to them. Further, the study found that less educated people against the otters in the region. Therefore, additional livelihoods and awareness education to

those poor fishermen need to be provided for the long term conservation of otters in the region. EGREE Foundation of Andhra Pradesh, a foundation established with support of GoI-UNDP-GEF Project to sustainably manage the Godavari estuarine has already initiated some programme in this regard but their programme should focus more on fishermen who are with low income

20. It is also proposed to have otter proof fencing for aquafarms especially those farms located along the Ramanapallam creeks. Developing eco- tourism in the sanctuary with the involvement of fishermen and small scale farm owners can also change their attitude towards otters.

Introduction:

Otters are members of the weasel family, *Mustelidae* that comprises 67 species (Ewer. 1973), is one of the largest families of order *Carnivora*. Mustelids are small to medium sized carnivores with characteristic short legs and long bodies. Most Mustelids feed on vertebrates with a few species of *Otters* as exception which feed on invertebrates.

Otters come under the sub-family *Lutrinae* out of five sub families of Mustelids. Otters occur on all continents except Australia and Antarctica. The first recognizable fossil of aquatic Otter lived 30 million years ago and therefore, had a long time to adapt to an aquatic way of life (Channin ,1986). Today 13 species of Otters exist in the world and all of them seek food from water. Although Otters are well designed for life in water, they have no unique adaptations to cope up with this way of life like no modified breathing structure to breathe underwater. So Otters are considered as semi- aquatic mammals.

Otters have webbed feet that help in efficient swimming along with streamlined body. The hair of otters interlock among themselves and trap air between them, thus helps in thermoregulation as they lack blubber unlike other aquatic mammals. Also the long stiff hairs (vibrissae) that located on the sides of the mouth of Otters assist in hunting prey even in murky waters (Mason and Macdonald. 1983; Channin. 1986). These adaptations make Otters excellent predators in the water. In India, three species of Otters occur, namely the most widely distributed Smooth coated Otter *Lutrogale perspicillata*, the Eurasian Otter *Lutra lutra* and Asian small clawed Otter *Aonyx cinerea*.

1.2 Smooth coated Otter *Lutra perspicillata*, Geoffroy 1826:

Smooth coated otter is characterized by a more rounded head and a hairless nose in the shape of a distorted diamond. As the name suggests they have short, smooth, shiny fur with reddish brown to dark brown in colour. The tail is flattened unlike many other otters and is essentially a lowland species and is distributed throughout Indian Subcontinent, Southeast Asia with an isolated race, *L.p. maxwelli*, in marshes of southern Iraq (Mason and Macdonald, 1983). They occur from the Himalayas to southward and are found normally in large rivers, lakes, peat swamp forests,

mangrove forests along coasts and estuaries. The total body length ranges from 106cm to 130cm (Duplaix and Davis, 1981) and weight ranges from 6.5kg in sub adults and 7-11.4 kg in adults (Harris, 1968)

Smooth coated otters were found to prefer two different types of substrates for holting and for other activities in two different studies (Hussain and Choudhury, 1997; Anoop & Hussain, 2004) indicating that their habitat preference varies with their habitat type. The smooth coated otter is opportunistic and predominantly a fish eater with similar food habits like Eurasian Otter and American river otter *Lutra Canadensis*. Smooth-coated otter like many other otters has been reported to live in small groups (Pocock, 1949; Prater, 1971; Mason and Macdonald, 1986; Hussain, 1993, 1996) with very less ecological studies on this species and vulnerable status in the IUCN red data book (Hilton-Taylor,2000) along with decreasing wetlands both in terms of area and quality (Gopal. B, 1995) conservation of this apex carnivore becomes important. Smooth coated otters are protected under Schedule II of Wildlife (Protection) Act, 1972.

1.3 The Eurasian Otter *Lutra lutra*, Linnaeus, 1758.

The Eurasian otter has one of the widest distributions of all Palaearctic mammals (Corbet, 1966). Its range covers parts of three continents: Europe, Asia and Africa and also the most well studied of all otter (Kruuk, 2003). Seven subspecies were reported (Pocock, 1941) till date.

The Eurasian otter lives in a wide variety of aquatic habitats, including highland and lowland lakes, rivers, streams, marshes, swamp forests and coastal areas independent of their size, origin or latitude (Mason and Macdonald ,1986). In Europe, they are found in the brackish waters from the sea level up to 1,000 m in the Alps (Ruiz-Olmo and Gosalbez, 1997) and above 3,500 m in the Himalayas (Prater, 1971) or 4,120 m in Tibet (Mason and Macdonald, 1986). In the Indian sub-continent, the Eurasian otters occur in cold hill and mountain streams. During summer (April - June) in the Himalayas, they may ascend up to 3,660 m.

The Eurasian Otter is characterized by rusty to dusky brown dorsal side and lighter ventral side with grey to whitish colour. The tail is hairy and flattened at its terminal half and tapered at its end. The rhinarium is bare and upper rim in the shape of 'W'. In size the Eurasian otter is similar to Smooth coated otter. The length ranges from 92cm to 120cm and weight ranges from 4-12 kg in

females and 7-12 kg in males (Duplaix and Davis, 1981; Reuther, 1991). The Eurasian Otter is listed as near threatened in IUCN red list.

1.4 Oriental small-clawed Otter *Aonyx cinerea* Illiger, 1889.

The Oriental small-clawed otter (*Aonyx cinerea*), also known as the Asian small-clawed otter, is the smallest otter species in the world, weighing less than 5 kg. It has a large distribution range and occurs in mangrove swamps and freshwater wetlands of Bangladesh, Burma, India, southern China, Taiwan, Laos, Malaysia, Indonesia, Singapore, the Philippines, Thailand, and Vietnam (Wozencraft, 1993). The name comes from, its characteristic feet in which the claws do not extend beyond the fleshy end pads of its partially webbed fingers and toes. This gives the advantage of finding and feeding on Molluscs, Crabs and other aquatic animals. The overall length of the body ranges from 70 to 100 cm and the body colour is typically dark brown with tawny or rufous tinge with tip of contour hair often paler (Pocock, 1941). In India, it is found in mountainous streams of Western ghats and North east India (Pocock, 1941). Oriental small clawed Otter is listed under vulnerable category in IUCN red list.

2.0 Study area:

The present study was carried out in the Coringa Wildlife Sanctuary, which is located in the mouth of river Godavari in Andhra Pradesh, India. The Coringa Wildlife Sanctuary lies in the Godavari delta forming the longest stretch of Mangrove forest in the state, located between 16°-30' to 17°-00' N latitudes and 82°-14' to 82°-23'E longitudes. This mangrove forest is the second largest continuous surviving stretch of mangroves in India covers an area of 235.7 square kilometers and is a part of the East Godavari Estuary system. The rivers Coringa and Gaderu and their deltaic branches intersect the region, along with other water channels. The mangrove forest is 30 km long continuous patches in the north - south direction and 15 km wide along east-west direction. The entire mangrove system is drained twice in the diurnal tide cycle. The phytosociology of the area reveals that the mangrove vegetation is variegated. Numerous mudflats and narrow creeks that criss-cross the area are subject to tidal intrusion as a result of which a high level of productivity occurs that can support good populations of Otters and other fauna (Nagulu et.al, 1997). This area forms about 335.7 square km of marsh vegetation along the coastal region. Though, the area is protected under a sanctuary, fishermen fish in the sanctuary extensively and many villages surrounding the sanctuary are dependent on this sanctuary for their livelihood. On the periphery of the northern part of the sanctuary, numerous Aquaculture farms are actively involved in fish and prawn culture. Day by day the growth of Aquaculture farms has been increasing in the recent years due agriculture failure, followed by conversion of paddy fields into Aquaculture farms. Polyculture of Indian major carps with exotic carps along with White leg Shrimp *Litopenaeus vannamei* or Tiger prawn *Penaeus monodon* or Scampi monoculture of prawn is practiced. In the present study about 154 square kilometer area were covered in the northern part of the sanctuary.

2.1. Climate and Rainfall:

The region experiences, Tropical Savanna climate with hot, humid weather for most of the year. The warmest time of the year is late May and early June, with temperature ranges between 38 and 42°C. January is the coolest month, with temperature ranges from 15 to 20°C. The study area receives mean rainfall of 1280 mm by southwest and northeast monsoons. More than half of the rainfall is brought by the southwest monsoon (June to August) while a large portion of the rest of the district receives rainfall from the northeast monsoon during October and November.

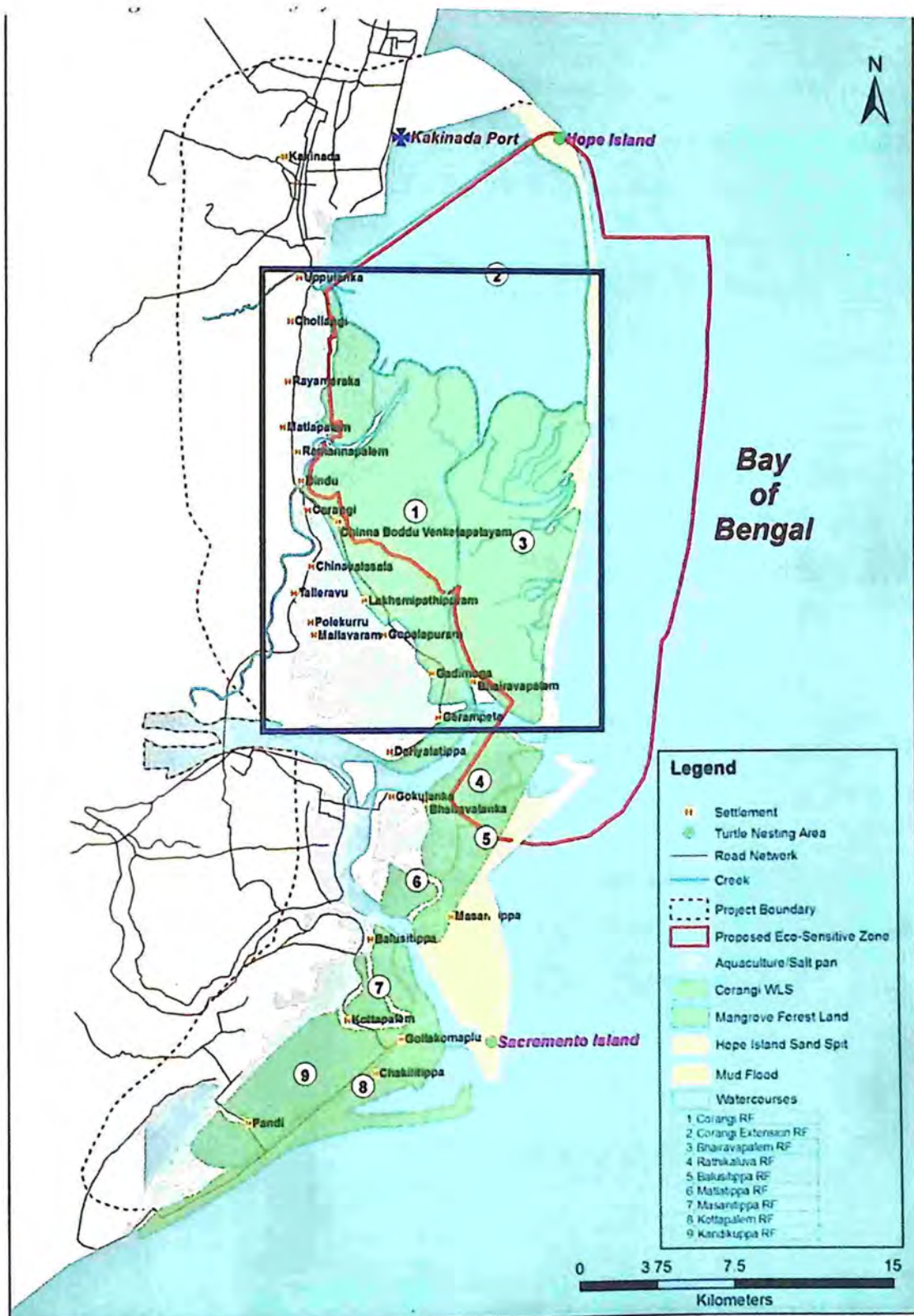


Figure: 1 and 2 Study area. Effective study area with dotted red outline surrounded by aquaculture farms. Number 1 represents the Coringa river drained area and number two represents Gaderu river drained area and Number 3 represents Kakinada bay.

2.2 Plant diversity of the study area

The plant diversity of this mangroves ecosystem was 35 species with 16 true mangroves and 19 species of associated mangroves. *Avicinnia marina* is the most abundant mangrove species and *Avicinnia officinalis* is usually encountered along the banks. Other important trees include *Avicennia alba*, *Excoecaria agallocha*, *Rhizophora mucronata*, *Ceriops decandra*, *Bruguiera gymnorrhiza*, *Lumnitzera recemosa*, *Sonneratia apetala*, *Rhizophora conjugata*, *Aegiceras corniculatum*, and *Hibiscus tiliaceus*.

Apart from the tree species, some of the shrubs found in the sanctuary are *Dalbergia spinosa*, *Derris trifoliata*. Herbs like *Sesuvium portulacastrum*, *Suaeda maritima*, *Suaeda monoica* and *Salicornia brachiata* and grasses like *Aeluropus lagopoides*, *Porteresia coarctata* and *Myriostachya wightiana* are also found in the sanctuary.

2.3 Animal diversity:

Animal diversity of Coringa WLS includes nearly 140 bird species most of them being winter visiting waders and more than 100 species of fishes along with diverse group of Molluscans and Crustaceans. Other large mammals found in the sanctuary are the endangered Fishing cat *Prionailurus vivverinus* and Golden jackal *Canis aureus*.

2.4 Threats to the Sanctuary:

Despite being remote and difficult to access the mangroves are being exploited by the local population. A socio-economic study by Indian Bird Conservation Network found that most of local fishermen harvest wood in the forest and depend heavily on the mangroves for their basic needs. The *Avicinnia* trees are being used heavily for fire wood. The fishermen around the sanctuary are also known to clear the mangroves and create prawn culture by encroaching into the sanctuary.

3.0 Literature review

3.1 Resource selection of otters:

3.2 Feeding habits: Otters are highly specialized animals compared with other carnivores in diet (Kruuk, 1995) and Smooth coated otter is no exception as they are piscivorous, though they feed on other invertebrates and birds occasionally (Hussain and Choudhury. 1998; Anoop and Hussain. 2005). The food of otters is one aspect of their ecology which has been studied quite thoroughly not because it is easy, but it gives information on many aspects (Mason and Macdonald. 1986). Analyzing the sprints of otters could reveal their food habits as well as their preference.

Otters need adequate food supply, especially of fish and better shelter in the form of Bankside vegetation, crevices etc. for various activities (Mason and Macdonald. 1986). Otters were observed to avoid the habitats that were under immense fishing pressure in Terai and lower Himalaya (Nawab and Hussain, 2012). The present study area also faces intense fishing pressure and with fish farms present along the sanctuary seems to be providing alternate food resource for otters.

3.3 Habitat choice:

Carnivores, are highly variable in the way in which they distribute themselves in their habitat, with large differences between species and within species. Resource dispersion hypothesis (Macdonald. 1985) states that size of home ranges, population size and conspecifics inhabiting each range are determined not just by the overall density of food in an area, but also by the distribution; the patchiness of the prey. Range size would be determined by the distances between individual patches, the number of animals inhabiting a range determined by the productivity of patches. In most of the studies on otters both Eurasian and smooth coated; it has been observed that they show preference to certain type of substrate for their activities (Khan.et.al, 2014; Bonesi and Macdonald. 2004; Ottino and Giller,2004; Anoop and Hussain, 2004; Hussain. and Choudhury,1997; Dubuc,. et.al, 1990; Prenda, and Granado-Lorencio, .1996, Shenoy.et.al, 2006). Many of these studies indicate that Otters in general and Smooth coated otters show preference for rocky sites for dens and sand substrates for grooming. Both these substrates are found nearby human habitation in the

study area. The presence of both suitable habitat and food nearby further supports the Resource selection hypothesis which enhances the possibility of otters occurring near the aquaculture farms.

3.4 Existing Conservation Measures:

It is commonly assumed that people are reasonably aware of the actual risk posed by wildlife, but this is often untrue. Understanding how people perceive risks is usually of interest mainly to policy makers dealing with safety issues, but such studies can also be valuable in examining the complex nature of human-wildlife interactions and can help inform our understanding of conflict (Dickman.A.J.2010).

The endangered Zanzibar red colobus *Procolobus kirkii* depends heavily upon agricultural areas, the farmers of that area perceived that this monkey causes great loss of coconut *Cocos nucifera* harvests (Siex and Struhsaker, 1999). However, contrary to expectations, studies revealed that red colobus coconut consumption was positively correlated with final coconut harvests, possibly due to pruning, so the species actually had a beneficial effect on crop production (Siex and Struhsaker, 1999). So finding the perception of people on threat and knowing whether there is actual threat can help in conservation of species.

In this study Smooth coated otter can be portrayed as a flag ship species for the conservation of the mangrove ecosystem of sanctuary. The concept of flagship species capitalizes on the fact that such species have the ability to capture the imagination of the public and induce people to support conservation action and/or to donate funds. The public in developed countries identifies with high profile, charismatic species, examples of which include tigers, dolphins, rhinos, elephants and gorillas. (Walpole et.al ,2002). Otters can be one such flagship species (Brooks. et.al, 2012) and portraying it as flagship species and drawing attention towards Smooth coated otter conservation can in turn conserve the mangrove habitat in present study and other wetland where ever they are found. Mangroves being highly productive ecosystem along with high human pressure on them their protection is essential for survival of many unique species that made mangroves as home (Vannucci, 2001).

3.6 Otters and Humans:

Otters had significant relationship with humans both positive and negative from centuries. The taming of otters around 1200 CE in China for fishing which goes on till today in many parts of Asia to vermin in many parts of Europe due to competition with fishing and consumption of fish from fish farms. In Yugoslavia, high bounties were paid to fishermen for killing otters until 1966 (Honigsfeld and Adamic, 1983). In Britain Otter hunting with hounds was legal till 1981. Otters like Sea otters were hunted for their pelts. Due to this Otter population in much of their range saw a decline and today Otters are protected species in most of their range. Even though Otters are legally protected in many areas they are still treated as vermin in many areas and are hunted. Frequently, death of otters at the hands of people is brought on to the animals by their own activities in some places they affect fisheries, or they take domestic fowl. Throughout much of their range otters prey on the same species as humans do, and they interfere with fishing nets and fish farms. This causes interspecific competition between otters and humans. Both the smooth and the small clawed otter have been mentioned as taking fish and shrimps from aquaculture projects in Malaysia (Foster-Turley, 1992). Eurasian otters are widespread in central European fish farms; especially in Austria and the Czech Republic the species is generally perceived as a pest (Kranz, 2000). They were also observed to be causing serious problems in Czech fish farms, with otters taking substantial numbers of large carp, up to 11 kg in weight, as well as perch and zander (Adameik et.al, 2003). Though otters competing with humans for fish is opportunistic rather than direct competition (Rosas-Ribeiro et.al, 2012). In many countries in Asia, otters are caught and marketed for food, or for medicine, and the African trade in 'bush meat' often involves otters and in Europe they are considered as honorary fish. Smooth coated otter meat and blood are considered to be having medicinal properties for curing epilepsy in Andhra Pradesh and also a delicacy (Nagulu. et.al, 1999).

From the above scenario Otters future does not look good as the people who live in proximity with Otters think them as vermin or food.

4.0 Research questions

In this particular case study there exists a two dimensional interface between otters and humans; otters predate on fishes from aquaculture farms and men are fishing inside the sanctuary. This study attempts to address the above issue through the following questions.

Question 1: - What is the dependence of Otters on fishes from aquaculture farms?

Question 2:- What factors affect Otter distribution in and around the sanctuary?

Question 3:- What is the attitude of people towards Otters and their feeding from farms?

4.1 Objectives

Objective 1: To find out the proportion of fish from aquaculture farms in Otter diet.

Objective 2: To find out factors effecting Otter distribution in a mangrove ecosystem surrounded by aquaculture farms.

Objective 3: To find suitable conservation measures for Otter conservation based on the questionnaire survey.

4.2 Hypotheses of the study

Hypothesis 1: Fish from aquaculture farms does not form significant part of Otter diet.

Hypothesis 2: Otters select their habitat randomly and are distributed evenly in the study area.

Hypothesis 3: The aquaculture farm owners are well aware of the threat from Otters and have a positive attitude towards them

5.0 Methods

5.1 Reconnaissance survey:

The study area was intensively explored for the presence of Smooth coated otter signs that include paw prints and spraints. The effect of high tide and low tide cycle in the study area and its influence on boat movements and Otter signs visibility were also observed during this survey. A sample questionnaire survey was conducted in the villages bordering the sanctuary to know their responses and to finalize the questionnaire. Based on this survey, sampling design for otter distribution study was finalized.

5.2 Factors effecting otter distribution:

5.3 Sign survey:

Extensive signs surveys were carried in the study area along the banks of the creeks starting from the villages and ending at the mouth of the river. Belt transect of 600 meters long and 10 meters wide were laid along the banks with 1 kilometre interval all along the selected creeks. Size and location of belt transects were decided based on reconnaissance survey. The number of signs encountered in each transect were noted (Jeffress, et.al, 2010). Any spraints encountered during the survey were collected. Habitat variables that are thought to be affected Otter presence in the study area were measured based on the literature and direct observation. Habitat variables measured in each transect were

- (i) Dominant tree species
- (ii) Width of the creek
- (iii) Depth of the creek
- (iv) Percent bank vegetation and type.
- (v) Number of open grass patches
- (vi) Number of *Suaeda maritima* patches
- (vii) Distance from village
- (viii) Disturbance
- (ix) Number of channels present in the 600m stretch

The above variables other than (v), (vi), (vii) were found to be effecting otter presence from previous studies. Since the study area is a mangrove habitat there are no rocky structures or sandy substrates where otters were found to be defecating and grooming respectively from previous studies. Otters were observed to be grooming, basking and defecating on open grass and *Suaeda maritima* patches during the study period and the fishermen were also found to observe otters basking on these patches. Moreover out of 81 spraints only 5 spraints were found on non-grass location. The reason for this could be the fact that otters mark their territories using their spraints and grass and *Suaeda maritima* patches are few areas in the study area which does not get inundated even during high tide so they remain dry.

Prior the sign survey the probability of finding signs with increasing distance from banks was measured wherever the signs were found. Most of the times otter signs were observed till 4m and in rare occasions till 6m. So the plot size of 600 x 10m was selected for the study. This was also evident from several studies (Kruuk and Conroy, 1987; Hussain and Choudhury, 1997).

A sign survivorship survey was done to know how much time it takes for a sign disappear or lose shape so that it can no longer be identified. For this sign at different distances from land were marked and were observed every day for presence and absence. This was done because of the highly dynamic nature of mangrove ecosystem where high tide and the low tide effect varies with the distance from the sea and the size of the creek. This in turn can affect the survival of signs. This can cause underestimation of the signs in areas where they quickly disappear. (Mathewson et.al, 2008; Rhodes, et.al; Weckerly et.al, 2000)

5.4 Food resource selection:

5.5 Collection of spraints:

The spraints were collected during the intensive signs surveys and once a sprainting location was identified the sight was revisited frequently to collect spraints. A spraint was defined as the collection of all faecal matters of an otter group deposited on one communal sprainting site. Only fresh spraints were collected since there is risk of losing some faecal matter with time. Further, it was found that fishing cat, dogs and birds feeding some foods items from the spraints. Fresh

spraints were identified by their Greyish black colour, moisture content and typical Smooth coated otter spraint odour. These spraints were collected in zip-lock bags for further analysis. A total of 81 spraints were collected during the study period.

5.6 Cleaning of spraints:

The collected spraints were soaked in detergent solution on the same day for 6 hours and transferred to iron sieve with mesh size 1mm and washed thoroughly under tap water. The spraints were then dried under shade and stored in zip-lock bags for further analysis.

5.7 Reference fish samples:

The present study mainly focused on the amount of fish that otters could take from fish farms, therefore, a reference sample of fish scales of all the five carps namely *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Cyprinus carpio* and *Ctenopharyngodon idella* cultivated in the farms were collected and preserved for identification. Further, 11 more fish species that were commonly found during fish sampling were also selected and their reference fish scale samples were preserved for future identification. Total body length and weight of the fish specimens from which scales were collected were also measured to estimate the body size of fish.

5.8 Preparation of reference samples:

The scales were stored in glycerine when collected and then soaked for 12 hours in lukewarm water for the scales to soften. This was done because the scales tend to curl during storage. Then the scales were mounted on a slide using DPX mount and covered with a cover slip.

5.9 Sorting prey items:

Identification of the items in the spraint was done using a hand lens with spraint placed in a Petri dish. The Scales, bones and other body parts were separated using forceps and needle. The venation pattern of the scales was used to identify fish from the spraint. Catfishes were identified by their sharp lateral spines. Crab and prawn remains were identified using colour and shape of the exoskeleton. Crabs and prawns were not identified to genus level. Also effort was not made to identify size class of the fish.

5.10 Estimation of the proportions of prey items consumed:

Frequency of occurrence:

The prey categories for each spraint were noted and the number of occurrences of a prey category in each spraints was expressed as a proportion of the total number of occurrences of all prey categories in a sample. So that the sum of frequencies would be 100 (Melquist and Hornocker. 1983, Hussain and Choudhury. 1998, Pardini.1998).

5.10 Score bulk estimate:

In this method the proportion of each prey item was estimated visually. Then each prey item was given a score from 1-10, so that the total for one spraint is 10. The score for each category was multiplied by the dry weight of the spraint and the resulting figures were summed for each category and expressed as a percentage (Wise et.al., 1981; Hussain and Choudhury, 1997).

5.11 Quantification of prey availability:

The amount of prey available could only be done in the natural system, i.e., creeks as it was possible to know the available fish from aquaculture farms.

5.12 Fish:

Gill nets were used for fish sampling to measure the relative abundance of different fish species and also abundance of different creeks. The gill nets were placed from one end of the creek to the other end during the low tide for one hour and fish caught in the nets were identified and noted with habitat variables. Cast nets were no used as the water is continuously flowing inwards or outwards.

5.13 Crabs and Prawns:

Crabs and prawns were not sampled as they were not under the study objective and they also form a minor part of Smooth coated otter diet (Hussain and Choudhury. 1997; Anoop and Hussain.2004)

5.14 Use vs Availability:

Ivlev's index was used to calculate the otters prey fish use and their availability. Score bulk estimate of fish from the spraints that have been collected exclusively from the mangroves areas

was considered as use and their relative abundances were considered as their availability for otters to feed.

The Ivlev's electivity (selection index) describe a predator's preference for prey. It scales from -1 to 1; where -1 indicates total avoidance of a prey; 0 indicates that a prey is taken in proportion to its abundance in the ecosystem. It is defined as: $E_i = (r_i - P_i) / (r_i + P_i)$

where r_i is the relative abundance of a prey in a predator's diet and P_i is the prey's relative abundance in the ecosystem.

5.15 Questionnaire Survey:

As this study focuses on identifying the level of interaction between Otters and Aquaculture farms, knowing the perception of people mainly aquaculture farm owners and workers becomes important.

For this a semi structured questionnaire survey was carried out for the aquaculture farm owners and workers about their perception on whether otters are feeding extensively on cultured fishes and if they are causing any economic loss along with the methods they follow to tackle this if they are any. A total of 8 villages have Aquaculture farms bordering the study area. In each village the number of people cultivating fish or prawn was first enquired and then 10 to 50 percent of the population that is into aquaculture were interviewed. The number of people in aquaculture varied from 3 people to nearly 100 people depending on the village. A total of 53 respondents were interviewed during the study period.

6.0 Analysis of data:

6.1 Habitat relationship:

Ordinal regression was used to find the relationship between otter signs intensity with their habitat variables. All the variables were 'Z' standardized before analysis. The signs were grouped as no signs, low signs, and medium to high signs based on the median number and range (Sokal and Rolf, 1995). The data were analyzed using SPSS 22.0. Graphs for this were also done using the same software.

6.2 Ivlev's index:

Ivlev's index was used to measure use vs availability in the natural system. This could not be done for aquaculture farms because it would require data from every farm owner and is not reliable.

6.3 Questionnaire survey:

Program 'R' was used to run generalized linear models with Poisson distribution to identify the attitude of farmers with different income levels and education status with their responses that are important for conservation (Sokal and Rolf, 1995). Clustered columns and scatter plots were used to show the percentage of particular response in the population. Graphs for this were generated using Microsoft Excel 2013.

7.0 Results

7.1 Food habits of otter in the Coringa Wildlife Sanctuary:

7.2 Relative abundance of fish in the sanctuary:

The relative abundances of fish in the sanctuary were estimated using the Catch per Unit Effort (CPUE). The effort for each fish sampling was one hour of gill netting at the mouth of each creek during the low tide. Further, three major creeks Coringa, the Matlapalem and the Gaderu were also surveyed for fishes. These creeks were divided into segments and the length of each segment was 1 km. Fish sampling was done at the beginning of each segment and effort was the same, i.e. one hour of gill netting.

A total of 93 species fishes was recorded in the sanctuary during the study period. The information such as size and weight of fishes along with other habitat variables were collected. Relative abundance was calculated by summing of total number of individuals of particular species encountered in one creek and dividing it by the total number of individuals of all species found in the sampling. Since the number of fish species is very high only the relative abundance of those fish species that were considered for diet analysis are presented.

Of these 93 species, 11 species were selected to prepare the reference samples for diet analysis based on their high abundance, size and prior knowledge of fishermen about the otter's food. Apart from this, reference samples were also developed for five most common fishes of aqua farms. Reference samples for *Megalops cyprinoides*, *Pomadasys kakan*, *Terapon jarbua*, *Dendrophysa russeli*, *Liza tade*, *Oreochromis mossambicus*, *Gerres sps*, *Cynoglossus cynoglossus*, *Pacu*, *Mugil cephalus* and *Mystus gulio* were developed as these species were the most common and medium sized fish that occurred in the sanctuary. Reference samples include details of scale, vertebrae and other morphometric characters of fish.

The relative abundances of fish found during the sampling are presented in the Table 1. The relative abundance of fishes that had been collected from the creek Gaderu was not considered due

to absence of otter spraints in that region. This could also be due to non-negotiable habitat with thorny bushes in this creek which caused difficulty in finding the sprainting sites (Figure 3).

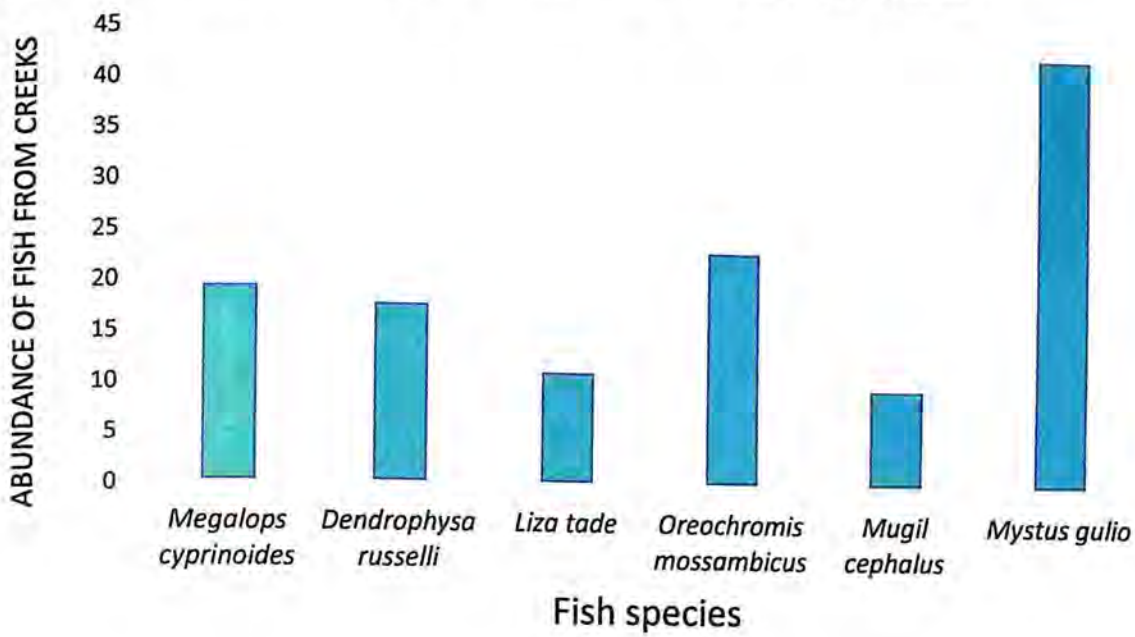
Mystus gulio was found to be most abundant fishes of the sanctuary with relative abundance of 42.8% followed by *Oreochromis mossambicus* which is an invasive species commonly called as Tilapia at 22.9%, *Megalops cyprinoides* showed a relative abundance of 19.24%, *Dendrophysa russeli*, *Liza tade* and *Mugil cephalus* have a relative abundance of 17.51%, 10.90%, 9.57% respectively (Figure 5).

There was a difference in the abundances of common fishes between the creeks. For example, the invasive tilapia was found in the Ramannapalem creek, but not in other creeks. Similarly, the abundances of *Dendrophysa russeli* and *Liza tade* were more in the Matlapalam creek compared to the Ramanapallam creek (Fig 3).

Table 1. Relative abundances of most common fishes of the Coringa Wildlife Sanctuary

Fish species	Relative abundance
<i>Megalops cyprinoides</i>	19.2476489
<i>Dendrophysa russeli</i>	17.51306165
<i>Liza tade</i>	10.90909091
<i>Oreochromis mossambicus</i>	22.98850575
<i>Mugil cephalus</i>	9.571577847
<i>Mystus gulio</i>	42.80041797

Figure:3 Relative abundance of selected fish in two different creeks



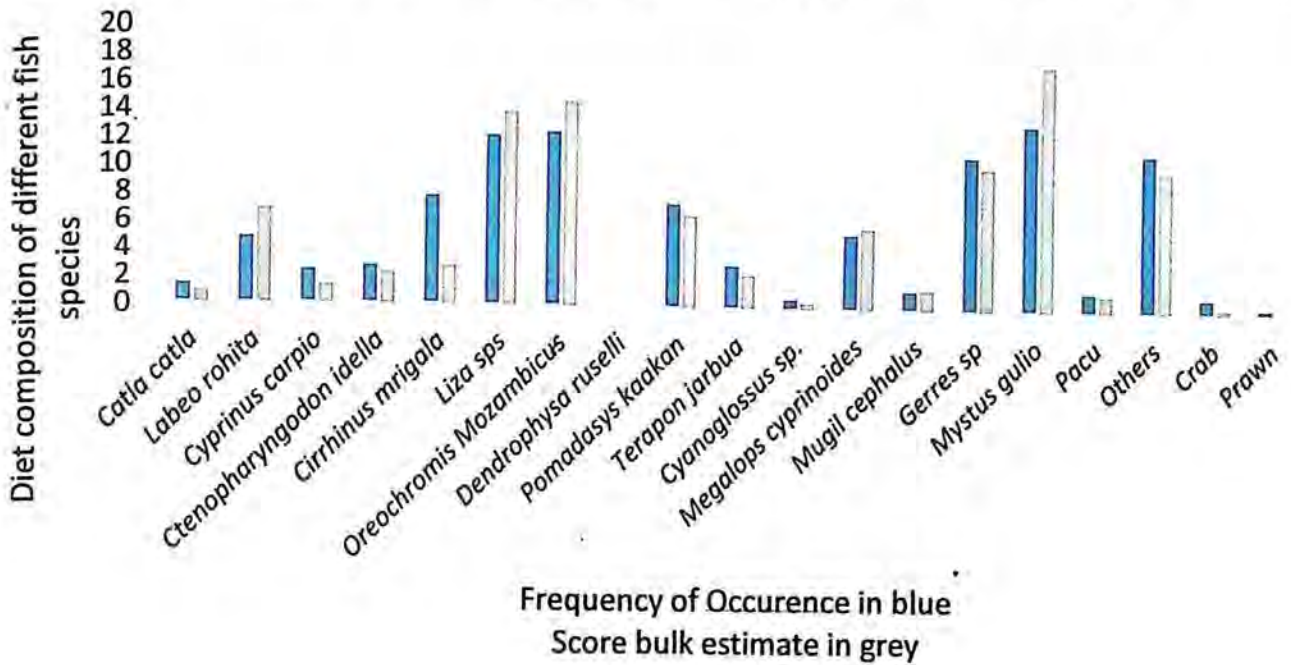
7.3 Diet composition of Otter:

7.4 Spraints contents analysis

The total number of prey items found in a spraint was varied from 1 to 11 revealing the diverse range of food preference of Otter in the study area. However, most of the spraints contained 5-7 prey species.

Frequency of occurrence of all food items found in the spraints was calculated. Fish was found in almost all spraints (98.6%). As per the score bulk estimates, fish was again dominated in all spraints (99.6%) with respect to their relative quantity found in all spraints collected in the field. Therefore, this result is once again confirmed that the most preferred food of Smooth coated otter is fish that was earlier support by Hussain and Choudhury (1997) and Anoop and Hussain (2004).

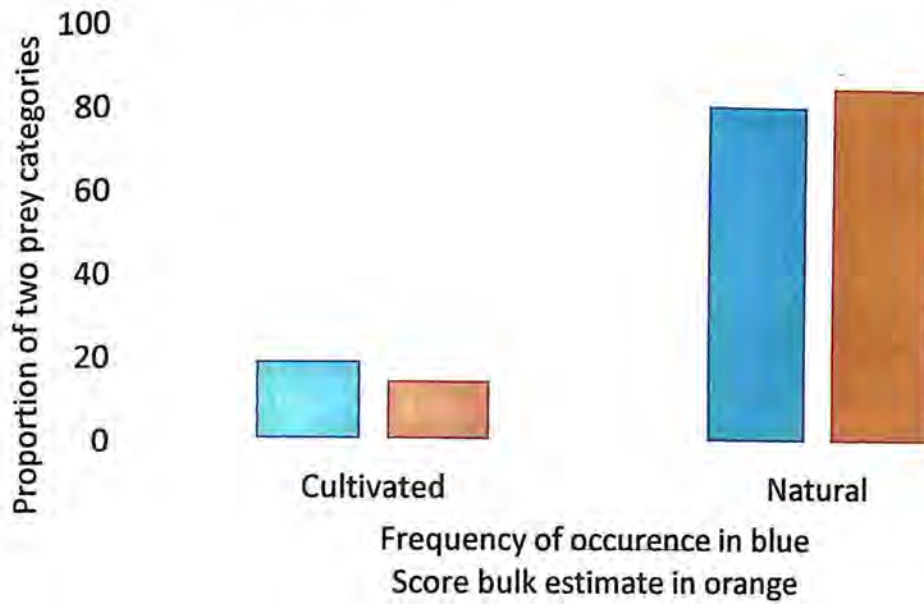
Figure:5 Diet composition of different species of fish for two different methods.



7.5 Proportion of different wild fish species in spraint:

Mystus gulio (long whiskers catfish) found to be the major prey of otter in the Coringa WLS, constituting 17.8% by weight of all food items found in the spraints and this fish was also eaten by many otters (found in 13.4% of spraints). *M. gulio* was also the most common fishes of the Sanctuary. *M. gulio* followed by *Oreochromis mossambicus* (Tilapia) constituting 14.6% of the weight of all food items found in the spraints (score bulk estimate) and 12.4% for frequency of occurrence method. *Gerrres sps* and *Liza tade* constituted 10.3% of the score bulk estimate and 11.1% for frequency of occurrence and 13.9% and 12.1% of the score bulk estimate and 11.9% for frequency of occurrence respectively. *Dendrophysa russelli* was never encountered. Pacu a native to South American river system was encountered with 1% constitution for both the methods (Figure 5).

Figure:6 Diet composition of fish from aquaculture farms and from mangroves for two different methods.



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7.6 Aqua farm fishes in the diet of otters:

All five major aquaculture species of fish were found in the spraints of Otter. Of the five species, *Labeo rohita* was most preferred farm fish of otter and this species was most preferred for fish farming. *L. Rohita* was constituted 6.8% of the score bulk estimate and 4.7% for frequency of occurrence method. *Cirrhinus mrigala* constituted 2.7% of the score bulk estimate and 7.7% for frequency of occurrence indicating higher preference of all cultivated species. Other three cultivated species constituted 1 to 2.2 percent in both score bulk estimate and frequency of occurrence method.

In overall, the aqua farm fishes constituted only the 14.4% of the weight of total food items found in the spirits of otter. Of the total spraints collected, only 17.8% of spraints contained the aqua farm fishes and remaining 82.2 % otter spraints did not have aqua farms fishes and these otters were seems to be eaten only the wild fishes (Figure 6).

7.7 Use vs Availability:

The ivlev's index did not seem to give appropriate results as the biomass of prey consumed could not estimate in the wild (Table 2). But, in the case *Dedrophysa ruselli* the index gave a value of -1 showing that this species was completely avoided by otters, as it was not found in the diet but found in creeks. The ivlev's index was negative for all species showing the avoidance even for

Mystus gulio which has the major share in otter diet. So the index values were not reliable in this study due to inherent problems in fish sampling.

Table: 2 Ivlev's index of different fish species.

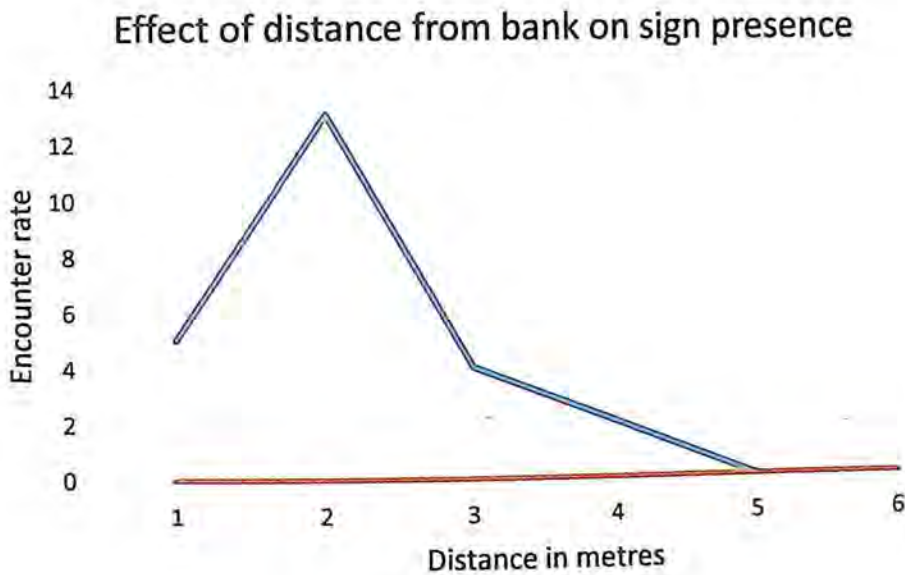
Fish species	Relative abundance	Score bulk estimate	Ivlev's index
<i>Megalops cyprinoides</i>	19.247	5.949	-0.527
<i>Dendrophysa russelli</i>	17.513	0	-1
<i>Liza tade</i>	10.909	13.924	0.121
<i>Oreochromis mossambicus</i>	22.988	14.683	-0.220
<i>Mugil cephalus</i>	9.571	1.518	-0.726
<i>Mystus gulio</i>	42.80	17.848	-0.411

8.0 Factors affecting otter distribution in the Coringa wildlife sanctuary:

8.1 Area of intensive sampling for the relative distribution of otters:

Prior to finalizing the area of the sampling plot, the distributions of otter signs from the either the banks of creek towards the mangroves were studied. A total of 19 such surveys was carried out in different parts of the sanctuary. It was found that almost all otter signs largely paw prints were found within 5m from the banks of creeks (**Figure 7**). Only two signs were found at 6 m distance. Based on this observation, the effective sampling plot size was decided as 600 X 10 m along either bank of creeks.

Figure: 7 Encounter rate of signs with increasing distance.

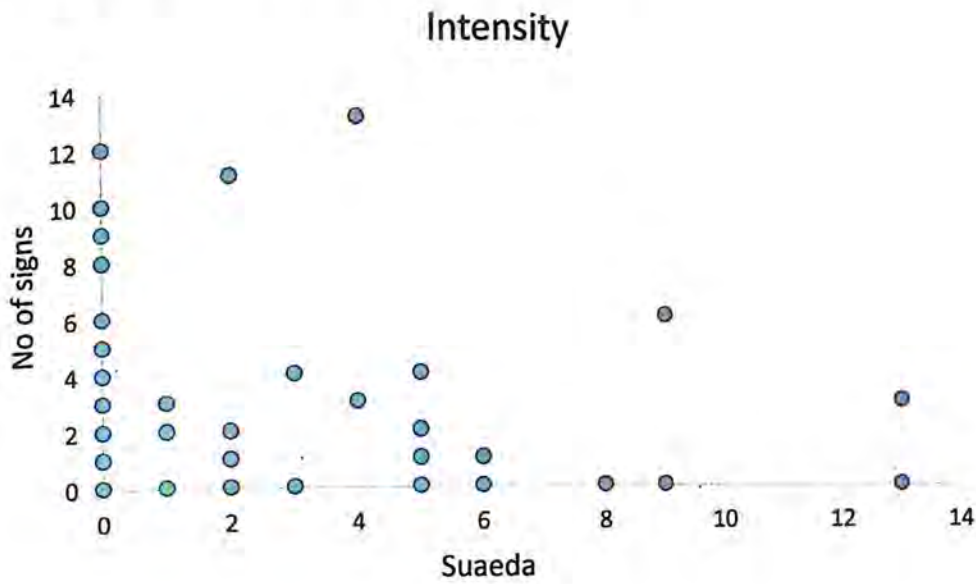


8.2 Habitat use of otters in the Coringa Wildlife Sanctuary:

The of otter signs such as paw-prints and spraints found in each sampling plots were related with following different habitat variables to understand the habitat selection of otter in the study area using the scatter plots. The habitat variables are;

- (i)Width of the creek
- (ii)Depth of the creek

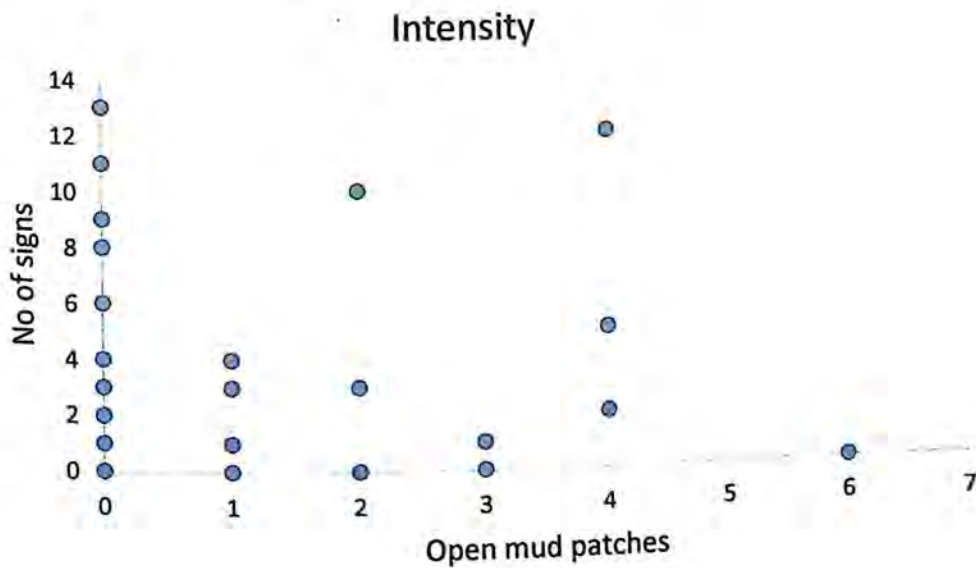
Figure: 9 Effect of *Suaeda* on sign intensity.



8.4 Effect of open mud patches on otters use (Figure 10):

Similarly Otters were observed to be basking and grooming on open mud patches. But no significant relationship was observed from the scatter plot between intensity of signs and open mud patches.

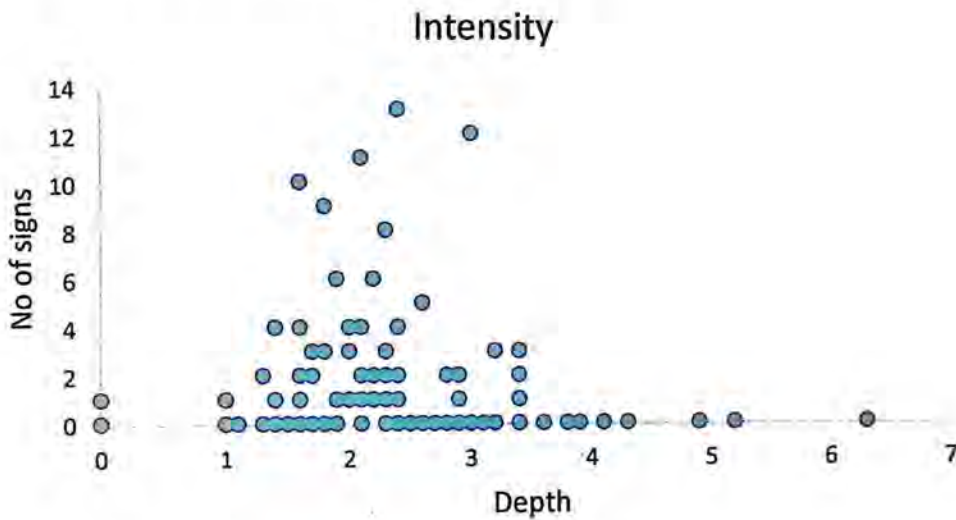
Figure: 10 Effect of open mud patches on sign intensity



8.5 Effect of depth on otters use (Figure 11):

The maximum intensity of signs was found in plots with an average depth of 1.7 to 2.8 meters and the intensity decreased with increased depth. This could be due to decreased efficiency of predation by otters with increasing depth.

Figure: 11 Effect of depth on sign intensity



8.6 Effect of Grass patches (Figure 12):

Otters were also observed to be basking, grooming and sprainting in open grass patches. But no significant relationship was observed from the scatter plot between intensity of signs and grass patches.

8.7 Effect of disturbance:

Though intensity was highest at medium level of disturbance, but it was not very prominent. So no relationship could be inferred (Figure 13).

8.8 Effect of distance from mouth of river (Figure 14):

Distance from mouth of the river changes many other factors like width, salinity, depth, species diversity, etc. Otter sign intensity increased with increasing distance from the mouth of the river or the closer to land the more intensity. Otter sign intensity was less very close to village because of dominance of *Caesalpinia crista* along the banks. *Caesalpinia crista* is a thorny and dense bushy

tree where sign survey could not be done efficiently due to which signs were not detected efficiently.

Figure: 12 Effect of open grass patches on sign intensity

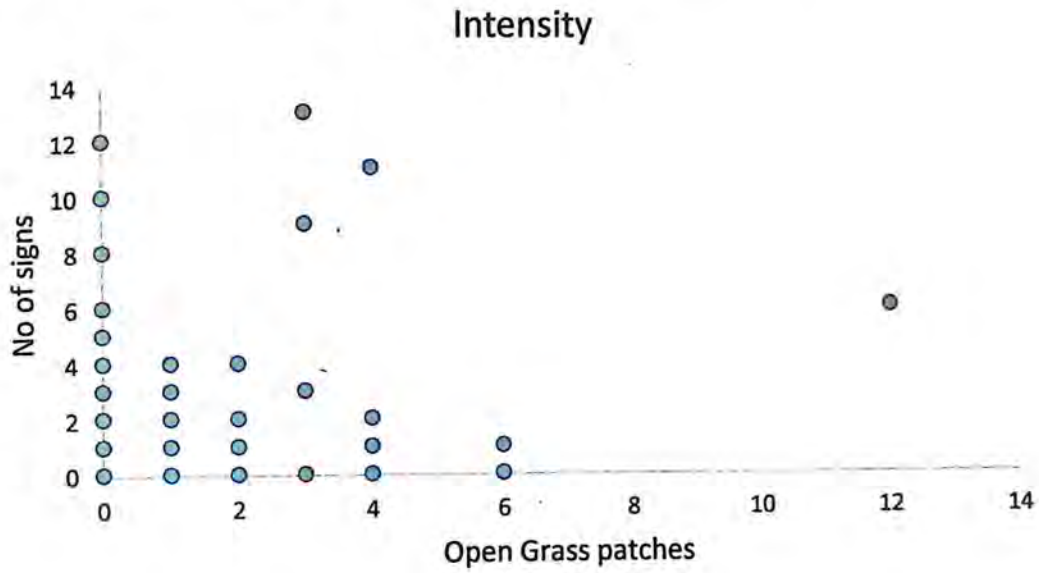
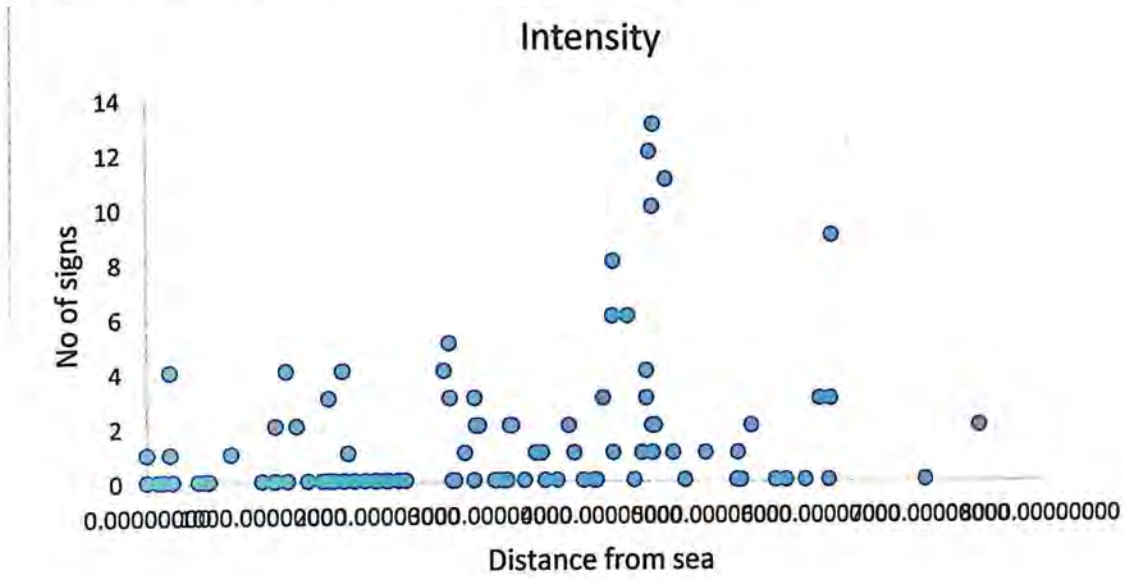


Figure: 13 Effect of disturbance on sign intensity.



Figure:14 Effect of distance from sea on sign intensity



8.9 Effect of bank vegetation (Figure 15):

Intensity of signs increased with decreased bank vegetation. This could be due to the presence of *Acanthus* as bank vegetation in many plots and as *Acanthus* is thorny and dense, the bank may be inaccessible for Otters.

Figure: 15 Effect of bank vegetation on sign intensity

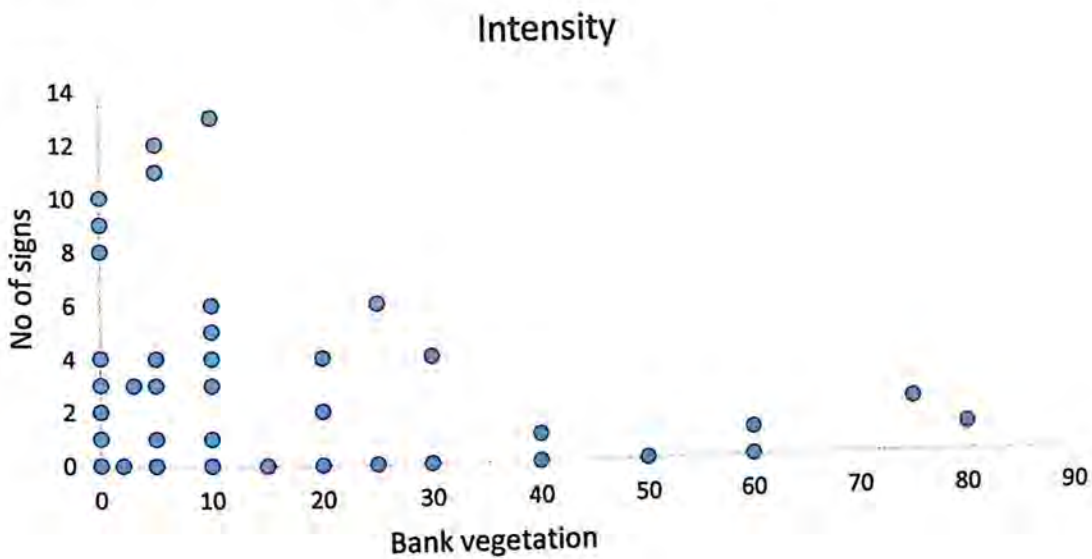
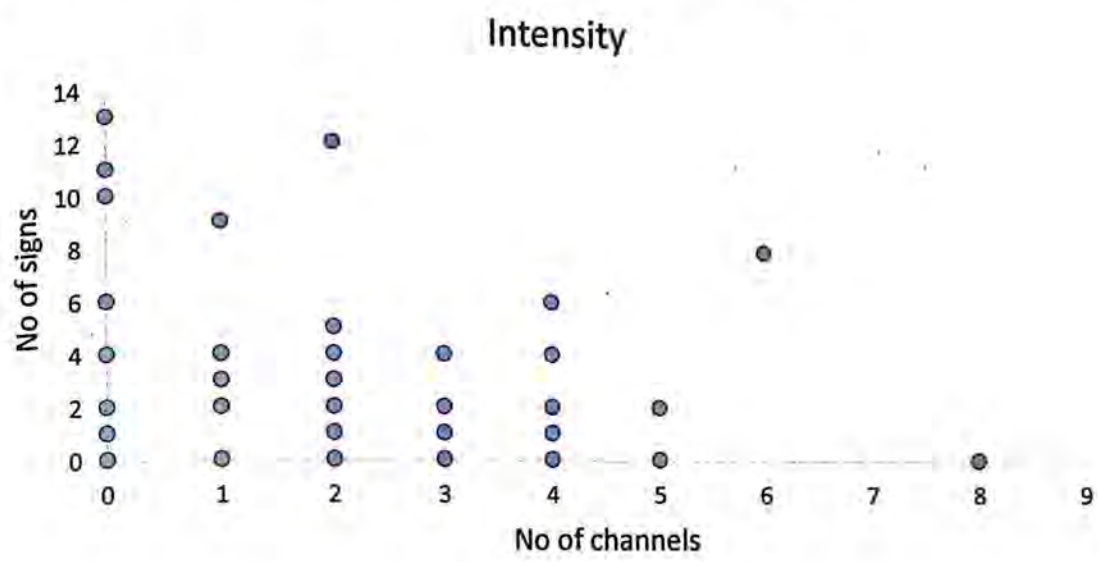


Figure 16: Effect of number of Channels on sign intensity



8.11 Factors affecting the distribution of otters:

The Ordinal Logical Regression was used to understand the factors that govern the distribution of otters in the sanctuary. Intensity was ranked as absent, low and medium to high, where low was intensity of 1 to 2 and medium to high was above 3 (median for intensity is 2 with a range of 0 to 14). These three categories were considered as response variables and independent variables was *Distance from the sea, Width of the creek, Depth of the creek, a number of open mud, grass and Suaeda patches and percent bank vegetation*. SPSS 19.0 version was used to run Ordinal logical regression.

Model fitting information:

The model was well fit with the final intercept value of 190.669 and **Chi-Square** value of 17.313 with **7 degrees of freedom** with a significance of 0 .015 i.e, **P value= 0.015** at 95% confidence interval.

Pseudo R square:

The **Nagelclarke** estimate for the model was **0.174** indicating that the model could not explain a lot of variation in the data. This could be due to other factors affecting the Otter sign intensity in the sanctuary.

Table:3 Parameter estimates of Ordinal regression model

		Parameter Estimates				
		Estimate	Std. Error	Wald	df	Sig.
Threshold	[Intensity = 1]	.351	.213	2.723	1	.099
	[Intensity = 2]	1.527	.263	33.704	1	.000
Location	Dis_z	.403	.225	3.205	1	.073
	Width_z	.509	.273	3.481	1	.062
	Depth_z	-.624	.322	3.759	1	.053
	Mud_z	.408	.209	3.805	1	.051
	Grass_z	.382	.279	1.874	1	.171
	Sueda_z	-.004	.252	.000	1	.987
	Bank_z	-.076	.220	.121	1	.728

The Parameter Estimate picked up four following habitat variables as most influencing factors for otter distribution in the Coringa WLS (**Table 3**);

- i) **Distance from sea:** Distance from sea had a marginal effect on Otter signs intensity with slope estimate = 0.403, Standard error = 0.225 and P value = 0.073. Though the P value was >0.05, twice the standard error is closer to the estimate. Thus the intensity of signs increased with increasing distance from sea i.e the otter signs were higher near villages where the salinity of water was also low and the aqua farms were present.
- ii) **Width of creeks:** Width of the creeks has a positive effect with increasing otter signs. Creeks with medium width had more otter signs. But the Parameter effect was marginal with Slope estimate = 0.509, Standard error = 0.273 and P value = 0.062.
- iii) **Depth of the creek:** Depth of the creek had a negative effect with otter signs intensity. Otter signs were high along creeks with low to medium depth, but it had decreased when the creek depth had increased. Slope estimate = -0.624, Standard error = 0.322 and P value = 0.053.
- iv) **Open mud patches:** Open mud patches had a positive relationship with sign intensity. More otter signs were present where the creek bank with more open mud patches. (Slope estimate = 0.408, Standard error = 0.209 and P value = 0.051)

Other habitat variables such as *Suaeda* patches, grass patches and bank vegetation did not show any significant relationships with distribution of otter's signs. Therefore, these habitat variables are not seeming to be important factors that could affect the distribution of otters in the Coringa WLS. However, otters were seen taking a rest or basking on the grass patches.

9.0 Fishermen's Traditional Ecological Knowledge of Otters in and around the Coringa Wildlife Sanctuary - Questionnaire surveys:

A questionnaire survey was carried out with the aim of understanding their traditional ecological knowledge of otters as well as their perspectives towards otters. This survey was conducted targeting only the men in the age group of 20 to 70 years, as they are involved in the management of fish farm farms in the region. The respondents were divided into five age classes of 20-29, 30-39, 40-49, 50-59 and 60-69 (Figure 17). About 38% of respondents were from the age class of 20-29 and the percentage of respondents decreased with increasing age classes. Least representations from 60-69 age class with only 1.9%. This could be due to the fact that the maintenance of aquaculture farm requires more dynamic and physical hard working young people. It was found that about 90% of the respondents had aquaculture as their primary occupation with minor secondary occupations largely related to agriculture and other works. This indicates that their higher level of dependence on aquaculture (Figure 18).

Figure: 17 Age group composition of people interviewed

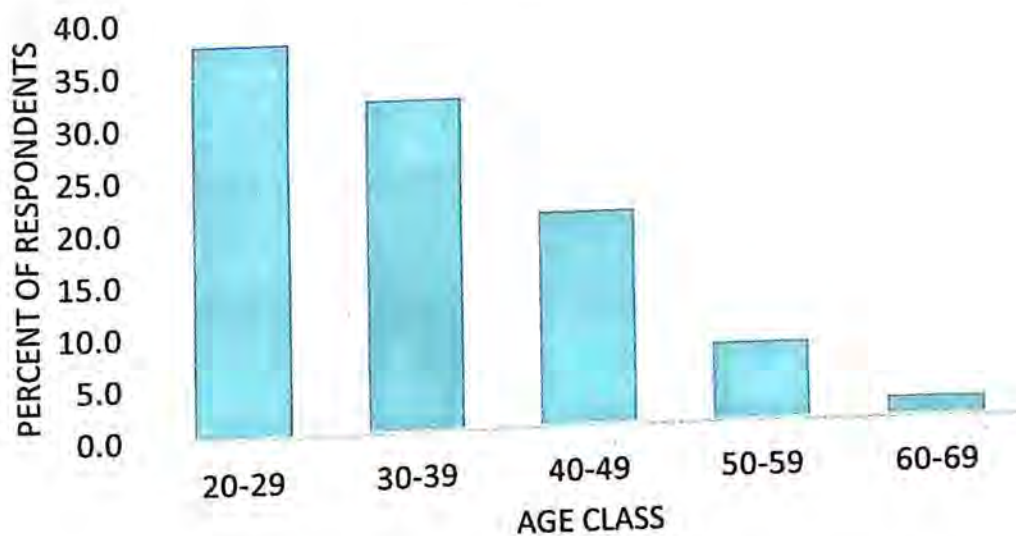
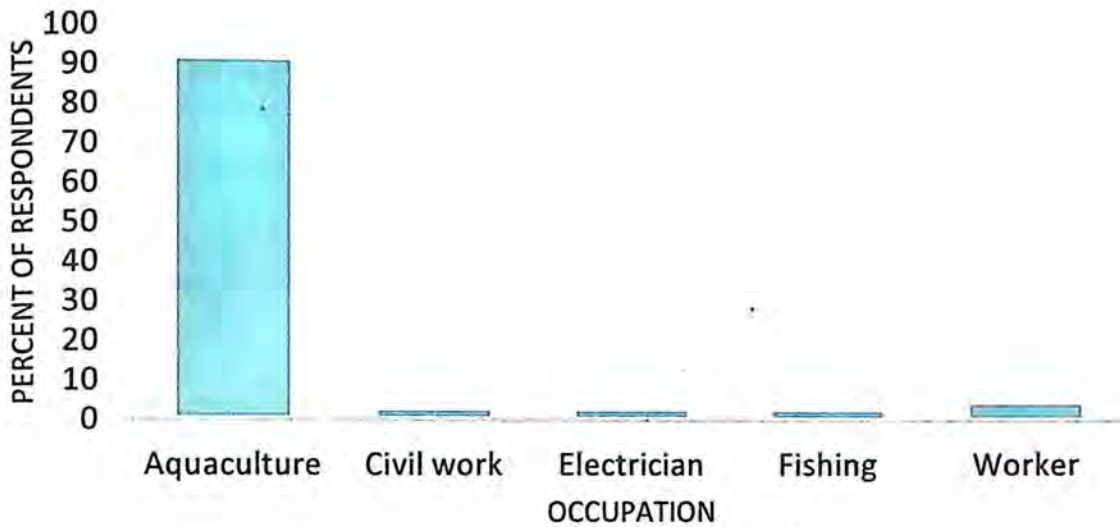


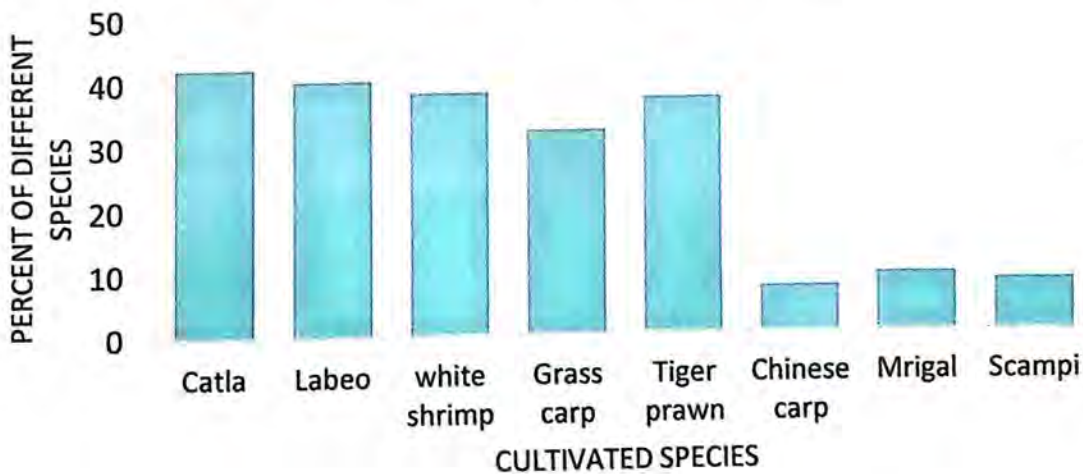
Figure: 18 Major occupation of respondents



9.1 Species farmed in the aquaculture ponds:

A total of eight species of fishes and prawns are cultivated in the fish farms around the Coringa Wildlife Sanctuary. They are *Labeo rohita*, *Catla catla*, *Liptopinnaeus vannamei* or White shrimp, Grass carp, Tiger prawn, Chinese carp, Mrigal and Scampi. *Labeo rohita*, *Catla catla*, White shrimp, Grass carp and Tiger prawn were preferred most by the farmers and these species were cultivated in polyculture aqua farms. Prawns were mostly cultivated in monoculture (Figure 19). However, these species that have been cultivated in the farms were not found in the mangroves of the study area.

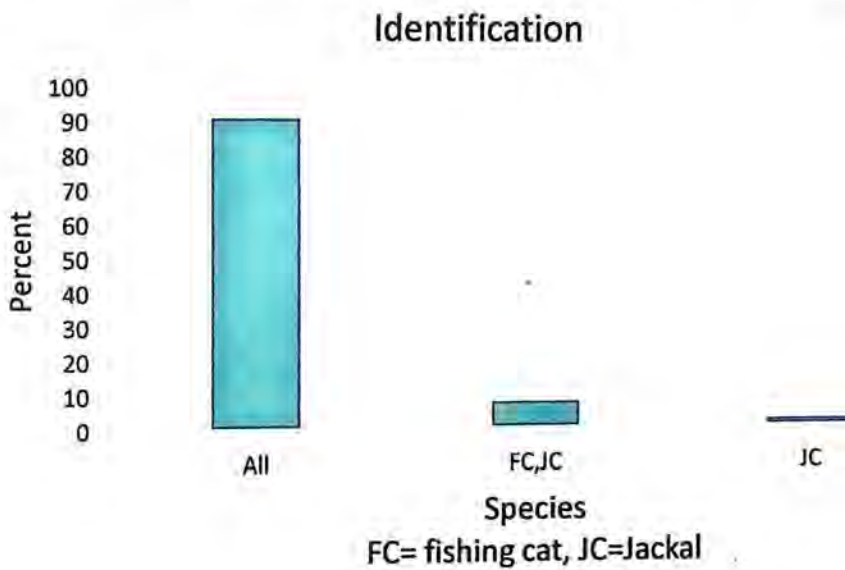
Figure: 19 Percentage of fish species in aquaculture farms.



9.2 People perspectives on otters:

About 90% of the people interviewed could identify otters along with fishing cats and jackals, which were also known to feed fish and shrimps of farms. All the respondents who could identify Otters could also identify other two species. But, those who could identify fishing cats and jackals were not necessarily could correctly identify otters. This reveals that both fishing cat and jackals may or may not be sympatric with otters (Figure 20).

Figure: 20 Percent of respondents who could identify Otter



9.3 Otters visits to aqua farms:

About 60% of the respondents felt that all three species such as otters, fishing cat and jackals visit aqua farms and feed farms fishes. However, few people (5%) felt that only Otter and Fishing cat feed on fishes from farms but not jackals. Interestingly, about 2% of respondents felt that none of these animals visit their farms (Figure 21).

9.4 Activity pattern of otters:

Based on interview survey, about 79% of the respondents felt that Otters visit their farms at night that confirms the nocturnal behaviour of otters around human habitation, which is supported by previous studies (Figure 22).

Figure: 21 Percent of aquaculture with Otter visits.

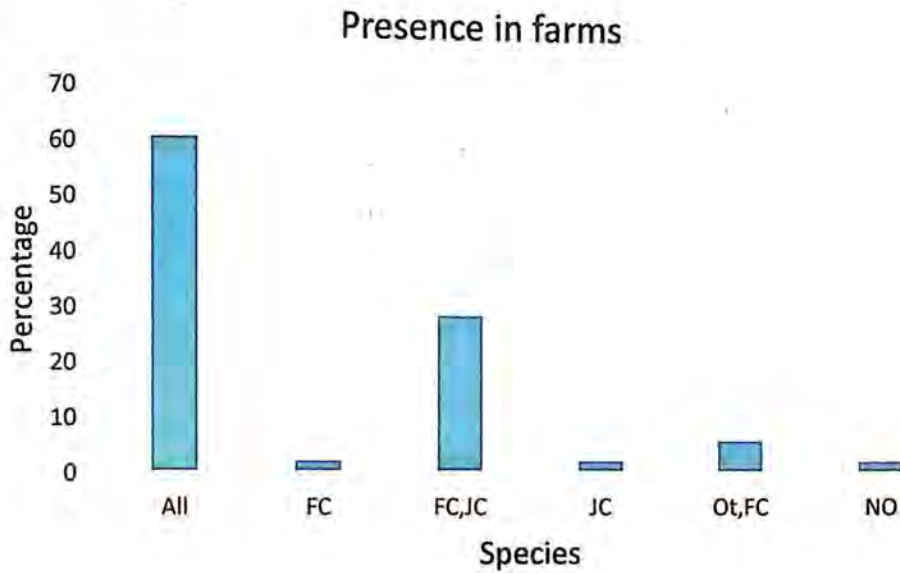
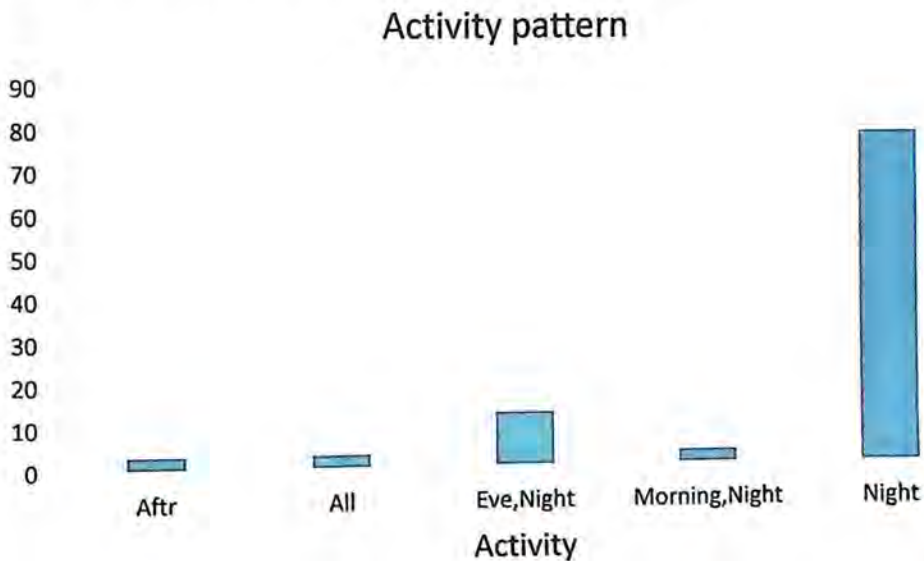


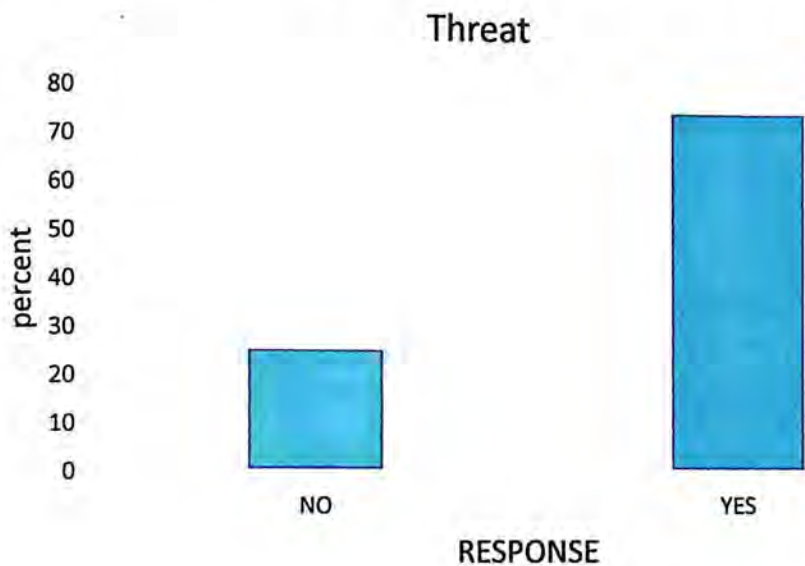
Figure: 22 Activity pattern of Otters near farms



9.5 Perception and attitude of respondents towards otters:

About 75% of the respondents believed that otters were a high threat to aquaculture when compared to fishing cat and jackals. This is due to their behaviour of feeding in groups, whereas fishing cats and jackals visit aquaculture ponds solitarily (Figure 23).

Figure:23 Percent of respondents who consider otters as threat to fish



9.5 Damage to aqua farms due to otters:

Nearly 11% of respondents felt that Otters have caused an income loss of 1-5%, followed by 9% of respondents who claimed a loss of 10-30%. Few farmers (2%) felt that Otters cause nearly 30-50% of loss (Figure 23). However, about 29% of the respondents did not know how much income loss Otters were causing but they felt that Otters are significant threat to their farms.

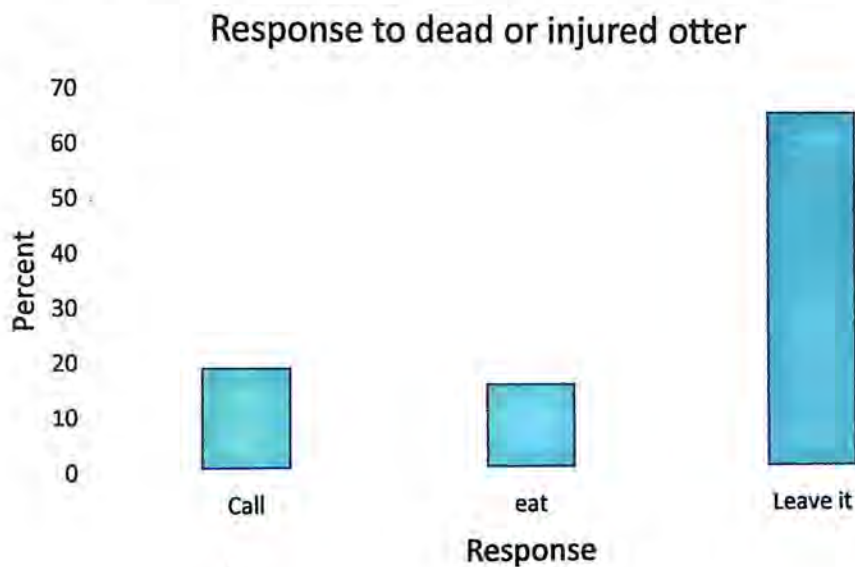
Figure: 24 Percent of income loss caused by Otter as perceived by owners.



9.6 People response to dead or injured otter:

The respondents were asked about their response if an otter was found injured or dead due to their protective measure. In response, about 65% of people informed that they normally leave the otter without touching it. However, the rest of the respondents admitted that they either eat the meat or sell to someone who eats the same.

Figure: 25 Response to injured or dead otter near farms



9.7 Observations on otter population trend in the Coringa WLS:

Nearly 65% of the respondents felt that there was a decline in the sightings of otters and they have also believed that the population had been declined in the region. However, in contrast, about 13% of them felt that there was an increase in Otter population over years and most of these respondents who have also believed that high loss of income due to otters visits to their aqua farms (Figure 26).

9.8 Is otter protected species?

About 60% of the respondents knew that Otter is a protected species under a law but 30% of them did not know whether it is protected or not and rest 10% did not know whether Otter is protected or not (Figure 27). However, the level of awareness about otters and other protected species have been enhanced in the recent past due to various awareness programmes organised by the EGREE (East Godavari river estuarine ecosystem) Foundation.

Figure: 26 Observations on otter population by respondents

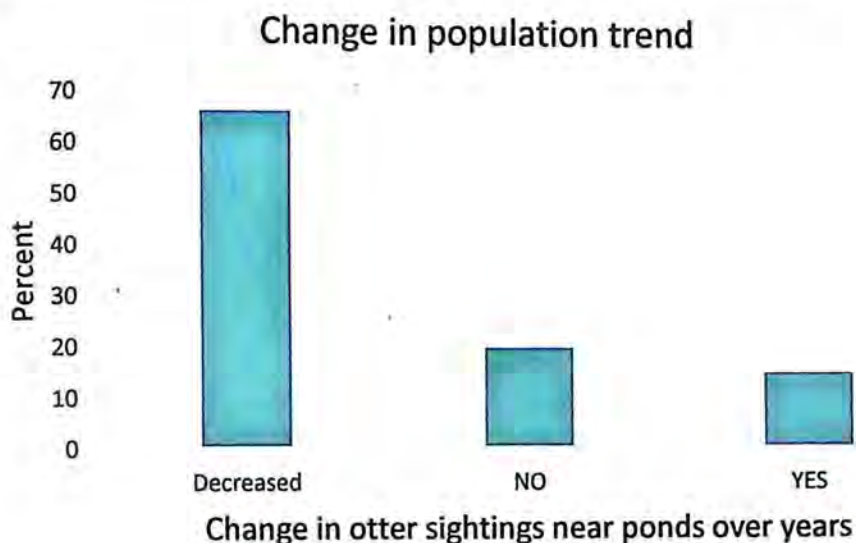
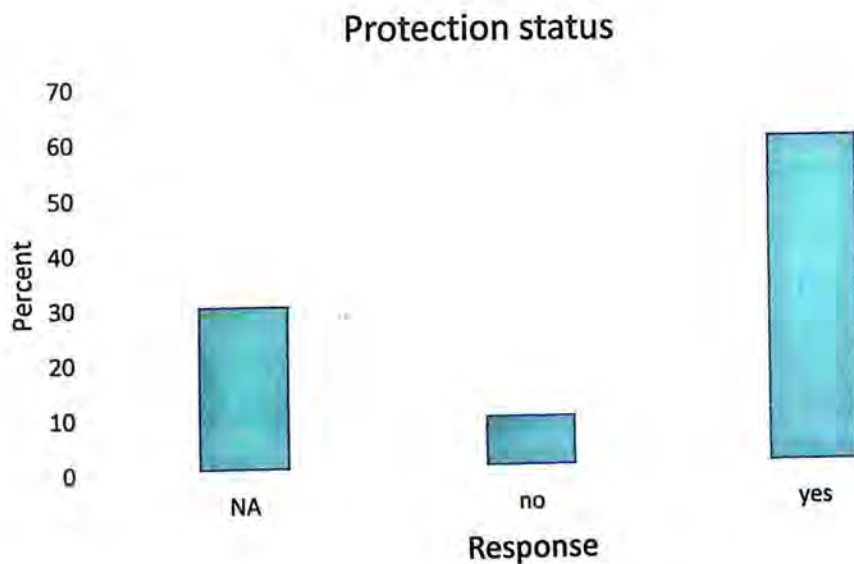


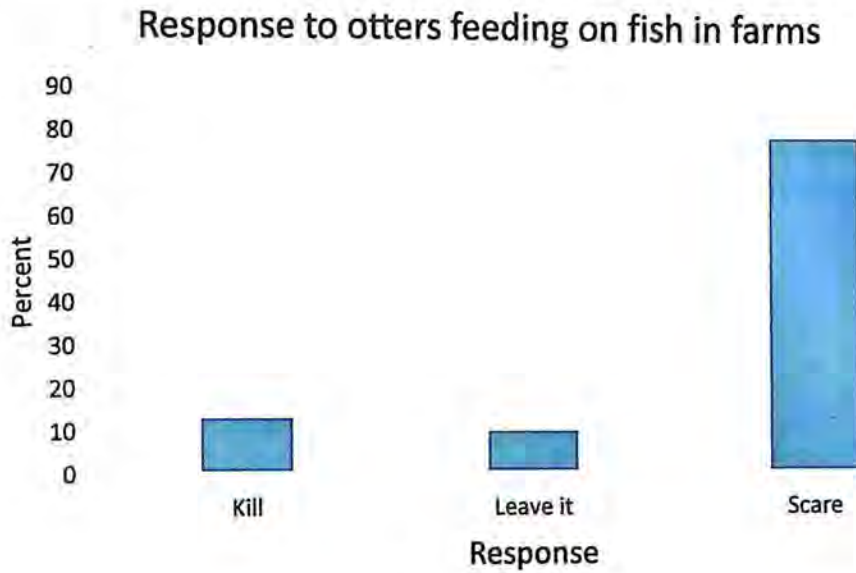
Figure: 27 Awareness of respondents to protection status of Otter



9.9 Reactions of people towards otter who visit aqua farms:

Most of the farm owners admitted that they always scare and chase away otters when they enter into their farms. Though only 11% of them opted for killing does not mean that people have a positive attitude towards Otter (Figure 28). This is due to the fact that killing an Otter is difficult as they are very fast and are known to attack on humans when approached closely. So scaring could be just an option but not their attitude.

Figure: 28 Response when Otter feeds in farms



9.10 Factors affecting negative and positive attitude towards Otter:

Generalized Linear Model (GLM) with Poisson distribution was used to see the relationship between income levels, education status and the response of owners when otters enter their farms. The income level of a particular respondent was calculated using the information of number of acres cultivated, types of species cultivated and yield of that species per acre. The income range of a owners was between Rs. 45,000 to Rs. 30, 00,000 per annum which was dependent upon size of farms and species cultivated.

Table: 4

Deviance Residuals:					
	Min	1Q	Median	3Q	Max
	-0.76839	0.01896	0.03111	0.05845	0.70316
Coefficients:					
	Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	1.953710	0.234688	8.325	<2e-16	***
income	-0.034919	0.176082	-0.198	0.843	
EDU1	-0.002031	0.030762	-0.066	0.947	
Null deviance: 10.711 on 69 degrees of freedom					
Residual deviance: 10.646 on 67 degrees of freedom					
AIC: 195.27					

Though the model seems to be well fit (intercept P value= $2e-16$) both income and Education status were not having significant relationship with high P values of 0.843 and 0.947 respectively at 95% confidence interval (Table 4) . This can be due to the less number of respondents i.e 53 and high variation in income.

Boxplot analysis to understand the relationship between people's action towards visiting otters to their farms and their income and education, has revealed that the farm owners who had less income have tried to kill the visiting otters due to their poverty. This could also be due to the fact that people with less income could not offered to lose even small amount of fish, whereas people with higher income in the case of response 1 have neither tried to kill or scare the visiting otters (Figure 29).

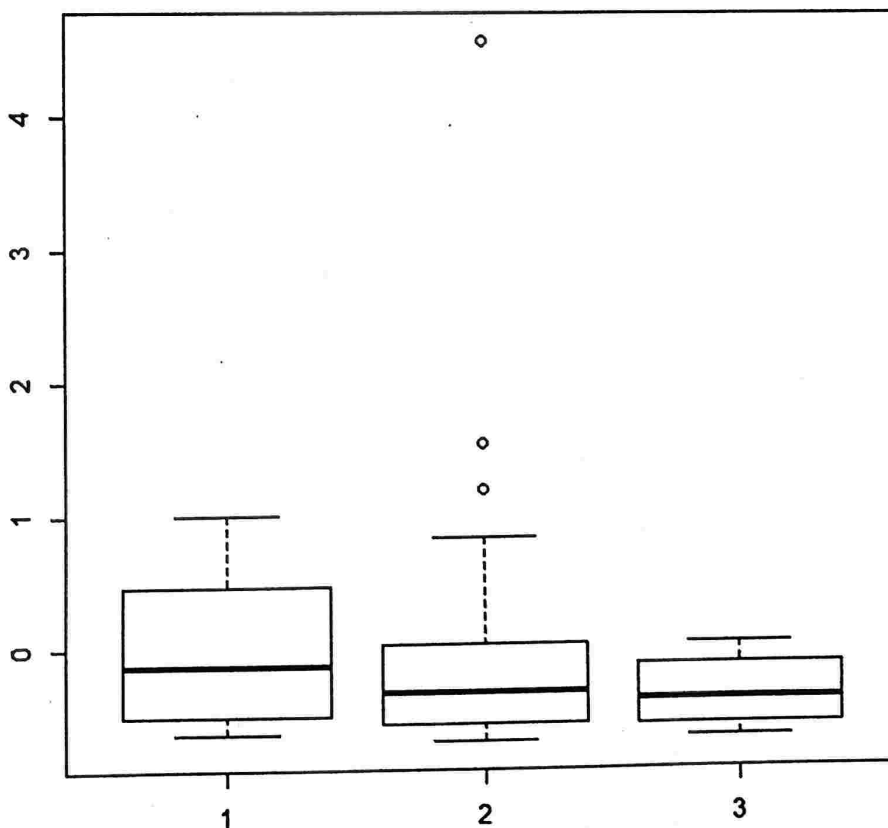


Fig 29. Boxplot showing responses 1, 2, 3 (1= leave it, 2= Scare it and 3= Kill) with level of income in 'x' axis that ranges from 45,000Rs to 30lakhs.

In the same above manner people who opted for kill were the people who had less education. They were not educated above 6th standard. Whereas people who opted to leave or scare others were the ones with huge range of education (Figure 30).

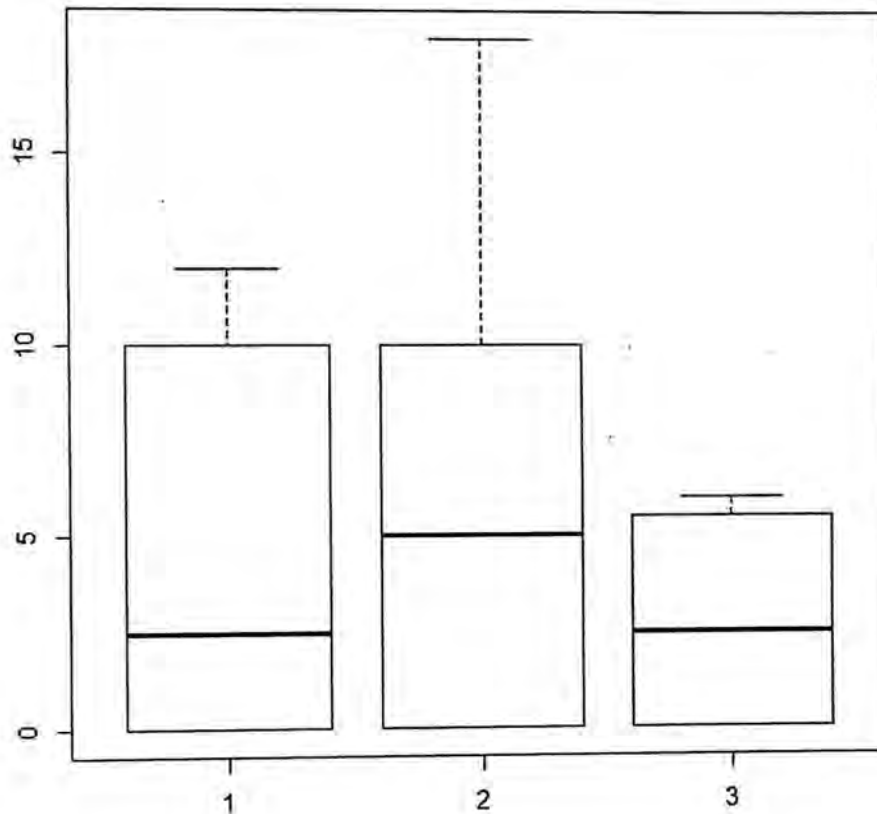


Figure: 30 Boxplot showing responses 1,2,3 (1= leave it, 2= Scare it and 3= Kill) with level of education in 'x' axis that ranges from 0 to 18.

10.0 Discussion and Conclusion

Smooth coated Otter being a plain's otter is able to adapt to diverse aquatic habitats with wide geographic distribution (Pocock, 1943). They are found in a semi arid region of North-Western region of India and Deccan plateau in India in varied aquatic habitats. From large rivers, rice fields, mangroves, Smooth coated Otter is found to utilize a variety of resources (Prater, 1971; Hussain 1997, Foster-Turly 1992).

Smooth coated Otters were found to be more abundant in mangroves than rain forest Rivers in Kaula Gula, Malaysia (Shariff. 1984). The present study is carried out in a mangrove habitat. Mangrove habitats are known for their high diversity, complex species interaction along with high level of productivity. Mangroves also serve as a mating ground for many aquatic species, both vertebrates and invertebrates and are also feeding grounds for many marine organisms (Vancucci. 2001).

With such diverse and productive ecosystem as habitat Smooth coated Otter expected to depend on a wide range of resources for their survival. The present study emphasizes on the understanding resource selection by Smooth coated Otter and also assessing the level of threat and conservation measures to be taken for its long term survival in an area where humans directly compete with Otters for food and also cultivate Otter food.

10.1 Resources essential for Otter survival:

For any Heterotroph availability and distribution of food is the most essential resource. Smooth coated otter being a piscivorous carnivore with high energy requirement the distribution, abundance of fish which the Otter can predate on is essential (Mason and Macdonald. 1983; Pardini 1998). Shelter is another essential resource for any animal and Otters live in dens called holts which are made very near to the feeding range. Smooth coated otter is a semi aquatic animal with adaptations to maintain their body temperature in water. Basking and Grooming are two activities

that assist them in keeping their adaptations in condition. So sites for basking and grooming that are near holts within foraging range are the resources that are essential for Otter survival.

10.2 Present study area:

The present study area is a mangrove ecosystem known for its high diversity of fishes. During the fish sampling 93 species of fish were found and the number could be much higher since sampling was not done in narrow creeks and all fishes do not get caught in gill nets. This study area contains highest diversity of fishes in comparison to other diet studies of Smooth coated Otter in India which are in fresh water system (Hussain and Choudhury. 1997; Anoop and Hussain. 2004). Also unlike river systems or other fresh water ecosystems Otters have to deal with many problems in a mangrove habitat. The effect of tidal cycle is very prominent in mangrove habitat where organisms have to adapt and deal with ever changing water level, speed and salinity. In Coringa wildlife Sanctuary semi diurnal tidal cycle occur with two high tides and two low tides each with 6 hour duration in a day. Thus the direction of water flow changes every 6 hours and swimming is efficient in the direction of water flow.

So Otters have to swim in the direction of water flow to conserve energy, so they are limited to certain direction of movement for conserving energy.

In a mangrove habitat presence of rocky structures in which Otters are known to make holts (Mason and Macdonald. 1983; Hussain and Choudhury. 1997) is very rare. Also the roots of trees do not protrude out creating a hollow space unlike trees in terrestrial system where otters make Holts. Due to the nature of soil the roots are deeply embedded in the soil with no space. Due to this finding a suitable place for holting is a challenge in such habitat.

Mangrove habitat does not usually contain sandy substratum for grooming and basking of Otters. Due to these factors the resources that Otters select in the mangroves are expected to be different from a fresh water system.

Along with these difficulties the most possible threat comes from deforestation of mangroves for creating aquaculture farms where fish are stocked at high density. Aquaculture farms form the

boundary of the sanctuary towards land. According to the Resource dispersion hypothesis animals tend to select those areas where resources are concentrated. So there is a high chance that Otters select areas closer to the villages. Incidentally the rocky structures, sandy substrates and other resources are concentrated towards the villages. Due to this combined factors Otters are frequently sighted near aquaculture farms and many times feed on fish from these farms thus coming into direct conflict with people. As Otter is considered as vermin and its meat is considered to be contained medicinal values in the present area Otters face everyday challenges for their survival.

10.3 Diet of Otter:

As expected cultivated fish species were found in the spraints of otters and most of the spraints were found near villages. But cultivated species did not form a major part of Otter diet. 18% of Otter diet was from five cultivated species (**Figure 4**). Major part of Otter diet consisted of *Mystus gulio* and *Oreochromis mossambicus* with 17% and 15% followed by *Liza tade* with 14%. Whether this 18% is high or negligible portion depends on the perception of the person. *Mystus gulio*, *Oreochromis mossambicus* and *Liza tade* are some of the most abundant fishes sampled. This indicates that Smooth coated Otter is an opportunistic feeder which is also evident from studies in Chambal river of central India and Periyar River in Western ghats (Hussain and Choudhury. 1997; Anoop and Hussain. 2004). Tilapia (*Oreochromis mossambicus*) is an invasive species in many parts of the world and occurs in both fresh water and estuarine ecosystem. The present study area also has Tilapia with high abundance and Otter is feeding on it to high extent. Also Tilapia is usually found near grass banks which are more towards villages or along aquaculture farms and many times fishermen were observed to catch Tilapia with bare hand from their nest. This indicates the easiness which one can hunt Tilapia. For a predator like Otter a prey that can be easily caught is preferred. Tilapia is known to compete with native fishes for resources, as Otter is feeding on Tilapia to a huge extent it is helping the native fish fauna by controlling Tilapia population. Tilapia was also abundant in man modified ecosystem of Periyar reservoir and nearly 51% of Otter diet composed of Tilapia (Anoop and Hussain. 2004). *Mystus gulio* is a slow swimming catfish which is also present in high abundance in sanctuary and this fish consisted major part of Otter diet. This could be due to a wide range of salinity tolerance of the fish so it could be having wide range of distribution in the sanctuary. *Liza tade* is a mullet species and mullets are known to move in schools so it would be easy for an Otter to hunt mullets.

Labeo rohita commonly called Rohu was highest in the diet of Otter of all five cultivated species followed by *Cirrhinus mrigala* both of them are column feeder. *Cyprinus carpio* and *Catla catla* consisted only 1-2% of otter diet. Grass carp is not stocked at high densities unlike other fish, usually 100 fish for acre in comparison to 800 -1000 fish for other species. So Grass carp being less abundant was found in negligible amounts in the diet.

Another invasive species the South American Pacu was found once in otter diet. Pacu was seen frequently in the fish market and the fishermen said that they occasionally get this fish in nets and also informed that some farms stock them in minor quantities. Though the pace was not captured during fish sampling the reference sample of the scale was obtained from the fish market.

As Pacu was found only once in the diet in negligible amounts it can be concluded that it is not abundant in both natural water and fish farms. These findings indicate that Otters in the study area are opportunistic rather than targeting a particular species of fish and are also opportunistically feeding on fish from aquaculture farms.

10.4 Factors effecting Otter distribution in the study area:

As mentioned earlier abundance of prey, suitable place to holt and substrate for basking and grooming are essential for survival of Otters. The results indicate that distance from land, depth of the creek, width of the creek and number of open mud patches play prominent role in Otter distribution.

10.5 Distribution of food resources:

Otters seems to be concentrated more towards villages where all the resources essential for Otters are present. One of the most abundant fish Tilapia (*Oreochromis mossambicus*) is usually found near the bank vegetation along the creeks near villages also abundant food resources are available along the villages in the form of aquaculture. Thus regarding dietary requirement of Otters creeks near villages seems to be an ideal place.

10.6 Holts:

Shelter for Otters are holts in which has to protect Otter from its threats where it can reproduce and perform other important activities (Kruuk, 2003). So a place which remains sturdy and dry even during high tide time and during rainy season would be ideal to make a holt. Because finding such place is difficult to search in a mangrove habitat only one Otter holt was found during the study period and that place turned out to be below pumping station of a Prawn culture farm near the border of village (Plate 1). The holt was identified by heavy sprainting activity near the holt and inside the holt and high intensity of pugmarks (Mason and Macdonald, 1983; Channin, 1988; Kruuk, 1995). The fishermen and farm owner around the holt were aware of Otters holting there. Also many villagers said that Otters frequently make holt in pumping stations of Aquaculture farms and in *Caesalpinia crista* patches. *Caesalpinia crista* is a thorny creeper that dominates the vegetation near the villages along the banks. Due to its dense thorny nature usually no one enters these patches. Due to this *Caesalpinia crista* could be providing refuge for Otters from human threat.

10.7 Depth and width of the creek:

Otters are air breathing mammals which need to surface for time to time during hunting for their oxygen requirement (Mason and Macdonald, 1983). Due to this constraint Otters usually prefer hunting in shallow waters which are 2-3 metres deep. In a study on Coastal Otters in Scotland, it was observed that most successful dives were on an average 36 percent shorter than unsuccessful dives (Kruuk and Hewson, 1978). So it is unlikely that Otters hunt at depths higher than 4 metres. In the study area depth higher than 4m exists near the mouth of the rivers where the wave action is also high and the Otter has to negotiate with the wave action for hunting. So it is unlikely that Otters prefer habitat near mouth of the river with higher depths. In contrast creeks near villages have a depth ranging from 1.5 to 3 metres and as earlier mentioned food resources are abundant near villages.

Width and depth are positively correlated in the study area, the creeks near villages have a width of 20 to 40 metres where high intensity of Otter signs are found. This could be because of depth and other factors rather than width itself. This is evident from the fact that Otter signs were

comparatively lesser in creeks of less than 15 metre width which are usually far from villages. So depth is another important factor that makes Otter choose habitat near villages.

10.8 Habitat for grooming, basking and sprainting:-

Otters require substrates for performing grooming, basking and sprainting activities (Dubuc, et.al 1990; Prenda, and Granado-Lorencio, .1996, Shenoy.et.al. 2006). Grooming and basking are two essential activities than maintain body temperature of Otters. In the present study area Otters were many times observed to be basking and grooming in open grass and *Suaeda maritima* patches which remain dry even during high tide and provide roughage required for grooming. The fishermen also know that Otters bask in grass and *Suaeda maritima* patches. Otters mark their territories using spraints. Grass patches are few places in the study area which remain dry and open, so for an Otter to select a sprainting site that remains dry and visible for other otters grass patches are a great option. This was evident from in the study area as only 5 spraints out of 81 spraints were collected from non-grass substrate. In one occasion where no grass patches were present nearby spraint was observed on an *Avicinnia officinalis* tree as the land gets inundated during high tide so there is a threat of spraints getting washed away. This behaviour is observed in Smooth coated Otter for the first time and is known from other otter species Hairy nosed otter (*Lutra sumatrana*) from South East Asia (Kanchanska. 2001).

The ordinal regression model did not show any significance of both grass and *Suaeda* patches, This could be because of the fact that there are many grass and *Suaeda* patches far away from villages but no otter signs were found near these plots. So it can be concluded that grass and *Suaeda* patches play an important role in other activities and distributed provided they are near to land.

Open mud patches are the areas where sighting an Otter sign is easy, also the absence of thorny *Acanthus* and other pneumatophores give otter an ease in movement. These could be reasons for the positive effect of mud patches on Otter distribution.

10.9 Effect of Distance from land:

From the above resources that Otter is utilizing in the study area, it is evident that distance from land effects every resource in the study area. This is because with increasing distance from land

the species composition, salinity, water flow, habitat type and many other factors change in a mangrove ecosystem thus forming a zonation. In the present study the resources that are essential for survival of Otters are concentrated towards the villages. So naturally Otters are utilizing habitat near villages and this is not because of aquaculture farms being present near villages, but various other factors are contributing to their presence near villages. So they are coming in direct conflict with the farm owners due to other factors. Therefore distance from sea or village could be the most important factor contributing to the Otter distribution in the study area.

Plate 1 A Smooth coated otter holt below the pumping station of a Prawn culture pond near village.



12.0 Constraints of the study:

12.1 The tidal influence:

The major constraint for the study is study area itself, a mangrove habitat unlike the other terrestrial habitat is difficult to negotiate by foot. Though the present study area is a protected area it is a human dominated landscape where things do not work without hiring a motor boat and a driver for it. As the people who rent the boat and driver are fishermen, they do not come to work regularly due to various reasons and to convince them to come regularly a hefty amount of money has to be paid.

In a mangrove habitat tidal cycle has a great influence on everything. Same is the case with boat, the time during which the survey or sampling is conducted and the location are crucial as in some areas the boat cannot move during low tide. So if the boat is at such location during the low tide time the boat cannot move at least for 3 to 4 hours. Due to this the sign survey took longer duration than planned as one has to wait for the water level to rise. And in areas where tidal effect is high the entire area gets submerged and during low tide the boat cannot move. So sign survey could not be done in such locations.

Also during sign survey any type of footwear did not work and one has to walk bare foot to walk efficiently in the study area. And the path is covered with pneumatophores which can pierce the legs once they become soft after certain distance due to high moisture and water coming in from channels. So the number of surveys per day has to be limited due to this. In the patches of *Exocaelia agallocha* efficient searching of signs could not be done due to low height of the branches which are usually present from 1.5 meters and accidental spill of the latex from the branches if they break while walking can cause blindness. So these patches were avoided when the tree height was found to be less than 3 metres.

Caesalpinia crista is a creeper that is dominant along banks near villages. Sign survey was also avoided in many cases in these patches due to their thorny nature and when tried to negotiate with this creeper it gave nasty cuts on the body.

Due to these factors sign survey could not be efficiently done or avoided in some patches while survey effort remained the same 600m in all plots.

12.2 Problem with release of water from dams:

Whenever Godavari water releases from dams the water quality and flow changes resulting in surfacing of many mussels and tree branches. During that period fish sampling could not be carried due to these mussels and branches damaging nets by cutting them. So due to this a lot of time was lost and due to this the number of sampling sites was decreased. Due to this the Ivlev's Index values are not reliable in this study.

Plate:2 A Smooth coated Otter paw print on mud substrate



Plate: 3 Dried otter scat on a bent *Avicinnia officinalis* branch



Plate: 4 A family of Otters basking on a grass and *Sueda* patch in Coringa wildlife sanctuary.



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