

A quantitative analysis of incidental capture and mortalities of sea turtles during commercial shrimp trawling using Turtle Excluder Device (TED) along the coastal waters of Orissa



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CONTENTS

List of Tables, Maps and Figures	i
1. Introduction	1
1.1 Specific objectives	3
1.2 Turtle excluder device	3
1.3 History of TEDs	4
1.4 Description of shrimp fishery	5
1.5 Review of literature	6
2. Study Area	8
3. Materials and Methods	9
3.1 Experiment in Sea	9
3.1.1 Trawlers	9
3.1.2 Description of the nets used	9
3.1.3 Construction and installation of TED in the net	10
3.1.4 Trawl procedure	12
3.1.5 Functioning of TED	13
3.2 Study aboard the trawler	13
3.3 Mortality survey along the coast	15
3.4 Determining Catch Per Unit Effort	15
3.5 Distance at which captures occurred	15
3.6 Relationship between tow time and mortality	16
3.7 Size class of turtles caught in the net and stranded.	16
3.8 Sea turtle stranding and spatio-temporal pattern of shrimp fishery	16
3.9 Impact of TED on fisheries.	16
3.10 Estimated annual incidental sea turtle captures	16
4. Results and discussion	17
4.1 Distance from shore at which captures occurred	20
4.2 Depth at which captures occurred.	21
4.3 Relation between CPUE and depth.	22
4.4 Relation between tow time and mortality.	23
4.5 Size class of the stranded and trawl caught turtles.	24
4.6 Sea turtle stranding and spatio-temporal pattern of shrimp fishery	25
4.7 Impacts of TED on fisheries	27
4.8 Efficacy of TED	27
4.9 Estimated annual incidental sea turtle captures	28
5. Conclusion	29
6. Recommendations	30
7. References	31
8. Appendix	36
8.1 OMFRA	36
8.2 Number of mechanized and non-mechanized crafts in orissa.	36
8.3 Details of Tag numbers of tagged turtles during this study.	37
8.4 Fish catch	38

List of Tables, Maps and Figures:

Table 1	Conservation status of sea turtles
Table 2	Worldwide estimate of incidental capture of sea turtles
Table 3	Total fishing efforts and number of turtles captured in selected study zones w.r.t months in nets fitted with TED
Table 4	Total fishing efforts and number of turtles captured in selected study zones w.r.t months in nets fitted without TED
Table 5	Estimated annual incidental captures
Table 8.1	OMFRA
Table 8.2	Base wise operation of mechanized and non-mechanized boats in orissa
Table 8.3	Details of Tag numbers of Tagged turtles during this study
Table 8.4	Fish Catch
Map1	Study area
Map 2	Sampled areas
Map 3	Observed Turtle sightings
Map 4	Trawls carried out in Gahirmatha zone
Map 5	Trawls carried out in Paradip zone
Map 6	Trawls carried out in Debi zone
Map 7	Trawls carried out in Gahirmatha zone and paradip zone
Fig 1	Turtle Excluder Device (TED)
Fig 2	Picture depicting Net fitted with TED and an extra cod end.
Fig 3	Picture depicting a turtle escaping through TED
Fig 4	Number of turtle captures in relation to distance from shoreline
Fig 5	Number of turtle captures in relation to depth
Fig 5.1-5.4	Relation between CPUE of sea turtles and depth of sea
Fig 6	Relation between tow time and mortality
Fig 7	Number of dead turtles in relation to size class of stranded turtles
Fig 8	Number of dead turtles in relation to size class of turtles caught
Fig 9	Stranded turtles counted along the southern coast of Orissa from Dec 01- Mar 02.
Fig 10	Zone wise catch loss of shrimps and fishes w.r.t class groups

1. INTRODUCTION

Sea turtles have been in existence for millions of years and are widely distributed. Their migratory paths extend all over the oceans of the world and take them across international boundaries. Of the seven species of sea turtles found world wide, five species are reported to occur in Indian coastal waters and Orissa a maritime state on the east coast has four of them, such as Olive ridley (*Lepidochelys olivacea*), Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*) and Leatherback (*Dermochelys coriacea*). All the sea turtles occurring in Indian coastal waters are listed as endangered species and are protected under schedule I of the Indian wildlife (Protection) Act 1972. They are also under protection from International Conventions such as Convention on Migratory species (CMS) and Convention on International trade on endangered species of wild Flora and Fauna (CITES), to which India is a signatory. On a global scale, the World Conservation Union (IUCN) lists all sea turtles as endangered with the exception of the Australian flatback turtle.

Table 1. Conservation Status of sea turtles:

Species		IUCN ^A	IWPA ^B
Green turtle	<i>Chelonia mydas</i>	Endangered	Endangered
Loggerhead turtle	<i>Caretta caretta</i>	Endangered	Endangered
Flatback turtle	<i>Natator depressus</i>	Vulnerable	Not listed
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Critically Endangered	Endangered
Olive ridley turtle	<i>Lepidochelys olivacea</i>	Endangered	Endangered
Leatherback turtle	<i>Dermochelys coriacea</i>	Critically Endangered	Endangered

^AInternational Union for Conservation of Nature red list of threatened animals 1999, ^BIndian Wildlife (protection) Act 1972: Schedule 1.

Sea turtles face threat in every stage of their life cycle due to natural and human factors, both on land and at sea. Natural threats include Predation, flooding of eggs by high tide, loss of eggs due to erosion, diseases. Human induced threats include modification of nesting beaches, accidental drowning in fishing nets, direct collision with boats, disorientation due to artificial illumination near nesting beaches etc. Of all the known threat factors, by far the most important source of death of sea turtles,

identified by the world scientific authorities is the human induced factor i.e. the incidental capture of juveniles, sub adult and adult turtles during marine trawl fishing. Some of the world's largest olive ridley mass nesting sites in Orissa i.e. Gahirmatha and Devi River mouth have been in the limelight for the last two decades due to the large-scale mortality of adult turtles in marine fishing nets at these sites and thus posing a serious threat to the only mass nesting population in India (Pandav and Choudhury 1998). Uncontrolled mechanized fishing in areas of high sea turtle concentration areas has played a major role in the large-scale mortality of adult sea turtles during the last two decades in Orissa. Dash and Kar (1990) reported about the stranding of 4682 adult olive ridley turtles along the 35 KM Gahirmatha coast during 1978 to 1983. In 1993 - 94, 5400 adult olive ridleys were found stranded during a six-month survey of sea turtle nesting beaches in Orissa, carried out by Wildlife Institute of India (Pandav et al., 1994, Pandav et al., 1997). Mortality due to mechanized offshore fishing reached an alarming number of 14,000 turtles in 1998 (Pandav and Choudhury 1999). During a study of sea turtles in Orissa Pandav (2000) counted 46,200 adult olive ridleys between 1993 to 1999. These 46,200 turtles were counted only in a stretch of 282 Kms out of the entire 480 Km coastal belt of Orissa. Hence the actual number of dead turtles would relatively be much higher without any doubt.

Although commercial shrimp fishing is currently the most valuable marine fishery in Orissa, in terms of export earnings and domestic fish supply it also plays a major role in important human induced source of sea turtle mortality. Sea turtles are captured in shrimp trawls towed along the sea bottom behind the shrimping vessels. Turtles swimming, resting, or feeding on or near the bottom in the trawl path are overtaken and enter the trawl with the shrimp and fish, get drowned and die due to suffocation and asphyxia. They are also slaughtered to save the trawl nets in which they are entangled. In

spite of the wide acceptance of this fact that thousands of endangered sea turtles are regularly captured and killed in the shrimping nets and also shrimp trawling was pinpointed to be the vital cause for the large scale sea turtle mortalities in Orissa, the trawl operators in Orissa have denied to accept this fact. They have rather come up with their point of view such as diseases, migration fatigue, marine pollution etc... to be the causes for the large-scale sea turtles mortalities. While the people involved in commercial fishing industry are reluctant to accept the fact that shrimp trawling is indeed a cause for the sea turtle mortality, responsible marine fishing nations have developed Turtle Excluder Device (TEDs) and Bycatch Reduction Devices (BRD), in which non-target marine turtles escape. However, fisher folks are reluctant to accept TED and BRD complaining that valuable fish and shrimp also escape along with marine turtles. Since TED and BRD have not been used significantly to substantiate such claims it is all the more important to provide some empirical data to counteract such arguments. To provide such data, Turtle Excluder Device (TED) was visualized to be used in the industrial shrimp trawl nets to prevent the retention and mortality of the endangered sea turtles and to scientifically calculate fish/prawn loss. *This study aimed to assess the efficiency of TED in reducing the mortality rate of sea turtles, with a view to lobby for the introduction and promotion of this approach in trawl nets in India. The aim was also to provide a realistic cost benefit analysis in terms of the economic loss to the fishing agencies on using the TED.*

1.1 The following are the specific objectives addressed during the study:

- To quantify capture frequency at both space (including depth) and time.
- To determine turtle catch per unit effort (CPUE) in shrimp trawls fitted with TED and without TED
- To assess if there is any relationship between sea turtle stranding and shrimp trawling patterns.
- To determine the turtle mortalities with relation to tow time.
- To estimate the perceived economic loss caused by TED on shrimp fishery.

1.2 Turtle excluder device (TED):

TED is an inexpensive trap door placed in trawling nets that allow shrimps and fishes to pass to the cod end while it allows larger animals like sea turtles to escape without drowning. They have been shown to reduce sea turtle mortality by 97% and do not significantly affect shrimp catch. These devices cost around 2000 Indian Rupees (US \$45). These devices were created to prevent the incidental capture of the non-target species in trawl nets, in other words to enable the nets to be made more selective in what they capture. TEDs have shown many advantages for the commercial shrimp fishery, since, apart from providing a technological solution to the problem of incidental capture and drowning of sea turtles, they reduce 40% of the incidental catches of other unwanted marine life such as sharks, rays, large fishes and trash. They also increase the fuel efficiency of a shrimp trawler and they reduce the time spent by fisherman in separating the shrimp from by catch; increase the quality and, therefore the value of shrimp catches (Wanukoya and Salm, 1998).

1.3 The history of TEDs:

In 1973, studies determined that a large number of sea turtle stranding were the result of commercial shrimp trawl operations. Because sea turtles can only stay under water for a period of about two hours in a resting state, being caught in shrimp nets prevent them from coming to the surface for the air they need. By 1978, the United States Endangered species Act extended protection to species of sea turtles found in U.S waters (Leatherback, Loggerhead, Green, Kemp's ridley and Hawksbill) by establishing education and research programs and providing funding for the development of Turtle Excluder Devices (TED). The same year, the National Marine Fisheries Service, part of the U.S federal government's executive branch, began working with shrimp industry representatives to develop an effective TED for a voluntary implementation program. This TED was developed in 1981, but because shrimping operations began to show a reluctance to implement TED's, the environmental groups, including Caribbean Conservation Corporation insisted that the NMFS require the use of TEDs by law. In 1987 NMFS required the use of TEDs by law and began using TEDs on a limited basis. Environmental organizations and shrimp operators began to lobby in US congress to extend the use of TEDs to foreign operations. Shrimpers in US were concerned that they could not compete with the foreign operators, while

environmentalists were worried that sea turtles would not be adequately protected due to their migratory habits and cosmopolitan distribution. In 1989, congress complied with these concerns by adding section 609 to the Endangered Species Act that extended protection to turtles caught in the foreign nets. Shrimp from countries that did not demonstrate a level of sea turtle protection equal to that of the U.S were banned from import. Countries were given a three years grace period to comply with this legislation. In 1990, the National Academy of Sciences released a report documenting that more sea turtles are killed as a result of shrimp trawl operations than from all other human activities combined. By 1994 NMFS required that TEDs be used on all U.S shrimp vessels in all U.S waters with very few exceptions.

In December 1995 the U.S court of international trade demanded that the department of state begin to enforce the mandates of section 609 on a global level. Since then, four countries (Thailand, India, Malaysia and Pakistan) filed complaints with World Trade Organization (WTO) claiming that the U.S ban on shrimp from other countries not protecting turtles to the same degree as the U.S created an unfair trade barrier and as such, was a violation to the general agreement on tariffs and trade. In April 1998, the W.T.O ruled that U.S efforts to protect endangered sea turtles were inconsistent with global trade rules. However, arguments were gaining grounds that US laws are covered under exceptions to WTO rules for measures relating to conservation of exhaustible natural resources, but only failed in the way in which the law was administered. The code of conduct for responsible fisheries (FAO 1995), which gives guidelines for sustainable development of fisheries, prescribes the need for protecting the endangered species like sea turtles. As a signatory to CITES, India is bound to conduct research and to develop appropriate devices and to implement measures for protecting the endangered turtles getting drowned in trawl nets. In this background TED was also visoned in India to protect the turtles from drowning in the trawl nets which inturn would stop the population decline of the sea turtles.

1.4 DESCRIPTION OF THE SHRIMP FISHERY:

The shrimp fishery has the highest product value of any fishery in orissa. The fishery industry not only solely relies on shrimps but also catches fishes. Orissa accounts for an annual production of 6,858 tones of shrimp and 1, 25, 000 tones of other marine annual production. A total of 236, 03,236,461 rupees are gained per annum due to export of marine products from Orissa (Handbook on fisheries statistics Orissa, 1996-97). The most

valuable shrimp species harvested in orissa are Tiger (*P.monodon*), white (*P.indicus*), flower (*M.dobsoni*) and brown (*P.japonicus*) prawn respectively. The peak of these shrimp harvests occurs during October to May months every year. As the shrimps mature, they migrate offshore and the vessels begin to fish very near to the offshore out to a depth of 25 meters. Normally maturing brown prawns continue to migrate to deeper waters and mostly the smaller trawls do not fish in deeper waters and the sona boats (larger trawlers or deep sea trawlers) gets access to this fishery. The small shrimping vessels used are usually around 6 to 30 m long and the large sona boats are 30 – 40 m long.

1.5 Review of literature:

The problem of stranded sea turtles appearing on beaches of the south eastern United States in relation to the activities of the shrimp fleet was first documented in the early 1970's (Talbert et al., 1980; Ulrich, 1978, Murphy and Hopkins- Murphy. 1989). In 1981, Hillested et al., highlighted that Sea turtles are caught in fishing activities around the world, especially in trawl nets and also have mentioned that incidental or accidental capture in fishing nets was emerging as a global problem for sea turtle survival. Pritchard (1976), Hillested (1978) and Hillested et al., (1982) reviewed the impact of incidental capture on kemp's ridleys, loggerhead and green turtle populations. Kilima et al (1988) reported that turtle capture may result in their drowning or may weaken their physical condition, putting them at a greater risk of predation. Dayton et al., (1995) pointed out about the near extinction of long-lived, susceptible species such as sea turtles as a negative ecological impact of the shrimp fishery related to the incidental take. Magnusson et al., (1990) emphasized that drowning in the trawl nets is the major cause of sea turtle mortality due to human activities in the Gulf of Mexico and along the US Atlantic coast, and this was already observed by Henwood and Stuntz, (1987) that 5000 to 50,000 turtles are estimated to be caught annually in shrimp trawl nets. In a recent review, 83% of 78 papers on the incidental capture of all Atlantic sea turtle species in fishing operations inferred that shrimp trawling is a major source of mortality (Murphy and Hopkins – Murphy, 1981). A 1990 National academy of sciences study estimated the annual mortality of sea turtles in the US to be between 11,000 and 55,000 before the implementation of TEDs. Studies carried out by Galveston office of the NMFS showed that the use of TEDs neither decreases the quantity of shrimp neither caught nor increase the number of tears or holes in the net. Henwood and Stuntz (1987)

demonstrated a strong positive relationship between tow time and incidence of sea turtle mortality in the shrimp fishery. Gove et al., (2001) have highlighted the impact of shallow water shrimp trawlers, operating in safola bank, which catch incidentally an estimated number between 1,932 to 5,436 marine turtles every year. This figure places shrimp fishery as one of the main sources of marine turtle mortality in central Mozambique. A total of 1264 leatherback sea turtle captures and 1337 loggerhead sea turtle captures by the US pelagic longline fleet were recorded by NMFS pelagic logbooks for 1992-95. Studies on the turtle captures in the prawn fishery of northern Australia (northern prawn fishery) estimated that 5730 turtles were caught each year and that 6% (Poiner et al., 1990) and 10.1% (Poiner and Harris, 1994) of turtles died in the trawl nets. Magnusson et al. (1990) considered the mortality of turtles in shrimp trawl to range from 5,000 per year for Kemp's ridleys. From the shrimp trawl data collected in Gulf of Mexico and US Atlantic coast during 1973 and 1984, Henwood & Stuntz (1987) estimated the mortality of 9,874 per year for loggerheads, 767 per year for Kemp's ridleys and 299 per year for green turtles. Patterson (1990) inferred Pacific ridley, green and leatherback turtles are being caught in Queensland catch. James et al., (1989); Dash and Kar (1990); Pandav et al., (1994) and Pandav et al., (1997) have all come up with a similar suggestion that uncontrolled mechanized fishing in areas of high sea turtle concentration has resulted in large scale mortality of adult sea turtles during the last two decades in Orissa. Concurrently, concern over the extent and impact of incidental catch related mortality by shrimp fleet has led to the quantification of capture levels (Bullis and Drummond, 1978; Hillested, Richardson, and Williamson, 1977). Hillestad et al., 1982; Robins 1995, pointed out that it is clearly visible that the primary cause of death of sea turtles is due to incidental capture in coastal waters of Australia, South America, Central America and North America, which has been well documented.

The review of the above-mentioned literatures abundantly makes it clear that shrimp trawling indeed plays a vital role in the large-scale mortalities of the sea turtles. However no quantified information is available in the coastal waters of Orissa about the sea turtle Vs shrimp trawling crisis. This study carried out a quantitative analysis on the commercial shrimp fishery related to the incidental off-take of the sea turtles in the coastal waters of Orissa vis-a-vis use of TED and its impact on commercial trawl fisheries.

2. STUDY AREA

Orissa an important maritime state on the east coast of India has a coastline of 480 Km, and a continental shelf area of 24,000 Kms forming 8% and 4.5% respectively of the countries total. The coastline stretches from east of Subernarekha river-mouth in west Bengal to the marshes of Ichhapuram in Andra pradesh. There are six coastal districts, viz., Balasore, Bhadrak, Kendrapara, Jagatsingpur, Puri, and Ganjam. The state enjoys a good southwest monsoon contributing to 90% of the total rainfall, the average rainfall being 148 cm. The coast is however cyclone prone. Southern Orissa comprising of Ganjam and Puri districts has a narrow continental shelf of about 40 km and open sandy beaches whereas northern orissa is characterized by an extended continental shelf of about 120 km, intertidal flats and extensive river deltas. The major rivers here are Subernarekha, Budhabalanga, Brahmini, Baitarini, Mahanadi, Devi, Rushikulya, and several smaller rivers such as Hansua, Kadua, Kushabadra and bahuda that drain into the Bay of Bengal. Out of all these river mouths, high sea turtle concentration is evidenced in Brahmini – Baitarini, Devi and Rushikulya River mouths. Out of these, the coastline between Brahmini – Baitarini and Devi River mouth were chosen for the study sampling. For easy accessibility to these areas, Paradip fishing base was selected as the base station to carry out the experimental trawling and also it is in this zones that sea turtles are most frequently caught in fishing trawlers operating from Paradip. Paradip base has excellent infra structural facilities with freezing ice producing etc. The selected coastline was stratified into three zones viz. the coastal waters of Gahirmatha (Zone I), coastal waters of Paradip (Zone II) and coastal waters of Devi river mouth (Zone III). [Map.1]

Zone I:

The Gahirmatha coast (35Km) extends from the Dhamra river mouth to Barunei, the mouth of river Hansua and forms the eastern boundary of the Bhitarkanika wild life sanctuary.

Zone II:

The Paradip coast (55 Km) stretches from Barunei to the mouth of jatadhara. Near Paradip, the only natural harbor along the Orissa coast, Mahanadi River enters the Bay of Bengal.

Zone III:

The Devi coast including the Kujang coast of 30 Km (60 Km) stretches from Jatadara river mouth to Kadua river mouth.

3. MATERIALS and METHODS

Data collection for this study was carried out between November 2001 and March 2002. The study was carried out both in sea and on the coast.

3.1 Experiment in sea:

A wide range of fishing gears and practices ranging from small scale artisanal fishing to large scale industrial systems are used for fish and shrimp capture in Orissa. Over the years, traditional fishing gears have been upgraded and more efficient fishing systems have been introduced, most important among these fishing gears are the trawlers, purse seines, lines and gill nets. Since this study was on the impacts of the trawlers on sea turtles, basic information of trawlers used in Orissa are given below.

3.1.1 Trawlers:

Trawlers are mechanized fishing boats, which are used for active fishing that requires extensive manpower, which in turn gets a good yield. They are very common and popular along the coast of all maritime fishing nations of the world. Trawlers became the most popular fishing gear in India since its introduction in 1960. The name trawl is derived from the manner of operating the fishing gear. This is a large bag net tapering from the mouth forming a flattened cone, with some device for keeping the mouth of the net open, while it is towed or dragged. There are different varieties of trawlers like 1) based on depth at which it operates (demersal trawl, midwater trawl or pelagic trawl), 2) based on material used in boats (otter board trawl, beam trawl etc.) and 3) based on number of nets used (single rigged, double rigged). For this experimental study otter board bottom single net trawling was used uniformly till the end of the study, as such trawlers are common along the Orissa coast

3.1.2 Description of the net used:

Trawl nets are funnel shaped body of netting closed by a bag or cod end. The net has the following parts: 1. Mouth piece (40mm mesh size), 2. wing piece (35 mm mesh size), and 3. Belly piece (30 mm mesh size), 4. Throat piece (30 mm mesh size), and 5. Cod end (25 mm mesh size). TED was fitted in the throat piece region before the cod end. Cod end mesh size was comparatively small; so that it retains the fish without gilling.

3.1.3 Construction and installation of TED in the net:

For sampling during the present study the Central Institute of Fisheries technology (CIFT) developed TED known as CIFT – TED was used. The details of which are given in Boopendranath and Percy Dawson (2001) and summarized below.

Construction of the Frame:

An oval frame of 1000 X 800 mm is constructed of stainless steel rod of 10mm diameter. Five vertical grid bars of 8 mm diameter stainless steel rod are welded to the inside of the frame. The spacing between the deflector bars is 142 mm and the maximum spacing between the frame and the adjacent deflector bar is 86 mm.

Construction of TED extension:

The TED extension is constructed of single piece of polyethylene netting of 40 mm stretched mesh size and 1.5 mm dm twine, of size 150 X 60 meshes. The 60 mesh sides of the netting piece are sewn together to construct a cylinder.

Construction of hoop:

A single hoop having a diameter of 900 mm was constructed of 8 mm stainless steel rod, for attachment of the leading edge of the TED extension.

Fixing the Grid at the correct angle:

Lace the hoop to the TED extension leaving 5 meshes from the leading edge. Slide in the TED frame to the other end of extension. Using the hoops stretch the extension tube, so that it is taut. Position the TED extension so that the extension seam is at the bottom. 36 meshes are counted forwards from the rear edge of the extension and attach the bottom center of the TED frame to the netting. 18 meshes are counted from the rear edge of the extension along the seam and then 75 meshes were counted perpendicular to the seam and

arrived at the top center attachment point and the TED frame is attached to the extension netting. The sides are secured TED frame were then sewn to the extension netting. Grid angle should be between 40 and 55° from the horizontal, for proper operation.

Cutting the exit hole:

Cutting was begun in front of the top center of the TED frame and continued to cut along the frame maintaining ½ mesh distance from the frame, to either side until 1st and 5th grid bars are reached. The distance between 1st and 5th grid bars is 620 mm and then turned and cut forward 19 meshes on either side; and again turned and cut to obtain a rectangular opening of 40 X 19 meshes in the extension.

Construction and attachment of exit hole cover:

The exit hole cover was made of a single piece of depth stretched and heat set polyethylene netting of 96X 50 meshes with 25 mm stretched mesh size. The center mesh of 96 mesh edge is attached to the center mesh of forward edge of the exit hole opening and continued to attach 45 meshes of the flap to 20 meshes of the opening on either side of the attachment point. Remaining meshes of the flap are sewed to the extension meshes to provide strength and shape to the flap. Along the sides 30 meshes of the flap are attached to the 19 meshes of the extension ahead of the TED frame. 6 meshes of the flap are attached to 4 meshes of the extension ahead of the TED frame. The remaining 14 meshes of the flap are attached with a second cod end bag (TED cod end).

Construction and installation of accelerator funnel:

Two trapezoidal pieces of depth stretched and heat set polyethylene netting (25mm stretched mesh size and 1.0 mm diameter twin size) with 75 meshes each in the leading edge Were cut; 30 and 42 meshes each in depth with a cutting rate of 1N1B resulting in 55 and 47 meshes, respectively, in the rear edge. Two pieces are sewn together along the tapered edges, beginning from the leading edges, to form a funnel. The funnel was installed inside the extension, forward of the TED frame with the longer half of the funnel positioned opposite to the exit hole. The funnel was sewn to the TED extension, immediately after the hoop, which is attached to the evading edge. 150 meshes of the funnel are attached mesh to mesh to the 150 meshes of the extension. The longer

half of the funnel was secured at appropriate intervals, to the grid bars, a few centimeters from the bottom.

Attachment of floats:

Two 150 mm hard plastic floats are attached to the outside of TED on the upper side, to the frame at the junction of the outer grid bars, and another float is attached to the top of the hoop for weight compensation and stability, during operation.

Installation of TED in Trawl net:

The completed TED is installed between cod end and hind belly/ extension of the trawl, with the exit hole facing upwards, by joining the edge meshes.

Installation of Extra cod end:

To determine the amount of catch loss through the escape hole an extra cod end was attached at this escape hole and after end of every haul catch at both main cod end and extra cod end were weighed to calculate percentage catch loss.

3.1.4 Trawl procedure:

The trawl net was rigged and kept ready in the fishing deck during shooting operation, cod end is closed properly and released first followed by the main body with the TED then it is inspected to ensure that the netting ahead of TED is not twisted. When the net is in water, with the sweeps connected to the otter boards the vessel slowly steams ahead so the net, sweeps and bridles spread out and open properly. The vessel's speed was increased before deploying the otter boards, so that the TED extension will ride high in water and twists, if any, could be easily detected. The gear is then lowered to the desired fishing depth by releasing sufficient length of the wrap. The length of the wrap released in bottom trawling depends on the depth of the fishing ground and nature of the fishing ground. The ratio of the depth of fishing ground and the wrap released is known as scope ratio and is typically around 1:6 in shallow waters less than 20 m with smooth ground. Trawling speed (speed against water) was maintained between 2 to 4.5 knots, since if the trawling speed were above the cruising speed of fish it would eventually tire and drop back to be caught in the cod end. Trawling was performed from up to down according to the tidal current. Trawl time usually was 1 – 2 hrs in research vessel and a minimum of 3 and a maximum of 4 hrs in observer

vessels. Propulsion was stopped for net hauling and the wrap as well as the net was rolled up by means of hydraulic powered net- roller, while the boat was being pulled back. The net roller was a quadraplex type, and the wrap was rolled up into the two side reels. After the otter boards are hauled up, the speed and direction of the vessel was maintained for a few minutes so that all catches were allowed to wash past the TED into the main cod end. Then the wrap and net were rolled up in to the two central reels. The hydraulic roller was stopped, and the bag net was pulled up to the stern after which it was hauled up and placed on the stern deck by hand. In case if the fish catch was high, a rope was attached to the bag net and the rope was rolled on the winch and rolled up which resulted in hauling of the net. The catch was then dumped on the deck. Large debris caught inside the net were immediately be thrown out while hauling the gear. After every haul, the debris and trash that was accumulated near the TED were removed. The grid angle was checked at regular intervals to ensure that it was between 40 and 55 °, from the horizontal axis.

3.1.5 Functioning of TED:

TED is fitted at the throat piece just before the cod end. Any turtles entering the net will pass through the net till the throat piece, and will hit the girded bars and will rest for a few seconds on the grid. Later on it will escape through the escape hole made at the top.

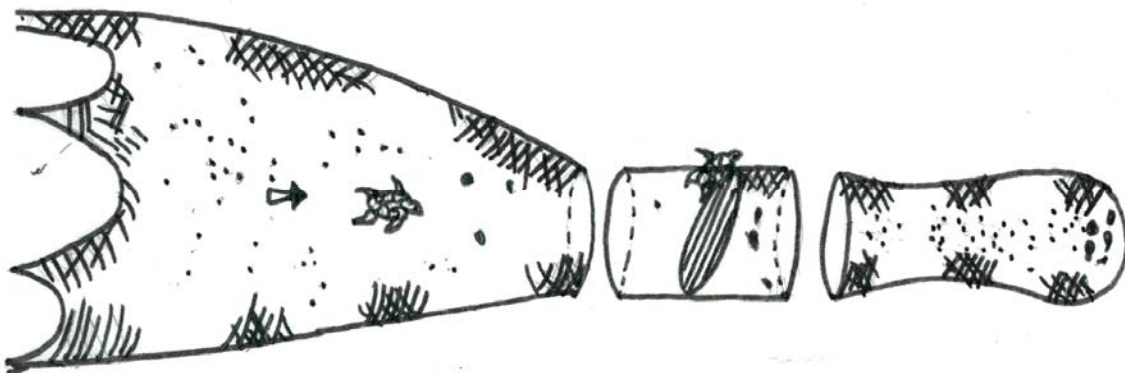


Fig.3 Picture depicting a turtle escaping though TED.

3.2 Study aboard the trawler:

The trawler vessel (M.V.Telaban) obtained from the Orissa State Fisheries Department had two types of gears viz. low opening net (80m) and high opening net (90m) of which, only one could be deployed at a time. Observations were also made on board another trawl vessel (M.V.Crown) of Orissa State fishery department, which also had similar low opening net (110m) and high opening net (130m). The observations were made being on board the observer vessel to get a general idea and data about their fish and turtle catch as they fish without TED and for a longer duration. The fish catches were sorted out on the basis of their economic value into A class, B class and C class fish. A class fishes include Shrimps and fishes that costs above 50 Rs/- per Kg and B class fishes include that costs between 25- 50 Rs/-per Kg and C class fishes include that costs below 25 Rs/- per Kg.

While carrying out experimental trawling, utmost care with respect to tow time was taken to avoid death of sea turtles due to drowning in trawl nets. Death rate of sea turtles in trawl nets are near zero until tow time exceeded 60 minutes; then they rapidly rise with increasing tow time to around 50 % for tow times in excess of 200 minutes (Henwood and stunz1987; Magnusson et al., 1990). Therefore, most of the trawls were carried out for 60 minutes duration and some trawls exceeding 60 minutes but never trawls were allowed to exceed 90 minutes. The geographic locations of all the sampling areas i.e., (start location of the trawl and end location of the trawl), were taken with the help of Garmin 12 GPS. Parameters such as start time and end time of the trawl, start depth of the trawl, end depth of the trawl, state of the sea, weather condition, turtle captures; turtle sighting areas were also recorded during the experimental trawling.

The turtles caught in the net were kept aboard the vessel and examined for their physical conditions i.e. whether the turtle is alive, comatose or dead. All the turtles caught were first identified for species and sex, checked for any tag markings (15000 number of turtles have earlier been tagged by the Orissa forest department during the years 1978- 1985 and 13500 number of turtles have been tagged by the WII study during the years 1996-1999

along the Orissa coast) and if not tagged, they were tagged (only alive) and their Curved Carapace Length (CCL), Curved Carapace Width (CCW), Straight Carapace length (SCL) and Straight Carapace Width (SCW) were measured, after which they were released back in to the sea carefully. The comatose turtles caught were carefully watched for their activity and they were recovered by placing them in a slant position with their hind part lifted up. These turtles were then released back in to the sea only after confirming that the turtle is breathing regularly and moving strongly. If dead turtles were captured they were also released back in to the sea after their morphometric measurements. The fish catch at both main cod end and TED cod end (second cod end) were separated as A class, B class, C class with respect to economic values and all of them were weighed. This was done to determine the percentage catch loss if any. All the fish catch were then returned back to the sea.

3.3 Mortality survey along the coast:

The coastline between Paradip and Sonapur the southern tip of orissa coast bordering Andhra pradesh were surveyed twice in a month either on foot or on a motorcycle. Dead turtles encountered on the beach during the survey were marked with white paint to avoid recounting in the subsequent surveys. While counting the turtles, species, sex, Curved Carapace Length (CCL), Curved Carapace Width (CCW), Straight Carapace length (SCL), Straight Carapace Width (CCW).

3.4 Determining Catch per Unit Effort:

For each trawls sampled, effort (E) was standardized to reflect hours towed with a 50 m net using the formula:

$$E = (\text{nets} \times \text{length} / 50 \text{ m}) \times (\text{minutes fished} / 60)$$

Where nets = Number of nets towed in a trawler.

Where length = head rope length of the net (meters)

Where minutes = minutes fished.

Catch per Unit Effort (CPUE) was calculated accordingly by methods described in Snedcor and Cochran (1962) using the following formulae:

$$R = \Sigma T / \Sigma E$$

Where R = CPUE

T = number of turtles captured

E= effort (Standardized to 50 m net hours)

95% c.i. on R= $R \pm 1.96 (1/\bar{x}) \sqrt{\sum(Y-RX)^2/(n(n-1))}$

CPUE data obtained from experimental trawling was plotted against depth to determine at what depths maximum capture occurred and also compared between trawls with and without TED to find the effectiveness of TED in a shrimp trawl.

3.5 Distance at which captures occurred:

The GPS locations of the trawls were plotted in the coastal map of Orissa with the help of ARC view software and the distance from shore where turtle captures were calculated and later the distance at which majority captures occurred was plotted against number of turtles.

3.6 Relationship between tow time and mortality:

Turtles captured during shrimp trawling were classified as alive, comatose and dead turtles (Magnusson et al., 1990). Both comatose and dead turtles obtained during fishing activities were taken into account for calculating mortality rate. Since the comatose turtles are already in a stressed condition, they will not be able to swim actively in sea and eventually will drown. So the comatose turtles were also taken into account to calculate effect on mortality. Tow duration of the trawls that resulted in turtle captures was plotted against the physical condition of turtles to check the relationship between tow time and mortality.

3.7 Size class of the turtles caught in the net and stranded:

The straight carapace length measurements (both caught in the net and stranded turtles in the coast) were taken for all the turtles and analyzed using statistical software (SPSS-PC).

3.8 Sea turtle stranding and spatio – temporal pattern of shrimp fishery:

The Coastline between Gahirmatha and Rushikulya was surveyed twice in a month for recording stranded sea turtles. This was correlated with the number of shrimp trawling vessels operating in the respective areas, to find out the spatio- temporal relationship of shrimp trawls with stranding of sea turtles.

3.9 Impact of TED on fisheries:

The impact due to use of TED to the fisheries industry in terms of fish catch loss was calculated. Total fish gain in each zone and total catch loss in each zone were taken as a measure to determine the percentage loss of fish catch both in terms of amount of catch (in Kg) and economic perspective.

3.10 Estimated annual incidental sea turtle captures:

A minimum estimate of 100 boats was taken into account in Gahirmatha and Paradip; a total number of 300 boats were taken into account in Paradip zones to calculate the annual incidental capture of sea turtles using the formula given below:

$$\text{Estimated captures} = (\text{CPUE} \times \text{trawling effort}) \pm 95\% \text{ c.i. on CPUE} \times \text{trawling effort}.$$

Trawling effort of fishing vessels was calculated as follows.

Minimum time per day per boat spent in fishing in the sea (a) = 15 hours.

Minimum number of fishing days in an average year (b) = 100 days.

Therefore, minimum trawling per year per boat (c) = a X b
= 1,500 hours.

Trawling effort (E) / boat was calculated

With the earlier given formula = 50

Minimum number of boats operating:	Zone I = 100
	Zone II = 300
	Zone III = 100
	Total = 500.

Total trawling effort in the study area:	Zone I = 5,000
	Zone II = 15,000
	Zone III = 5,000
	Total = 25,000

4.RESULTS AND DISCUSSIONS

Turtle captures and mortalities by study zones with associated trawling efforts were analyzed. In total 52 trawling efforts with TED were carried out in the research vessel (M.V.Telaban) and data from 24 trawling efforts were taken from the observer vessel (M.V.Crown) that were carried out without TED between January to March 2002. (Map.2)

Table3: Total Fishing Effort and Number of turtles captured in selected study zones w.r.t months in nets fitted with TED

Zones	January			February			March		
	Trawls	Hours	Turtles	Trawls	Hours	Turtles	Trawls	Hours	Turtles
I	0	0	0	12	15.30	9	0	0	0
II	4	6.05	0	8	12.05	2	17	20.10	1
III	0	0	0	11	10.15	9	0	0	0
Total	4	6.05	0	31	37.50	20	17	20.10	1

Table4: Total Fishing Effort and Number of turtles captured in selected study Zones w.r.t months in nets without TED

Zones	January			February			March		
	Trawls	Hours	Turtles	Trawls	Hours	Turtles	Trawls	Hours	Turtles
I	0	0	0	3	12.35	1	7	32	0
II	0	0	0	15	67.20	4	0	0	0
III	0	0	0	0	0	0	0	0	0
Total	0	0	0	18	79.55	5	7	32	0

In Zone I, 12 experimental trawls were carried out (Map.4). Depth in which trawls were carried out varied from 6 to 10 fathoms with mean value of 7.72 ± 0.2085 . Average duration of the trawls was 1.24 ± 0.1090 hrs. Average trawl distance in Zone I varied from 3.39 km to 14.36 km with an average of 6.68 ± 0.9339 and distance of trawl path from nearest shore line varied from 0.77 to 23.48 km with a mean of 5.85 ± 1.9851 km.

In Zone II, 29 experimental trawls were carried out (Map.5). Depth in which trawls were carried out varied from 5 to 20 fathoms with mean value of 10.13 ± 0.47 . Average duration of the trawl was 1.21 ± 0.065 hrs. The trawl distance covered during trawling in Zone II varied from 1.7 to 8.8 Km with an average of 4.4 ± 0.29 km and the distance of trawl path from nearest shoreline varied from 0.43 to 14.07 Km with a mean of 4.9 ± 1.08 km.

In Zone III, 11 experimental trawls were carried out (Map.6). Depth in which trawls were carried out varied from 6 to 13 fathoms with mean value 9.5455 ± 0.46 fathoms. Average duration of the trawl was 1.24 ± 0.0916 hrs. The distance covered during trawling in Zone III varied from 1.02 to 7.75 Km with mean value 4.5 ± 0.53 and the distance of trawl path from nearest shoreline varied from 1.4 to 5.8 Km with a mean of 3.19 ± 0.533 .

Data from 24 trawls were taken from the observer vessel (Map.7). Depth in which trawls were carried out varied from 9 to 35 fathoms with mean value of 17.41 ± 0.82 . Duration of the trawls varied from 1.45 to 6.45 hr with mean value of 4.29 ± 0.22 . Distance covered during trawling in the observer vessel varied from 0.8 to 24.02 Km with mean value of 13.42 ± 1.17 and the distance of trawl path from nearest shoreline varied from 3.42 to 46.47 Km with a mean of 26.40 ± 2.28 .

In total 26 turtles were caught in the research vessel as well as observer vessels and all the turtles caught during the study were olive ridley, of which 13 were male and 13 were female respectively. *The morphometric measurements* of the turtles captured in trawl nets in the study vessel and in the observer vessels are as follows: curved carapace length (CCL): 69.1 ± 2.62 (male) and 68.69 ± 2.61 (female) Curved carapace width (CCW): 66.87 ± 2.57 (male) and 67.32 ± 1.71 (female) Straight carapace length (SCL): 64.5 ± 2.51 (male) and 64.75 ± 1.98 (female)

Straight carapace width (SCW): 57.33 ± 3.34 (male) and 55.83 ± 2.50 (female).

4.1 Distance from shore at which turtle captures occurred:

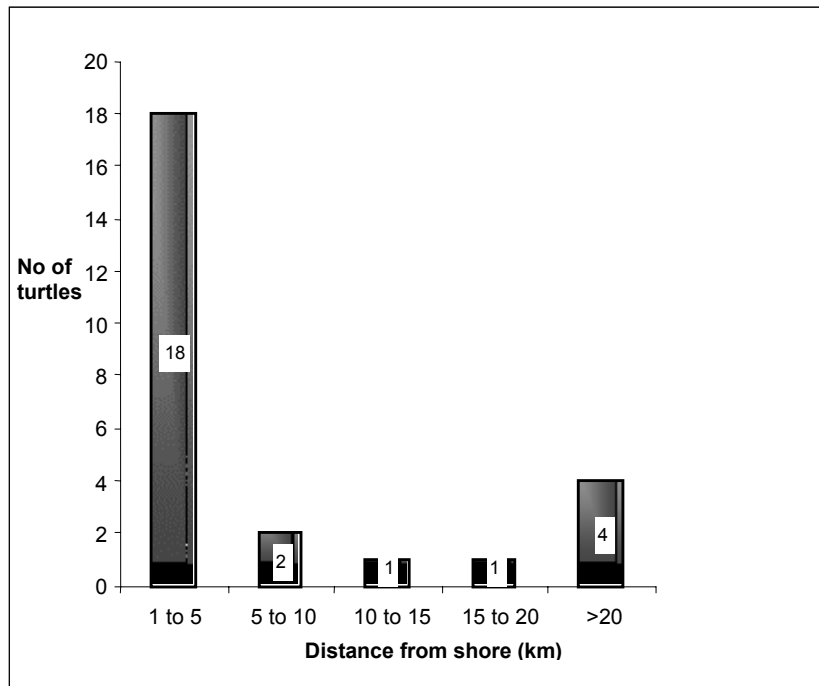


Fig.4 Number of turtle captures in relation to distance from shoreline.

The GPS locations were taken during every trawl operations and all the locations were plotted in the coastal map of Orissa with the help of ARC view software. Then the distance between every trawl and the nearest shoreline were taken. The buffer line of 5 Kilometers from the coastline is given the study area figures (Fig 1 to 5). 70% of the turtle captures occurred in less than 5 kilometers from the shore and remaining 30 % of the catches were recorded at varied distances from the shoreline. As observed during the study, day trawlers operating from fishing bases in Orissa trawl mostly within 5 km of the shore line. Although, Orissa Marine Fishing Regulation Act prohibits mechanized trawling within 5 km from shoreline, the trawl operators in Orissa needlessly operate in the prohibited zones. This could possibly be resulting in a large-scale captures of sea turtles in the near shore area.

4.2 Depth at which Sea turtle captures occurred

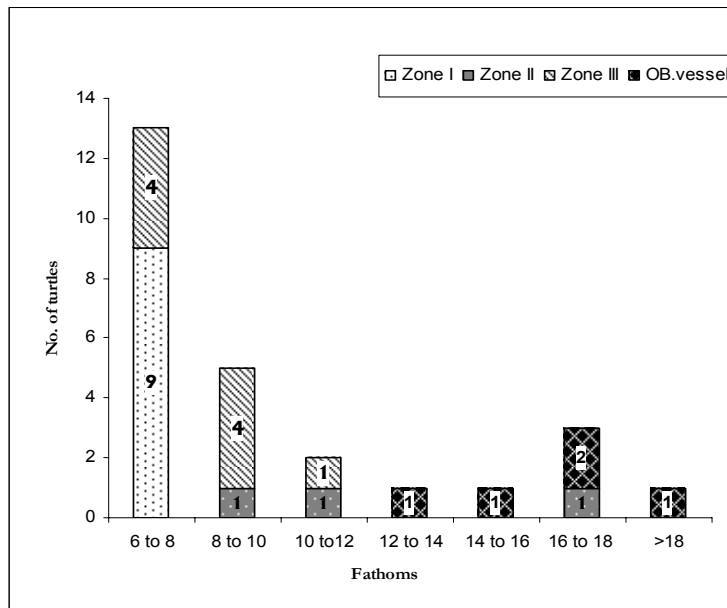


Fig.5 Number of turtle captures in relation to depth.

During start or finish of each and every trawl the depth at which trawl was carried out was recorded using a traditional method i.e. using an iron ball of 500 gm tied with a nerve fiber rope. During measuring the depth of the sea, the boat was slowed down to a stop position and the rope with the iron ball, which is marked for every fathom, was thrown in front of the boat's moving direction. Once the thread comes straight and hits the seabed the rope was lifted and the depth was measured. Depth was also measured once in the middle of the trawling activity. Of the 26 turtles captured 18 were captured below 10 fathoms, All the captures in zone I were between 6 to 8 fathoms, in zone II captures occurred between 8 to 18 fathoms, and in zone III also majority of captures were recorded below 10 fathom depth which was well supported when CPUE was calculated and analyzed.

Catch per unit effort (CPUE) was calculated for every trawl in each study zones. The CPUE was higher in all the three zones of study and CPUE was comparatively much higher below 10 fathom depth. The data which was collected from observer vessel

shows that the CPUE obtained from the captures were very less i.e. 0.1 and below. Although captures occurred during the observer vessel trips the intensity of captures were quite low and this may well be attributed to the depth at which the trawling took place i.e. beyond 14 fathoms to 35 fathoms, where normally turtles do not dwell enmass.

4.2.1 Relationship between CPUE of sea turtles and depth of sea:

Fig 5.1 Relation between cpue and depth in zone 1.

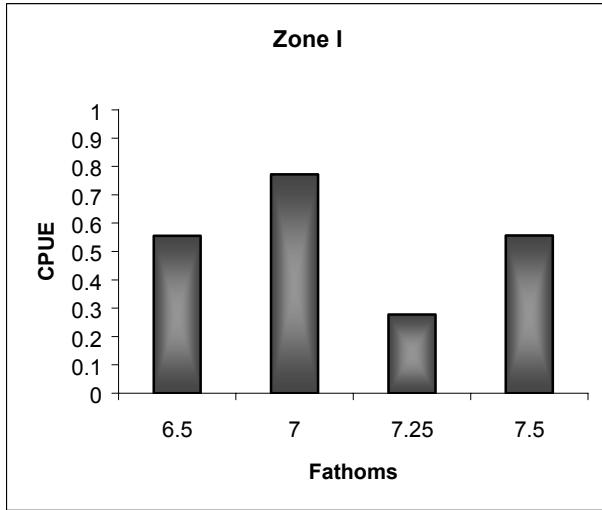


Fig 5.2 Relation between cpue and depth in zone II

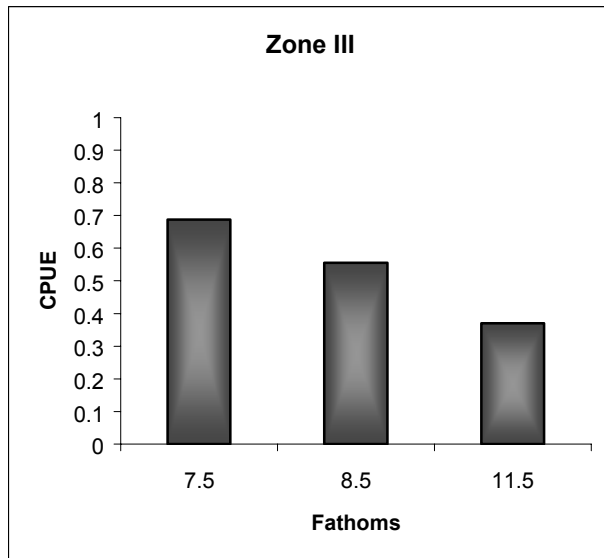
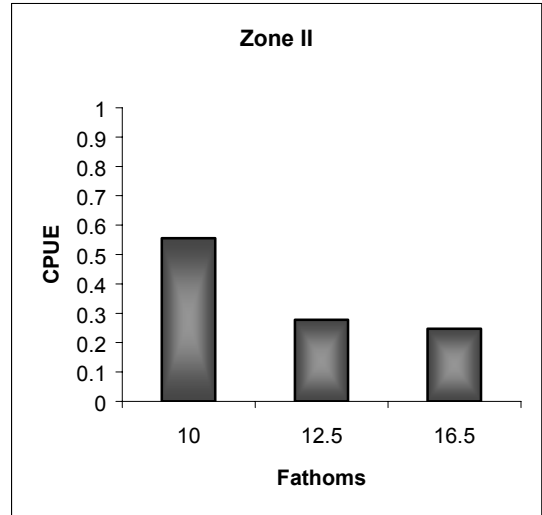


Fig 5.3 Relation between cpue and depth in zone III

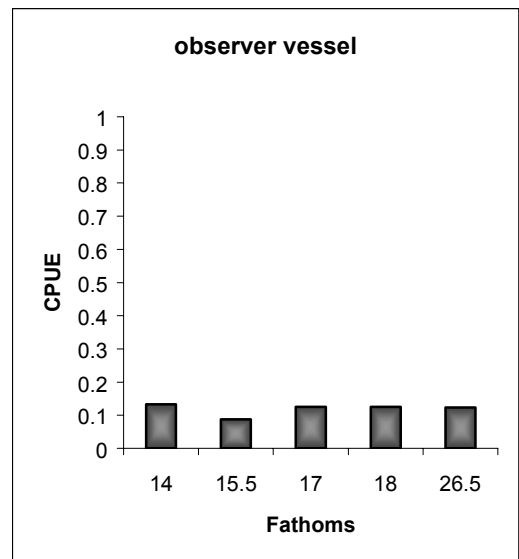


Fig 5.4 Relation between cpue and depth in O.V

4.4 Relationship between tow time and mortality:

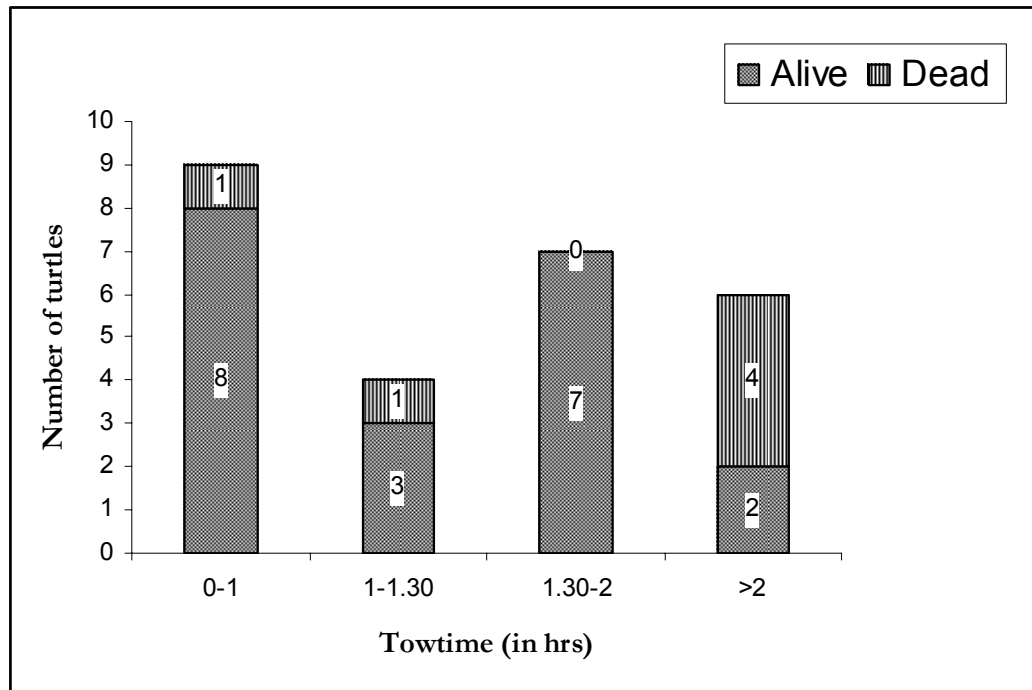


Fig.6 Relation between towtime and mortality:

Turtles captured during trawling were classified as alive, comatose and dead turtles (Magnusson et al., 1990). Both comatose and dead turtles obtained during trawling activities were taken into account for calculating mortality rate. Although taking comatose turtles as dead turtles may provide a biased estimate in terms overestimation, but it is a clearly known fact that

comatose turtles once thrown back to the sea may be able to swim for a while and eventually get drowned. Most of the trawls were restricted to 60 minutes duration and only some trawls exceeding 60 minutes duration were attempted, but never trawls were allowed to exceed 200 minutes in the research vessel. However in the observer vessel the minimum trawl duration was 180 minutes and maximum of 6 hours 45 minutes. Mortality was negligible in very short tows i.e. less than 60 minutes of tow duration and never reached 100% because turtles captured at any time during the one hour trawl would survive even if they were captured in initial stages also. Majority of the turtles that were caught within

one hour duration were alive i.e., the mortality rate was 11.1% for 1hr and less than one hour duration. This suggests that the most dead turtle caught in the net would have been caught by other trawl before being again captured in the research vessel's net and thrown back to the sea and might have been in a camotozed or stressed condition. Trawls with more than 2 hours duration of trawling had a high mortality rate of 66.6% which supports the study of Henwood and Stunz1987; Magnusson et al., 1990who depicted that death rate of sea turtles in trawl nets are near zero until the tow time exceeds 60 minutes; then they rapidly rise with increasing tow time to around 50 % for tow times in excess of 200 minutes Also during the study a turtle was caught alive during a 5 day cruise in the observer vessel during a 6 hour 15 minutes trawl, which doesn't mean that the turtles can stay under water for that longer duration since it all depends upon when the turtle exactly enters the net, either at the initial or at the later part of the fishing stage.

4.5 (a) Size class of the stranded turtles:

The coast between Gahirmatha and Sonapur was surveyed twice in a month to determine the numbers of dead turtles that are stranded during this season. During the survey, stranded turtles were measured to determine the actual size classes, which are deeply impacted. It was observed that all the dead turtles encountered were adult turtles comprised of both the sexes. A total of 1012 dead turtles were measured and it was found that the size class of males ranged from 50 cm to 65 cm where as for the females it ranged from 50 cm to 75 cm confirming breeding females to be larger in size than males in case of the Olive Rيدleys. Average size of males being 64.4 ± 2.42 and of females being 66.6 ± 1.98

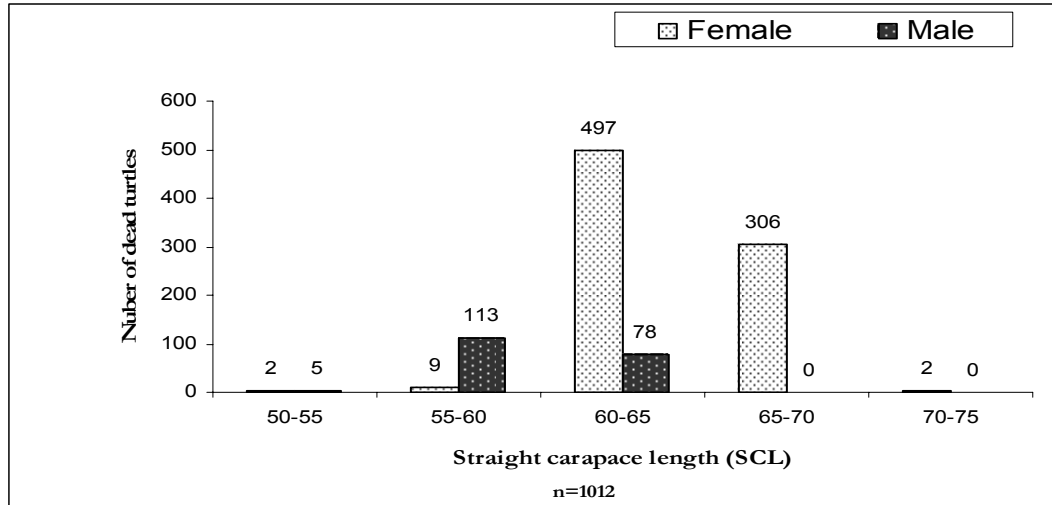


Fig.7 Number of dead turtles in relation to size class of stranded turtles.

4.5 (b) Size class of turtles caught in the net:

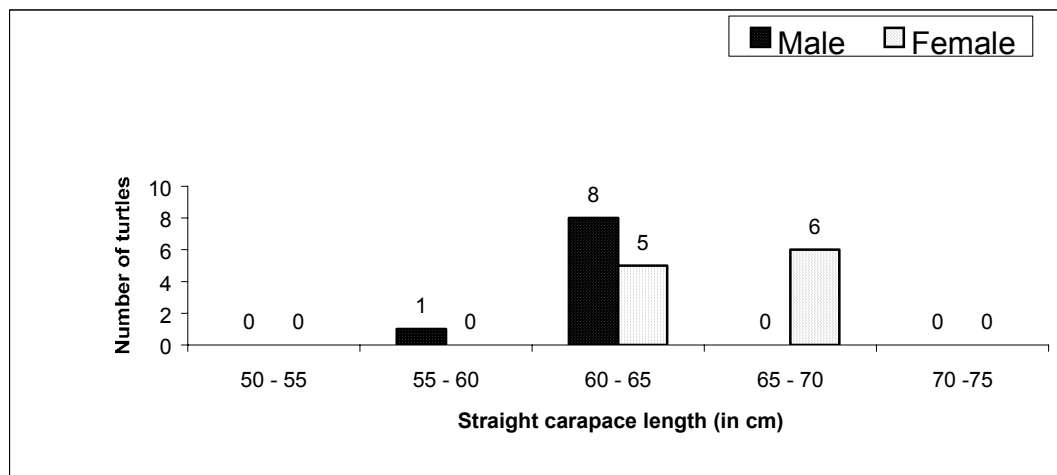


Fig.8 Number of dead turtles in relation to size class of turtles caught.

4.6 Sea turtle stranding and spatio – temporal pattern of shrimp fishery:

Sea turtle strandings are mostly the result of a complex interaction between sea turtles and trawl or other fishing gear related mortalities. Strandings occurs when carcass decomposition begins, and internal gases make the carcasses to float and the prevailing winds or near shore currents bring some of them shore. An unknown number of turtles never reach the shore because they are either eaten by scavengers or break apart and sink. Strandings have been used as an index of sea turtle mortality from shrimping activities (Murphy & Hopkins – Murphy, 1989; Magnusson et al., 1990; caillonet et al., 1991) but are subject to error due to many factors like wind/currents etc. which are perhaps most important. Murphy and

Hopkins-Murphy (1989) in their experiment reported only 6 of 22 tagged loggerhead carcasses releases at sea turn up as strandings. Thus the number of sea turtle mortality estimated due to strandings is only a small fraction of actual death. A total number of 11,593 (2,714 – Male, 7147 – Female, 1,732 – Unknown) stranded dead turtles were counted along the southern coast between Paradip to Sonapur. It was observed during this study that mortality rate was higher during the months of December and January since it is the peak of fishing season. Most of the females encountered during February and March were egg bearing gravid females. Paradip and Konark coast accounted for high mortality, which can be attributed to two major reasons i.e. 1. high abundance of turtles in theses coasts and 2. high intensity of trawling operations. Although sea turtles are abundant in Rushikulya coast due to presence of the arribada site, strandings were much less compared to other coast due to less intensity of fishing in that area.

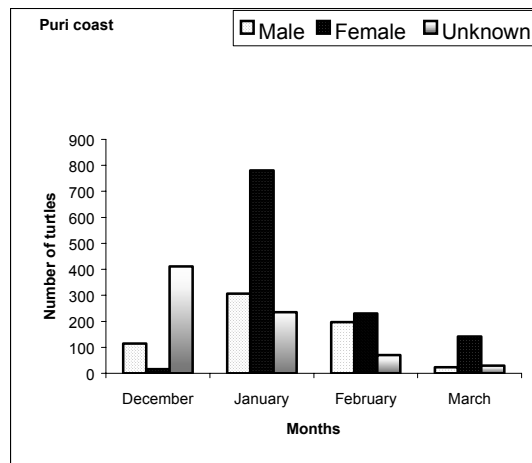
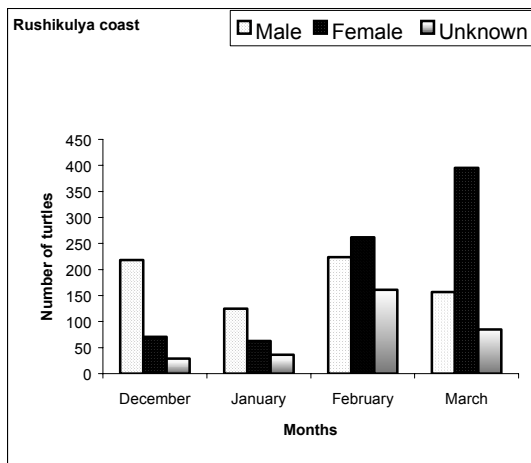
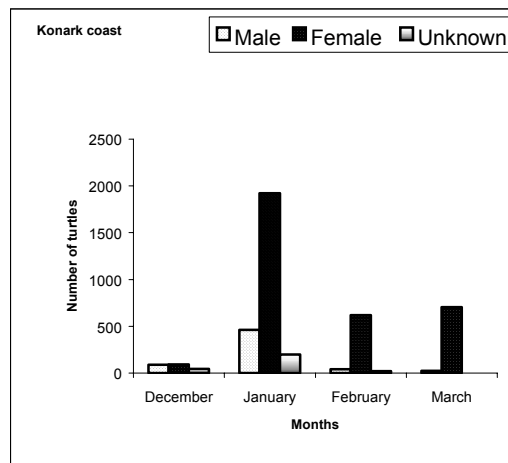
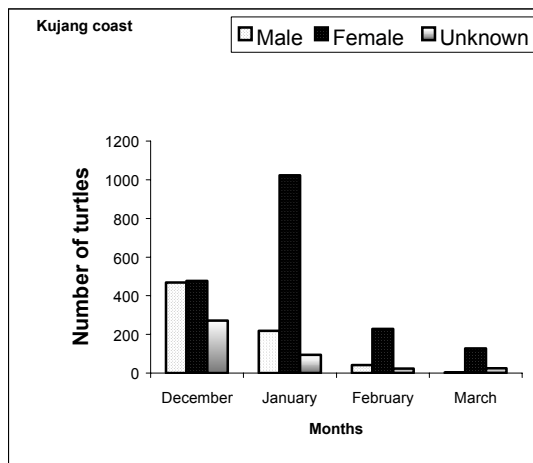


Fig 9: Stranded turtles counted along the southern coast of orissa from Dec'01- Mar'02

4.7 Impacts of TED on the fisheries:

The marine fishing agencies in Orissa and other coast of India even now have refused to accept the TED because of the fear that they may loose the fish catch, since TED has an escape opening for the turtles and they feel most fish/ shrimp may also escape through that. It is therefore very essential to prove that TED does not allow maximum catch loss. During the study, catch at the main cod end was compared with catch loss in the second cod end that was attached to the TED opening to determine the amount of loss to the fishing industry. It was found that the catch loss was very minimal as shown in the figure below.

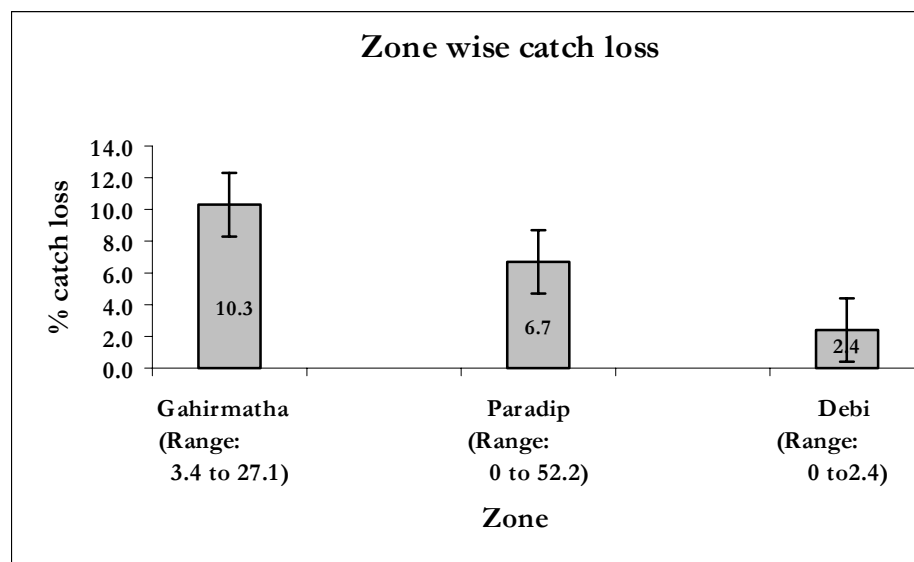


Fig10. Zone wise catch loss of shrimps and fishes w.r.t class groups.

4.8 Efficacy of TED:

The CIFT- TED excluded 100% of turtles. Out of the 26 turtles only one turtle was found stuck to the TED while hauling, which may be due to late entry of the turtle in to the net and may not have found time to escape during hauling since, the motion in which nets are hauled are at a higher pace than while it was in motion during fishing. Otherwise it was found that no debris clogged the bars and the fish, shrimps passed without much loss. Clogging and fouling of TED are likely to occur only in areas with higher concentration of plants and other debris near or in the bottom of the sea floor such as sea grasses, sargassum, plastic bags, tunicates, macro algae, lost fishing gear and jelly fish etc... which were assumed to be low in the study zones since during the study no such incidence of clogging of TED took place.

4.9 Estimated annual incidental captures:

Table.5 Estimated annual incidental captures

Zone	CPUE \pm 95%C.I on CPUE	Trawling efforts	Estimated captures
Gahirmatha	0.2508 \pm 0.0119	150000	37620 \pm 1785
Paradip	0.0724 \pm 0.001	450000	2359 \pm 450
Debi	0.4878 \pm 0.0001	30000	1,46340 \pm 30

Estimated Captures = (CPUE X trawling effort) \pm 95% c.i on CPUE X trawling effort

The estimated annual incidental capture is found to be highest in Devi and Gahirmatha zone. During the study high sea turtle congregations were observed in Devi and Gahirmatha Zones, where as no such congregations were observed in Paradip Zone. This reflected in the estimated annual incidental sea turtle captures.

5.CONCLUSION

- *Majority of the turtle captures occurred in less than 5 Km range.*

70% of the turtle captures occurred in less than 5 kilometers from the shore and remaining 30 % of the catches were recorded at varied distances from the shoreline
- *Majority of the captures occurred below 10 fathoms depth.*

Turtle captures were high in shallow waters than in deeper waters, most of the turtle captures were recorded below 10 fathoms.
- *As Towtime increases mortality also increases.*

There was a steep increase in the mortality rate when the duration of the trawl was extended beyond 2 hours.
- *TEDs Efficacy*

TED was 100% efficient in excluding the turtles that were caught in the net.
- *Minimal catch loss.*

The Perceived economic loss to the fishing industry was very minimal in all the three stratified study zones.
- *There exists a strong relation between the Sea turtle strandings and the spatio temporal pattern of sbrimp fishery.*

Strandings were higher in the zones where there is heavy interface between marine fishing and Sea turtle abundance and vice-versa while the interface was low.

6. RECOMMENDATIONS

Based on the study conducted by the wildlife Institute of India in collaboration with the Orissa Fisheries Department on use of TED and reduction in sea turtle mortality, the following recommendations are suggested.

1. Initiation of a National TED demonstration and extension programme by the state fisheries departments of maritime states and by the wildlife Departments of maritime states and by the wildlife Departments in coastal protected areas, where sea turtle mass nesting takes place.
2. Setting up a centralized database on results of TED used trawl nets. This could be done through a proper extension programme and supply of simple profomas to trawl operators for return to fisheries departments.
3. Subsidized or no cost supply of TED to trawl operators along with simple instruction manual on how to use and operate TED fitted trawl nets.
4. Creating a network of independent agencies to monitor use of TED and its impact on reduction of Sea turtle mortality and fish catch loss.
5. Constitution of inter ministerial group consisting of MOEF, MOC, MOA, MSW to develop a proper action plan for responsible Marine fishing that will not jeopardize fisheries and ecological concerns.
6. Initiate studies to determine other causes of sea turtle mortality and their intensity.

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8. APPENDIX

Table 8.1 Orissa Marine Fishing Regulations and Act, 1982 and rules, 1983

Act/Rule	Area extremely reserved for traditional crafts	Area extremely reserved for mechanized crafts
OMFRA	5 Km off-shore	1. Upto 15 mts length crafts to operate beyond 5 Km from shore 2. Above 15 mts length crafts to operate beyond 10 Km from shore

Table 8.2 Base wise operation of Mechanized and non-mechanized boats in Orissa

Base	Wooden trawlers	Gill netters	Motorized country crafts
Balosore	293	322	592
Bhadrak	59	220	335
Balasore	1207	1500	475
Jagtsingpur	267		282

Kendrapara	28	48	
Puri	39	18	854
Ganjam	686	1702	938

Table 8.3 Details of Tag Numbers of Tagged turtles during this study.

S.no	Date	Sex	Tag Number		Size class	
			LF	RF	SCL	SCW
1	03.02.2002	F	WG12590	WG12591	66.2	58.6
2	03.02.2002	F	WG12592	WG12593	62.2	56.5
3	03.02.2002	F	WG12594	WG12595	66.2	56.5
4	03.02.2002	M	WG12596	WG12597	63.8	54.8
5	05.02.2002	F	WG12598	WG12599	66.4	55.4
6	05.02.2002	F	WG12600	WG12976	66.7	59.6
7	06.02.2002	F	WG12977	WG12978	68.7	59.6
8	07.02.2002	F	WG12979	WG12980	62.4	54.3
9	07.02.2002	F	WG12981	WG12982	63.5	57.1
10	07.02.2002	F	WG12983	WG12984	63.0	55.5
11	07.02.2002	F	WG12985	WG12986	65.6	55.4
12	12.02.2002	M	WG12987	WG12988	65.3	55.6
13	12.02.2002	M	WG12989	WG12990	64.7	62.3
14	20.02.2002	M	WG12991	WG12992	64.6	57.1
15	24.02.2002	F	WG12993	WG12994	63.8	53.2
16	24.02.2002	M	WG12995	WG12996	60.5	54.1
17	24.02.2002	M	WG12997	WG12998	62.9	65.0
18	24.02.2002	M	WG12999	WG13000	65.3	55.4
19	7.03.2002	M	WG20040	WG20041	61.6	54.1
20	28.02.2002	M	WG20038	WG20039	59.4	55.3

8.4 Fish catch :

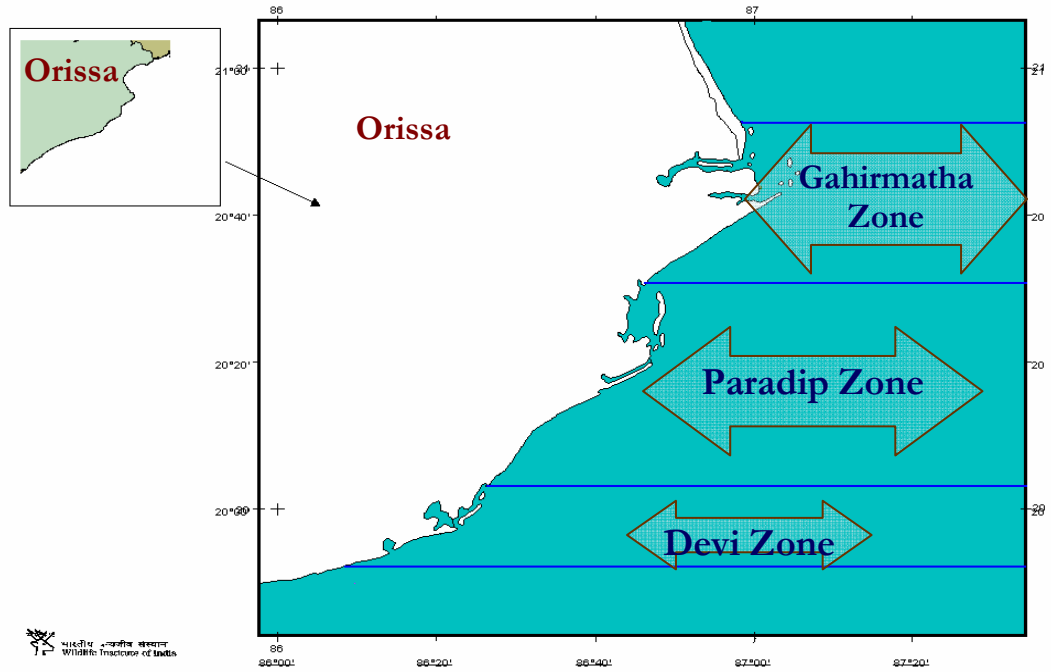
Scientific name	Common name	Vernacular name
Sharks		
Galeocerdo cuveiri	Tiger shark	Bagha magar
Scoliodon laticaudus	Yellow dog shark	Haldia magar
Sphyrna mokarran	Squat - headed hammer head shark	Zulai magar
Eusphyra blochii	Arrow - head headedhammer - shark	Kammu magar pakhi magar
Rays		
Dasyatis zugei	Pale-edged sting ray	Kala sankara, sankucha
Gymnura poecilura	Long-tailed butterfly ray	Sankusa
Himantura bleekeri	whip-tail sting ray	Sankara , sankkucha
Narcine brunnea	Brown electric- ray	Bijali magar
N.timlei	spotted electric- ray	Bijali magar
Sardines and shads		
Anodontostoma chacunda	Chanunda gizzard-shad	Chakunda
Ilisha elongata	Elongate ilisha	Bongola, Panikhia
I.melastoma	Indian ilisha	Paniakhia
Nematolosa nasus	Bloch's gizzrd shad	Ulitee, Dahala, Koomu
Pellona ditchela	Indian pellona	Ranikhia, Panikhia, Engallu
sardinella fimriata	Fringe scale- sardine	Kovullu, kabala, kokili
S.gibbosa	Gold stripped- sardine	Petna kabala
Lizard fishes		
Saurida tumbil	Greatr lizard- fish	Budinote, Andolla, Balia girrida
S.undosquamis	Brushtooth lizard-fish	Budinote, Andolla, Balia girrida
Trachinocephalus myops	Blunt-nose lizard fish	Balia gadia

Bombay duck		
Harpodon nehereus	Bombay duck	Bomalo, Naluna, Banamotta
Cat fishes		
Arius tenuispinis	Slender - spined cat fish	kala kantia, Nellajella
A.thalassinus	Giant cat fish	Dhala kantia, Thella jella
Osteogeniosus militaris	Soldier cat fish	Kantia
Plotosus canius	Canine cat fish	Kohanda macha
Eels		
Anguilla bicolor bicolor	Level - finned eel	Dantia sapa, lahantara
Congresox talabanoides	Indian pike - conger	Danti sapa, Taloban
Muraenesox cinereus	Dagger- tooth pike- conger	Sata hali
Exocoetus voliatans	Two-winged flying fish	Udukku mach
Barracuda		
Sphyaena barracuda	Great barracuda	Gayali, Seela betu
Mulletts		
Liza parsia	Gold spot-mullet	Persey
L.Tade	Tade grey-mullet	Khanga
Mugil cephalus	Flat - head grey mullet	Meji
Bulls eye		
Pricanthus cruentatus	Blood-coloured bulls-eye	Alta punti
Carangids		
Carangoides armatus	Armed trevally	Munda parai
Megalaspis cordyla	Hardtail scad	Langudo mundi, Vanagara
Scomberoides commersonianus	Telang queen- fish	Kantia, Taleparai
S.tala	Deep queen fish	Para
Black pomfret		
Parastromateus niger	Black pomfrets	Kala chandi, Bahala
Moon fish		
Mene maculata	Moon fish	Pakhichanda, Mongala katera
Silverbellies		
Gazza achlamys	Naked toothed pony-fish	Tanki chandi, samudrakara
G.minuta	Toothed pony-fish	Tanki chandi, samudrakara
Leiognathus bindus	Orange-fin pony fish	Tanka chandi
L.dussumieri	Dussumier's pony fish	Tanka chandi
L.equulus	Common pony-fish	Bara tanka chandi
Secutor insidiator	Pugnose pony - fish	Chande, Kara
S.ruconius	Deep pug-nose pony- fish	Chandee, Kara
Mojarras		

Gerres filamentosus	Whip-fin mojarra	Gaudunee, jaggiri, Dhala ghotaki
Grunters		
Pomadasyss hasta	Lined silver - grunt	Telia bhetki
P.maculatus	Blotched grunt	Gulura
Butter fish		
Scatophagus argus	Spotted butter- fish	Chitra chandi
Tuna, Mackerels & Seer fish		
Euthynnus affinis	Little tuna	Tumbada, Soora
Rastrelliger kanagurta	Indian mackerel	marua, Kanagurta
Scomberomorus commerson	Narrow-barred seer -fish	Mingiram, koni, konemu
Sword fish		
Xiphias gladius	Sword fish	Mayur pankhi
Pomfrets		
Pampus argenteus	silver pomfret	Ghee chandi, Chandua
P.chinensis	Chinese pomfret	Dhala chandi
Crustaceans		
Penaeid prawns		
Solenocera crassicornis	coastal mud prawn	Nalli chungudi, Erra reyya
S. hexitti	Deep-sea mud prawn	Nalli chungudi, Erra reyya
Metapenaeus affinis	Jinga prawn	Khopra, Kali reyya
M.brevicornis	Yellow prawn	Khopra, Kali reyya
M.dobsoni	Flower -tail prawn	Khopra, Rani chingudi
Penaeus indicus	Indian white prawn	Chapda, Tella reya
P.monodon	Giant tiger prawn	Bagda, Katla reyya
Non-penaeid prawns		
Acetes indicus	Paste shrimp	Chungudi
Crabs		
Scylla serrata	green mud crab	Chilika kankada, Mandapeta
Portunus pelagicus	Reticulate crab	Chitra kankada, Toppa kankada, Chukkapata
P.sanguinolentus	Spotted crab	Kankada, Cheralapeta
Charybdis cruciata	Cross crab	Kankada
Stomatopod		
Oratosquilla nepa	Mantis shrimp	Ailia poka
Molluscs		
Cephalopods		
Sepia aculeata	Needle cuttle fish	Kumiti muna, Kalrinda

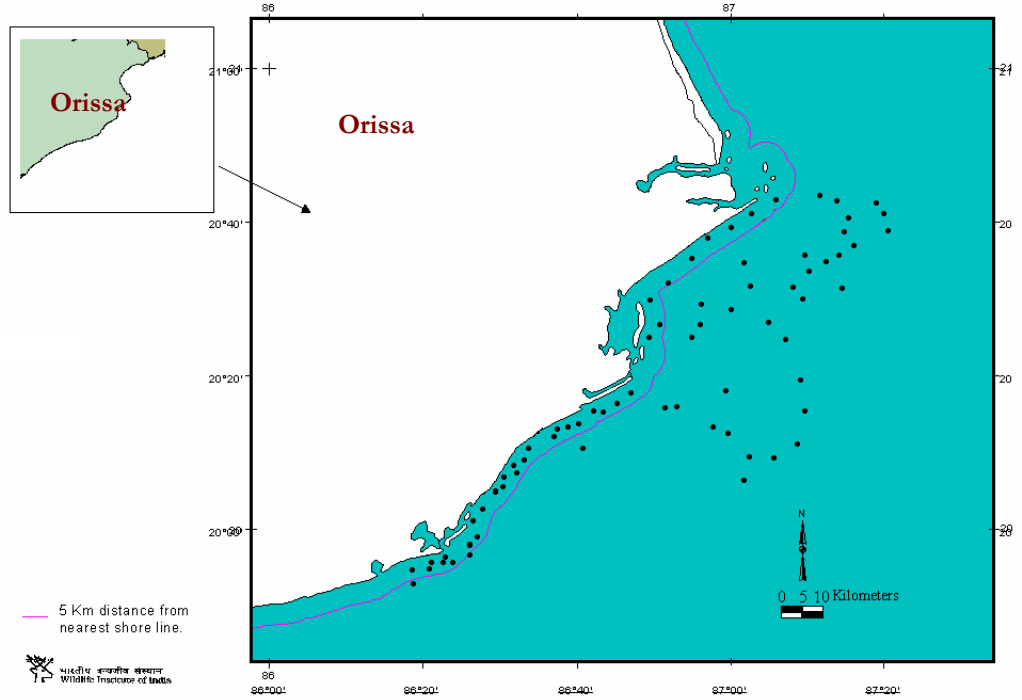
Sepiella inermis	spineless cuttle fish	Kumiti muna, Kalrinda
Loligo duvaucelii	Indian squid	Kumiti muna, Kalrinda
Reptiles		
Turtles		
Lepidochelys olivaceae	Olive ridley	Kaincha

Map1. Study Area



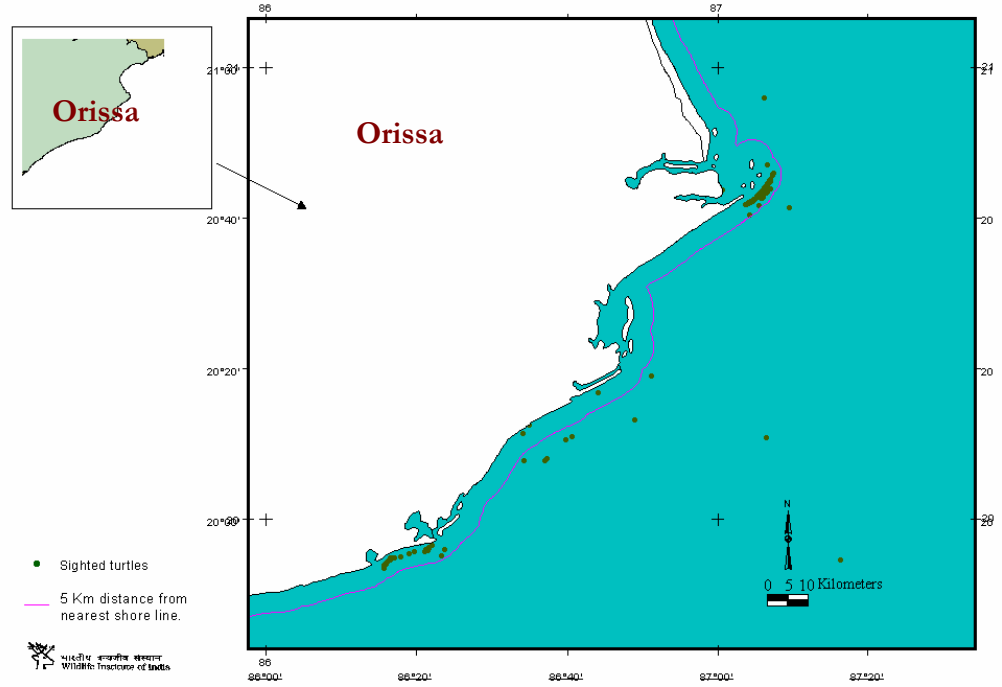
Map.2 Sampled Areas

Total # of trawling =76



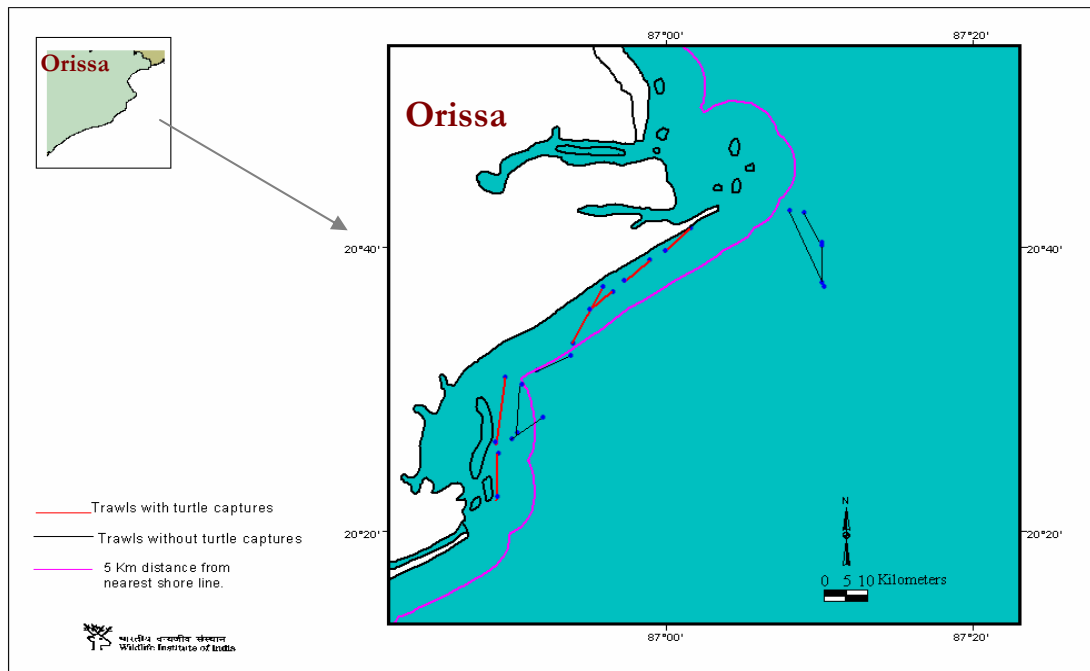
Map.3 Observed turtle sightings during the study

(n=167)



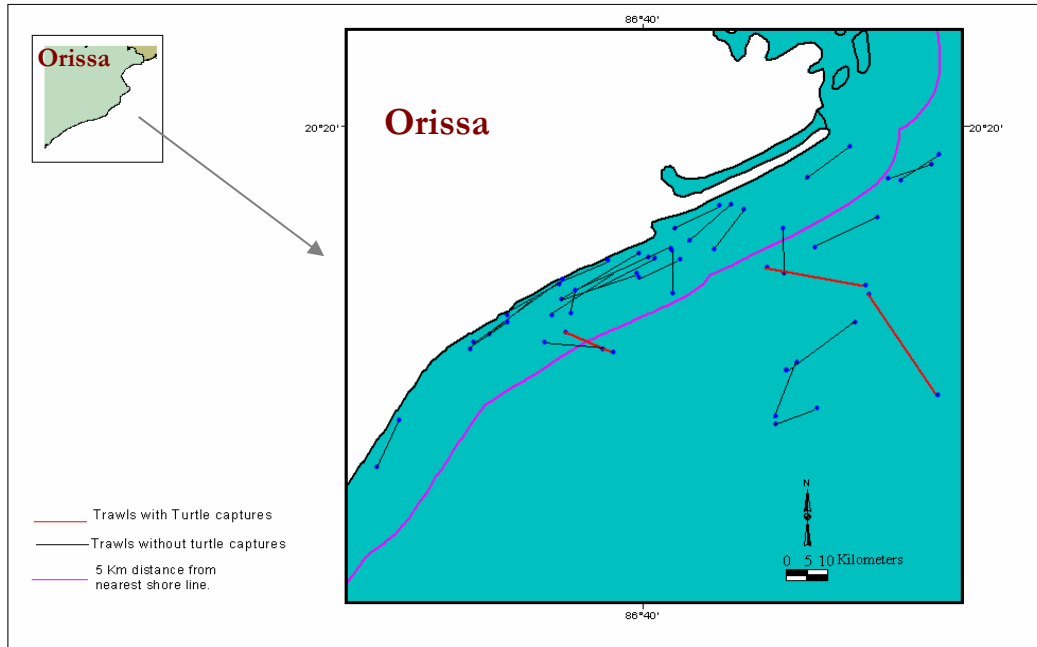
Map.4 Trawls carried out in Gahirmatha zone

(n=11)



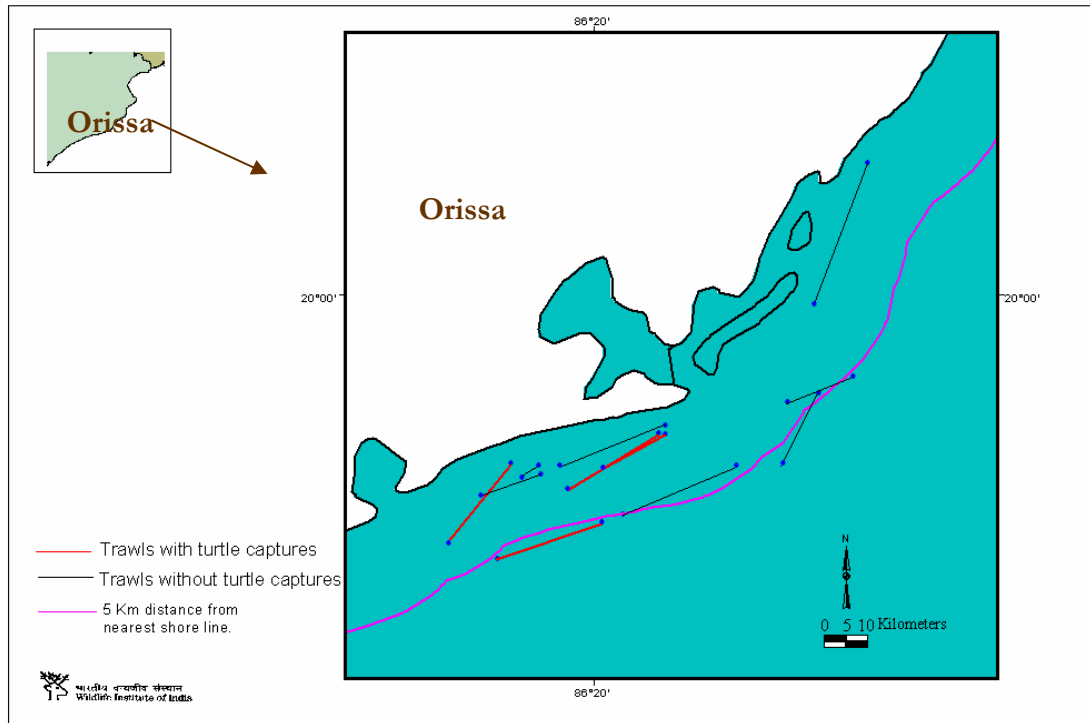
Map.5 Trawls carried out in Paradip zone

(n=29)



Map.6 Trawls carried out in Devi zone

(n=11)



Map.7 Trawls carried out in observer vessel in Gahirmatha and Devi Zones.

(n= 25)

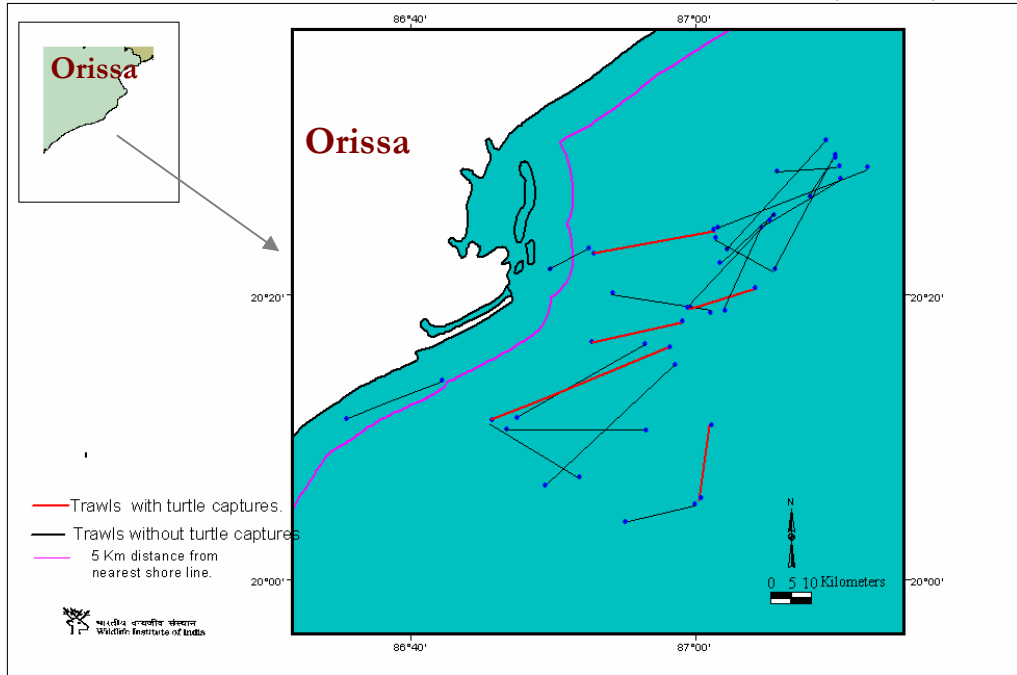


Fig.1 Turtle Excluder Device (TED)

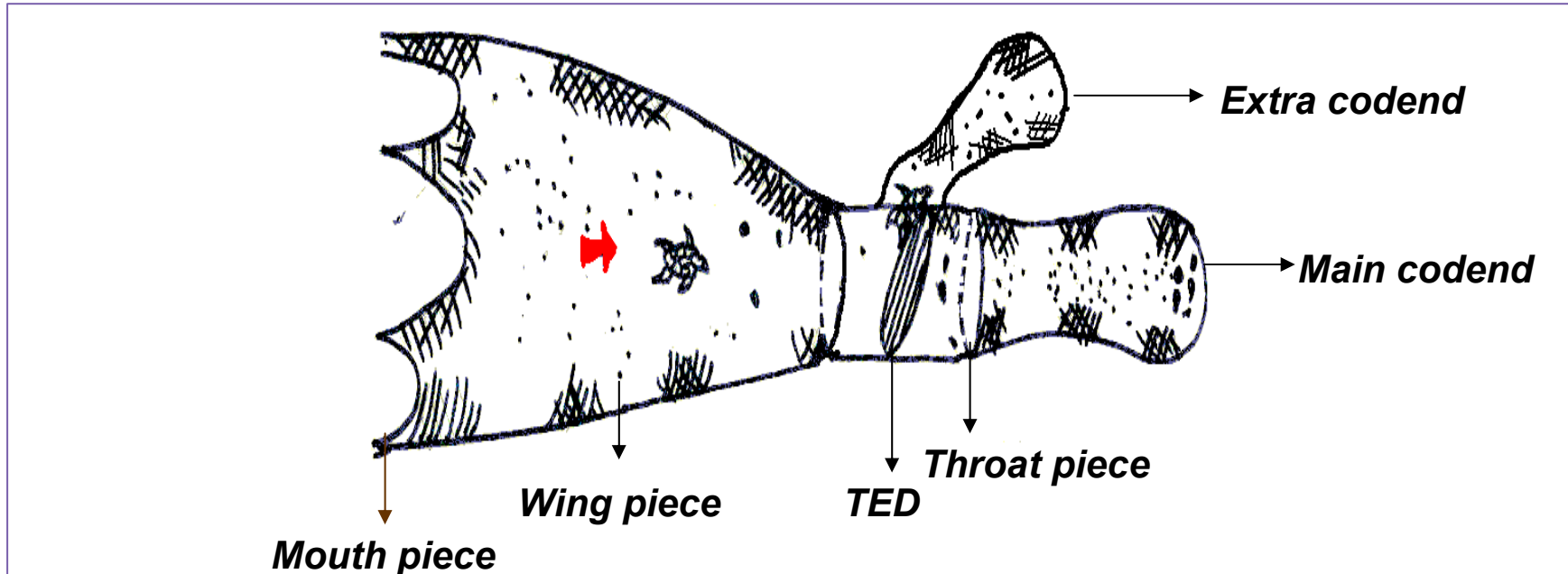


← Mouth piece of the net

Cod end →

↘ Escape hole

Fig.2 Picture depicting Net fitted with TED and an extra cod end



➤ Fish catch at both main and extra cod end were weighed to calculate the percentage loss.