Fishing Technology interventions for sea Turtle conservation

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Sea turtles are endangered species which are protected under schedule I of the Indian wildlife protection act 1972 and its amendment in 1991. Sea Turtles are listed as critically endangered or threatened on world conservation Union Red list. Sea turtles interact with trawl gears, pelagic long line gear on the high seas, and beach seine, gillnet and shrimp trawl gears in coastal waters. These interactions can lead to death, most frequently through drowning, when the turtles cannot climb to the surface of the ocean to breathe after becoming hooked or entangled in the fishing gear. New types of gear or ways of fishing can significantly reduce the rate of interactions between turtles and gear or the mortality rate after an interaction has already occurred.

The code of conduct of responsible fisheries (FAO 1995) gives guidelines for sustainable development of fisheries, prescribes the need for protecting endangered species like sea turtles. As a signatory to the code, India is bound to conduct research, develop appropriate devices and practices and implement regulatory measures for protection of endangered turtles. The fundamental objective of responsible fishing is to maximise economic returns to the fishermen without affecting the long term sustainability of fishery resources and with minimum impact of ecosystem

Trawling and sea turtle interactions

Trawling is considered to be a very effective method of fishing for demersal population in terms of investment and yield. Trawl nets are towed gears consisting of funnel shaped body of netting closed by a bag or cod end extended sideways in front to form wings. Trawling targets at mainly shrimps gained popularity over the years and led to the development of an organised fishing industry. Trawlers form nearly 80 % of the small scale mechanised fleet in India. Even though bottom trawl is an efficient fishing method for targeting demersal resources, it is less a selective fishing technique. Along with the targeted resources a large number of non target resources which include protected and endangered species such as sea turtles are also caught during trawling. Rajagopalan *et al.* (1996) reported that trawls accounted for 17.8% of the incidental catch along the Indian coasts. Along the east coast this problem has been aggravated due to rapid expansion of the mechanised fishing industry. Incidental mortalities of turtles is highest in Orrisa due to presence of large congregations of marine turtles.

An US law (section 609 of of public law nos 101 -162) introduced in May 1996 restricted imports of shrimp harvested with fishing equipment such as trawls nets not equipped with Turtle excluder devices (TEDs). The subsequent shrimp turtle case brought environmental requirements in the WTO into the mainstream, through its interpretation of relevant WTO articles. In view of these concerns, with respect to trade and the environment, the Department of Animal Husbandry and Dairying, Ministry of Agriculture, Govt of India constituted an expert panel

to conduct detailed investigations on marine turtle distribution in Indian waters, their incidental mortality in fishing nets and use of TED in trawl nets.

TED For Indian Fisheries

The Turtle excluder devices consist of panels of large mesh nettings (soft TED)or a frame consisting of a grid deflector bars (hard TED), installed before the cod end of the trawl net at an angle leading upward or downward into an escape opening. Small animals such as shrimp slip through the mesh lumen of the netting panel or gap between the deflector bars and are retained in the while large fishes and elasmobranchs are stopped by the netting or the grid of the deflector bars and can escape through the opening (Fig 1). Thus air – breathing marine turtles were prevented from capture and subsequent death after prolonged entrapment in the trawl.

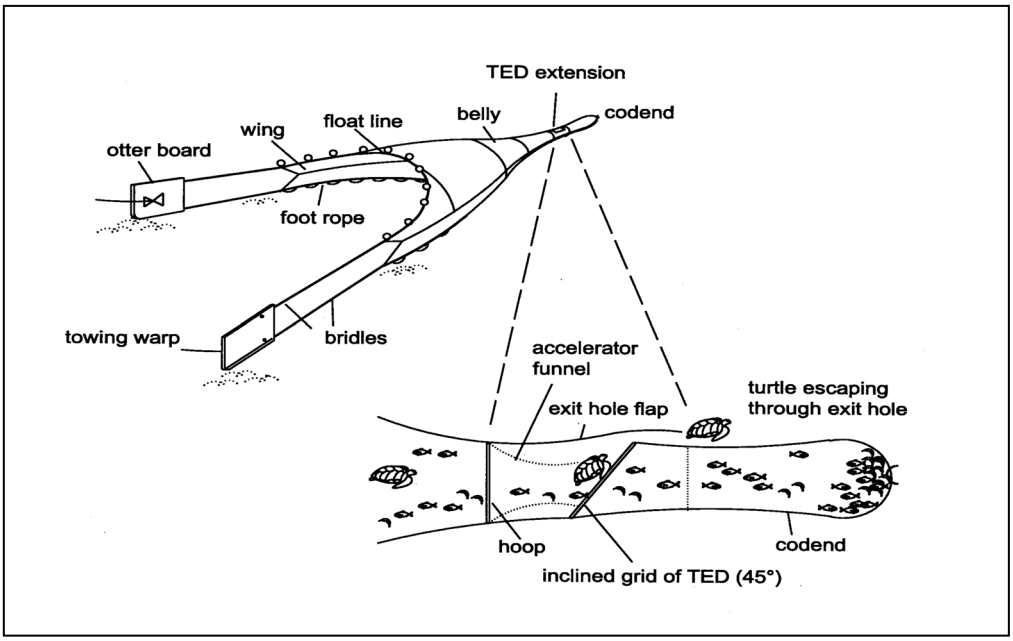


Fig. 1. Principle of TED operation

Different designs of TED are available today and they vary with regard to their construction, principle of operation and materials for construction depending on the target groups and fishing conditions (Fig 2). Soft TED and Hard TEDs are the two types that are used worldwide (Mitchell et al 1995, Anon 2002a). The hard TED is rigid frame device installed ahead of the cod end to separatety and exclude turtles from the trawl catch. Designs of hard Ted include Gorgia Jumper, NMFS hooped TED, Fixed angle TED, Antony Weedless, Flounder TED, Super Shooter (Watson and Taylor 1988), Cameron TED, Jones TED, Thai turtle free device.

Modifications of the basic TED design have been carried out by different nations. Thai Turtle free device was developed by Kasetsart University and SEAFDEC/TD, in Thailand (chokensanguan et al 1996, Chokesanguan 2000). The AusTED (Australlian trawling efficiency device) was developed in Australia (Mounsey et al 1995, Ribon-Troeger and Dedge 1995, Brewer et al 1998, Robins- Troeger and McGilvray 1999, McGilvray *et al* 1999) and CIFT –TED in Inda (Dawson 2001, Dawson and Boopendranath 2001, 2002a,b, 2003).

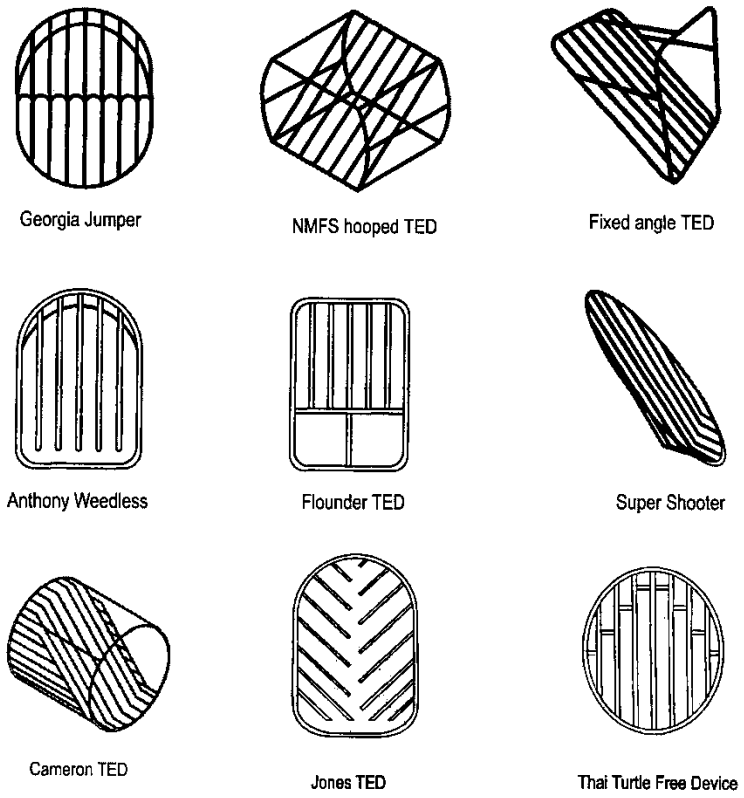


Fig. 2 Variation in single grid hard TED designs

CIFT was closely associated with evaluation of Super shooter TED designs of US origin. as envisaged under the mandate of expert scientific panel along with CIFNET with the support of MPEDA and FSI. Results of The experiments conducted by CIFT to evaluate the Super Shooter TED imported by MPEDA on *Matsya Shikari* has been detailed. The Shooter TED was of 1030 x 850 mm size with a deflector bar gap of 90 mm.

6 Fishing operations were conducted off Andhra, off Kalingapatnam at a depth of 45 – 55 m. The catch retained in the cod end comprised of catfish, perchs, pomret, seer and carangids. No turtle was retained in the experiment.

Experiments continued along the Bheemili and Chilka with a additional exit hole cod end provided at the exit hole to retain the catch excluded due to the installation of TED in the trawl net (Fig 3). During the 5 operations which was done at a depth of 45 -140 m a total of 676 kg was landed of which 469 kgs was retained in the main cod end. The results indicated an overall escapement of 30.8 % fin fish. Turtles were not retained in the main cod end or exit hole covered cod end (Ramarao, 1995a)

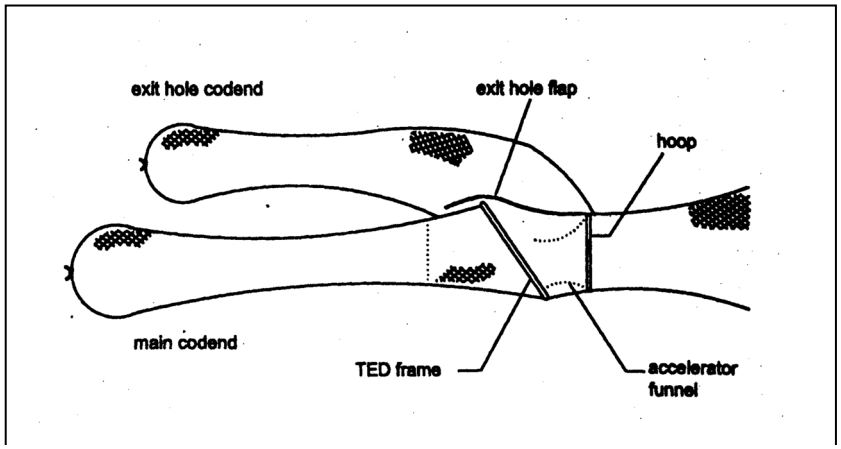


Fig. 3. Details of rigging of exit hole cod end for experimental operations

During the operations off Andhra Pradesh using Super shooter TED on board MV Skipper in the depth range of 36 -50 m (Kirubakaran et al 2002) two turtles were excluded during the operation. The TED operations with Exit hole at the top of the net resulted in a catch loss of 13.7 %, while operations with exit hole at the bottom resulted in a catch loss of 43.3%. (Kirubakaran *et al.* 2002).

Unlike fishers in USA, Australia and other advanced maritime nations, fishers on the Indian coast target both shrimp and non-shrimp resources. Experiments with TED designs which have a deflector gap of less than 90 mm in Indian waters, though successful in excluding turtles showed poor performance in retention of targeted non shrimp catch components. Hence these TEDs are not considered suitable for Indian conditions, nor were they acceptable to Indian trawler owners and operators (Mishera and Behara 2001).

Development of CIFT-TED

An Indigenous design of TED was developed at CIFT with a focus on reducing by catch loss. THE CIFT-TED is a simple single grid hard TED with a top opening. The device can be fabricated and installed with minimum training using locally available infrastructure and net making skills at a cost of approximately Rs. 2500. The design, construction, installation and operation of CIFT-Ted have been elaborated by Dawson & Boopendranath (2002) (fig 4 -8).

Field trials and demonstration with CIFT-TED along the east coast of India

A Total of 25 field trials were conducted with CIFT TED yielding a Total catch of 889.8 kg. (Table 1) The mean catch rate in operations with a CIFT-TED installed in trawl was determined to be 35.5 kg.haul $^{-1}$. The catch composed of fin fishes Prawns, Cephalopods, Crabs, Sharks, Jellyfish. The predominant fin fishes included Pomfrets, Mackeral, Upenoids, Perches, Ribbon fish, Catfish, Bombay duck, Squilla, Silver bellies Soles, Puffer fish, Sciaenids, clupeids. Relative exclusion and retention rates during CIFT-TED installed operations along the east coast of India is given in Fig. 9. The catch loss due to CIFT TED installation was estimated to be 3.3 % for non shrimp resources. Out of a total of 26.8 kgs of shrimp landed only 0.5 % was observed to have been excluded after the installation of CIFT TED.

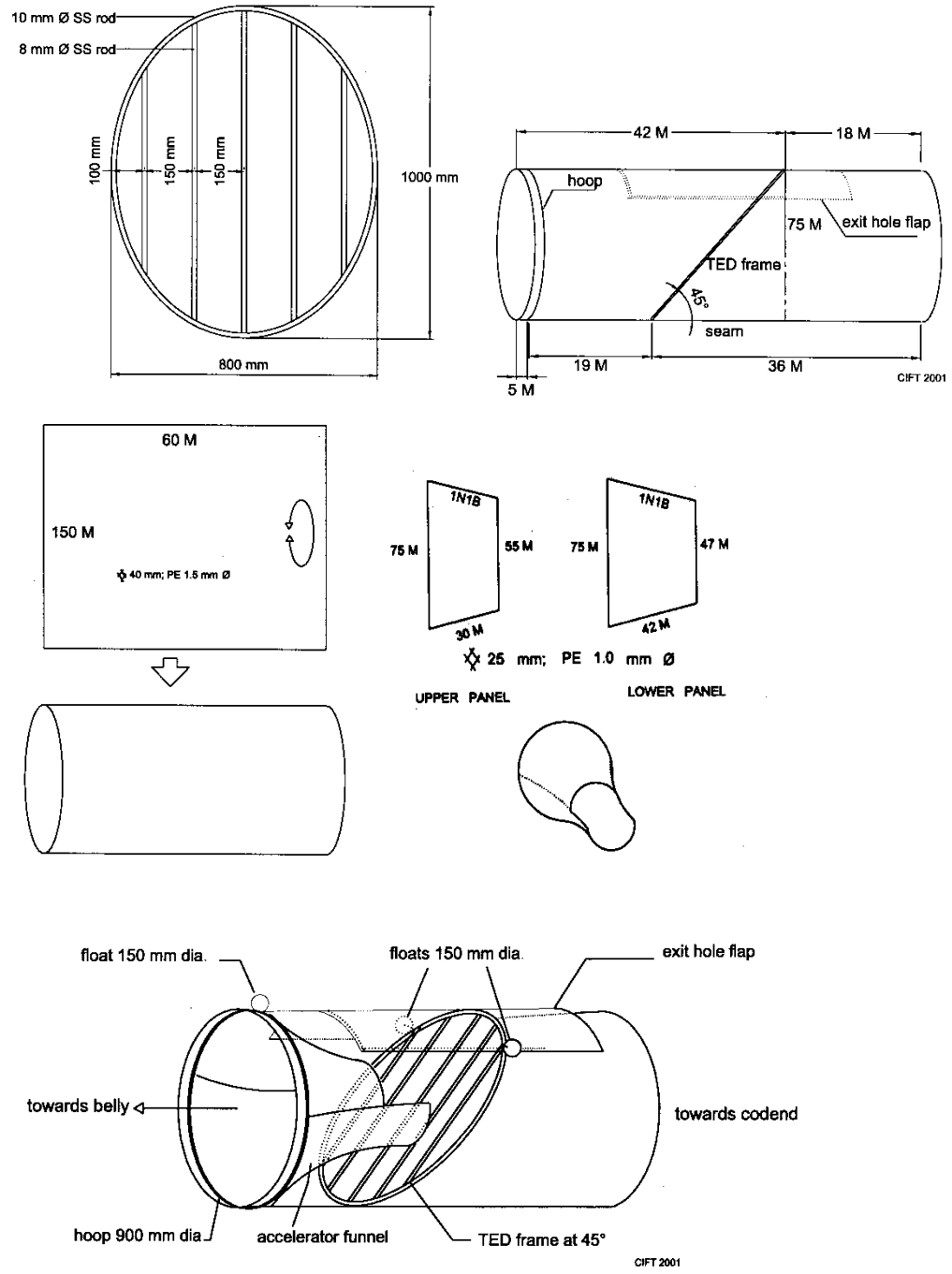


Fig 4-8 Method of installation of the TED

Table 1. Details of TED installed trawl operations along east coast coast

Area	No of hauls	No of hours	Catch retained(kg)	Catch loss(kg)	Catch loss (%)
Paradeep (Orissa)	7	7	422.6	14.3	3.3
Dhamara (Orissa)	1	1	79.23	0.07	0.08
Astrang (Orissa)	1	1	50	0.05	0.1
Bahabalpur (Orissa)	1	1	22	0.3	1.36
Balaramagad (Orissa)	1	1	44	0.8	1.81
Visakhapatnam (A.P)	5	5	69	0.13	0.18
Kakinada (A.P)	6	6	133	1.8	1.35
Nizampatnam (A.P)	2	2	35	0.25	0.71
Krishnapatnam (A.P)	1	1	25	0.7	2.8
Vadarevu (A.P)			10	0.2	2
Total	25	25	889.83	18.6	2.09

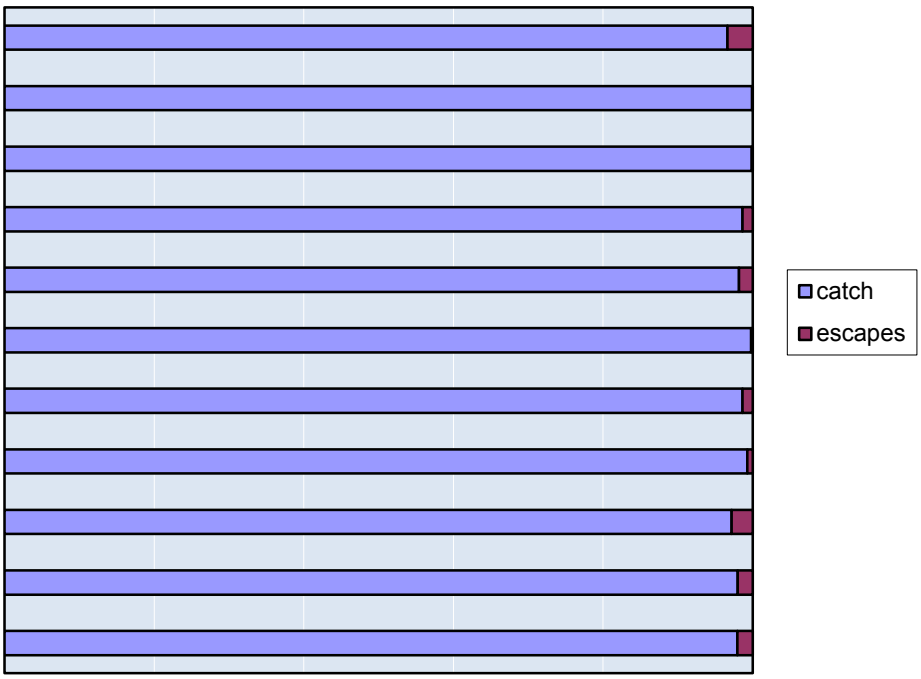


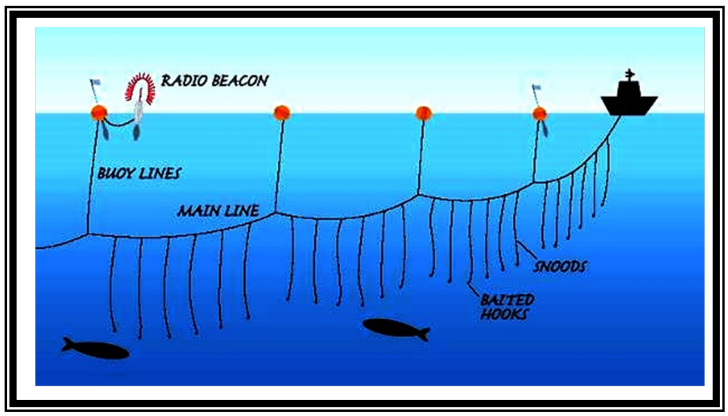
Fig. 9. Relative exclusion and retention rates during CIFT-TED installed operations along the east coast of India

Fig. 10. Relative exclusion rates of different species groups after installation of CIFT-TED durng experimental trawling along east coast of India

Longlining and sea turtle interactions

Incidental mortalities of sea turtles in pelagic long lining , a fishing method intended to catch migratory top predator fish, primarily tuna and swordfish is a global conservation concern. Scientists, managers and fishermen are working co-operatively to develop mitigation measures to reduce this mortality. Assessment of turtle avoidance measures in longline fishery contributes to a small but growing body of research. Research on methods to avoid sea turtles in pelagic long line fisheries has been initiated only recently. Most experiments had small sample sizes and had been conducted over only a few seasons in a small number of fisheries (Gilman *et a*l., 2006a).

Further-more, few studies considered effects of turtle avoidance methods on other bycatch species, including seabirds (Gilman *et al*., 2005), sharks (Gilman *et al*., 2007) and cetaceans (Gilman *et al*., 2006c).



Hook Design

Most turtles are either hooked as they attempt to eat the bait or are entangled in the line. Changes in hook design and bait type were a few as measures to reduce the bycatch of sea turtles on pelagic longlines. Studies have showed that Use of large circle hooks with no greater than a 10 degree offset, combined with whole fish bait have been effective in reducing sea turtle mortality in longline fishing . Circle hooks reduce turtle mortality because the size and shape of the hooks makes it more difficult for the turtles to swallow, avoiding damage to internal organs.

These hooks are typically wider than the traditional hooks J hooks and have barbs pointed back towards the shaft of the hook, making ingestion more difficult. Therefore even the sea turtle being caught by the circle hook, hooking position will be around its jaw and the hook can be easily removed. Circle hooks are currently being tested in many fisheries and have been proposed by fishery managers as a practical and economical measure to reduce sea turtle mortality in pelagic longline fisheries. Specifically, the effectiveness of 18/0 circle hooks has been evaluated with respect to reducing sea turtle interactions and maintaining swordfish and tuna catch rates. Individually, circle hooks and mackerel bait significantly reduced both loggerhead (*Caretta caretta*) and *leatherback (Dermochelys coriacea)* sea turtle bycatch *(*Watson *at al* 2005*).*

Setting longlines

Longline set depths can be critical to incidental sea turtle mortality. The depth at which longline gear are set and the length of leaders for individual hook lines from the main line affect both the takes and mortality of sea turtles. Arrangement of gear configuration and setting of the line such that the hooks remain active only at depths beyond the range of sea turtle interaction would reduce sea turtle mortalities. Shallower sets of longline gear are more likely to result in interactions between the turtles and the gear, since turtles are more likely to swim higher in the water column. Longer leaders can reduce sea turtle mortality. In addition after hooking, by pelagic gear, line cutters can reduce sea turtle mortality by allowing the turtle to swim away rather than bringing the turtle onboard. Retrieval of longline gear earlier in the day and reducing soak time of hooks is also suggested.

Purse seine fishing and sea turtle interaction

Sea turtles are occasionally caught in purse seines in the tuna fishery. Most interactions occur when the turtles associate with floating objects (for the most part fish-aggregating devices (FADs), and are captured when the object is encircled; in other cases, the net, set around an unassociated school of tunas or a school associated with dolphins, may capture sea turtles that happen to be in the location. In these latter cases, the presence of tunas and turtles together may be influenced by oceanographic features such as fronts, but is essentially a chance event because turtles cannot swim fast enough to travel with tunas or dolphins. Once captured, the turtles may be released unharmed, injured, or dead. They can drown if they are entangled for a prolonged time and are unable to reach the surface to breathe. The actions to reduce sea turtle mortality in purse seines include :-

- Avoid encirclement of sea turtles to the extent practical.
- If encircled or entangled, take all possible measures to safely release sea turtles.
- For fish aggregating devices (FADs) that may entangle sea turtles, take necessary measures to monitor FADs and release entangled sea turtles, and recover these FADs when not in use.
- Conduct research and development of modified FADs to reduce and eliminate entanglement.
- Implementation of successful methodologies developed.

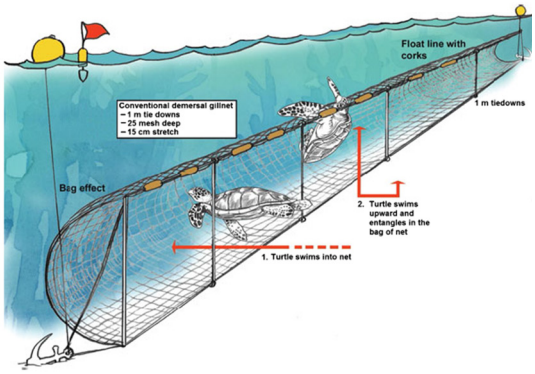
Gillnets and sea turtle interaction

Gill net fishery is the man stray of the traditional sector along the Indian coast. In Andhra Pradesh about 7,12,362 gillnets and 4,013 drift gillnets are being operated. (CMFRI census, 2002) Turtles become entangled in artisanal gill nets set inshore close to the nesting beaches and on the path of the sea turtle migration. On the high seas they get caught in massive drift nets. Rajagopalan (2001) reported that gillnets accounted for 76.8 percent of turtles landed or trapped along the Indian coast. Therefore the crucial factor to be considered in planing conservation measures is the livelihood of coastal fishers.

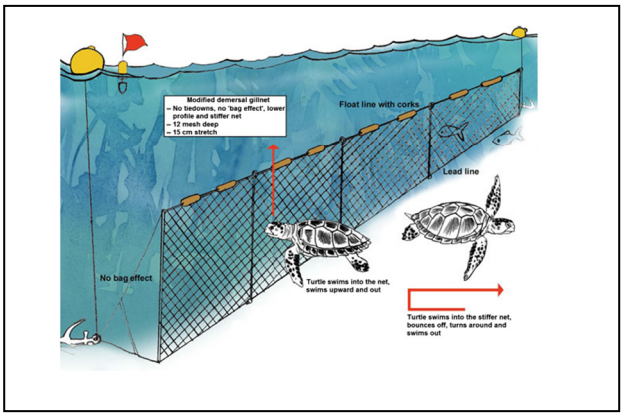
The following are gear-technology approaches that have been shown to significantly reduce sea turtle catch rates in individual gillnet fisheries:

- Reducing net profile (vertical height; Eckert et al. 2008).
- Increasing tiedown length, or eliminating tiedowns (Price and Van Salisbury 2007).
- Placing shark-shaped silhouettes adjacent to the net (Wang et al. 2009);
- Illuminating portions of the net using green lightsticks (Wang et al. 2009).

In demersal gillnet fisheries, use of narrower (lower profile) nets is an effective and economically viable method for reducing sea turtle by-catch rates due to the combined effect of: The net being stiffer, thereby reducing the entanglement rate of turtles that encounter the gear, as sea turtles that do interact with the gear to "bounce out" and free themselves more readily than with conventional gear and the net being shorter, thereby reducing the proportion of the water column that is fished and so reducing the likelihood of turtles encountering the fishing gear.



Increasing tiedown length, or avoiding the use of tiedowns, has also help decrease turtle entanglement rates in demersal gillnets . In demersal gillnet fisheries, tiedowns are typically used to maximize the catch of demersal fish species. Tiedowns are lines that are shorter than the fishing height of the net and connect the float and lead lines at regular intervals along the entire length of the net. This net design creates a bag of slack webbing which aids in "entangling," rather than "gilling," demersal fish species. The shorter the length of tiedowns, the deeper the webbing pocket is. Unfortunately, this technique also poses an entanglement hazard to sea turtles that encounter the gear. Several studies in North Carolina's flounder (Paralichthys lethostigma) gillnet fishery found that lower profile nets without tiedowns resulted in a significantly lower incidence of seaturtle entanglement, compared with traditional gillnets containing twice as much webbing (twice the number of meshes) and containing tiedowns regularly placed throughout the gear (Price and Van Salisbury 2007). Research has also demonstrated that entangled turtles have a higher rate of escape when longer tiedowns are used (Gearhart and Price 2003).



Illuminating nets with green lightsticks attached to the net can reduce green sea turtle by-catch rates without adversely affecting the catch rate of target species when compared to control nets without illumination research in a Mexico demersal gillnet fishery (Wang et al. 2009).

Incorporating a shark shape was also found to result in a significant reduction in sea turtle catch rates; however, this resulted in a large and significant reduction in the target species catch rate (Wang et al. 2009)

Aspects of gear design, materials and methods that affect turtle survivorship after interaction with gear is also limited. This information is fundamental to guiding further research and development of gear-technology approaches to by-catch. Mitigation. Unfortunately Technological interventions in this case is scarce. Therefore a dynamic spatial temporal restriction seems may be an alternative since turtles show a preference to specified area and seasons for migration and nesting. Once vulnerable areas are identifies, it should be possible to evolve and adopt suitable measures with active participation of the community. Research on the turtle mortality in relation to type of gillnet, depth of operation and time of operation would help in evolving a framework for conservation measures.

Fisheries management guidelines for fisheries activities and conservation and management of sea turtles.

FAO 2003 prepared to Guidelines offer guidance to the preparation of national or multilateral fisheries management activities and other measures allowing for the conservation and management of sea turtles. They apply to those marine areas and fisheries where interactions between fishing operations and sea turtles occur or are suspected to occur. They are global in scope but in their implementation national, subregional and regional diversity, including cultural and socio-economic differences, should be taken into account.

Fishing operations

Appropriate handling and release.

(i) In order to reduce injury and improve chances of survival:

(ii) Requirements for appropriate handling, including resuscitation or prompt release of all bycaught or incidentally caught (hooked or entangled) sea turtles.

(iii) Retention and use of necessary equipment for appropriate release of bycaught or incidentally caught sea turtles.

Coastal trawl

(i) In coastal shrimp trawl fisheries, promote the use of turtle excluder devices (TEDs) or other measures that are comparable in effectiveness in reducing sea turtle bycatch or incidental catch and mortality.

(ii) In other coastal trawl fisheries, collect data to identify sea turtle interactions and conduct where needed research on possible measures to reduce sea turtle bycatch or incidental catch and mortality.

(iii) Implementation of successful methodologies developed.

Purse seine

(i) Avoid encirclement of sea turtles to the extent practical.

(ii) If encircled or entangled, take all possible measures to safely release sea turtles.

(iii) For fish aggregating devices (FADs) that may entangle sea turtles, take necessary measures to monitor FADs and release entangled sea turtles, and recover these FADs when not in use.

(iv) Conduct research and development of modified FADs to reduce and eliminate entanglement.

(v) Implementation of successful methodologies developed

Longline

(i) Development and implementation of appropriate combinations of hook design, type of bait, depth, gear specifications

(ii) Fishing practices in order to minimize bycatch or incidental catch and mortality of sea turtles.

Other Fishery management stategies

(i) Spatial and temporal control of fishing, especially in locations and during periods of high concentration of sea turtles.

(ii) Effort management control especially if this is required for the conservation and management of target species or group of target species.

(iii) Development and implementation, to the extent possible, of net retention and recycling schemes to minimize the disposal of fishing gear and marine debris at sea, and to facilitate its retrieval where possible.

Research, monitoring and sharing of information

Collection of information and data, and research

(i) Collection of data and information on sea turtle interactions in all fisheries, directly or through relevant RFBs, regional sea turtle arrangements or other mechanisms.

(ii) Development of observer programmes in the fisheries that may have impacts on sea turtles where such programs are economically and practically feasible. In some cases financial and technical support might be required.

(iii) Joint research with other states and/or the FAO and relevant RFBs.

(iv) Research on survival possibilities of released sea turtles and on areas and periods with high incidental catches.

(v) Research on socio-economic impacts of sea turtle conservation and management measures on fishers and fisheries industries and ways to improve communication.

(vi) Use of traditional knowledge of fishing communities about sea turtle conservation and management.

Information exchange

(i) Sharing and dissemination of data and research results, directly or through relevant RFBs, regional sea turtle arrangements or other mechanisms.

(ii) Cooperation to standardize data collection and research methodology, such as fishing gear and effort terminology, database development, estimation of sea turtle interaction rates, and time and area classification.

(i) C. Review of the effectiveness of measures

(i) Continuous assessment of the effectiveness of measures taken in accordance with these guidelines.

(ii) Review of the implementation and improvement of measures stipulated above.

Ensuring policy consistency

A. Maintaining consistency in management and conservation policy at national level, among relevant government agencies, including through inter-agency consultations, as well as at regional level.

B. Maintaining consistency and seeking harmonization of sea turtle management and conservation-related legislation at national, sub-regional and regional level.

Education and training

A. Preparation and distribution of information materials such as brochures, manuals, pamphlets and laminated instruction cards.

B. Organization of seminars for fishers and fisheries industries on:

   A. Nature of the sea turtle-fishery interaction problem
   B. Need to take mitigation measures
   C. Sea turtles species identification
   D. Appropriate handling and treatment of bycaught or incidentally caught sea turtles
   E. Equipment to facilitate rapid and safe release
   F. Impacts of their operations on sea turtles
   G. Degree to which the measures that are requested or required to adopt will contribute to the conservation, management and recovery of sea turtle population.

H. Impacts of mitigation measures on profitability and success of fishing operations

I. Appropriate disposal of used fishing gear

C. Promotion of awareness of the general public of sea turtle conservation and management issues, by government as well as other organizations

Capacity building

A. Financial and technical support for implementation of these guidelines in developing countries.

B. Cooperation in research activities such as on status of sea turtle incidental catch in coastal and high seas fisheries and research at foraging, mating and nesting areas.

C. Establishment of a voluntary support fund.

D. Facilitation of technology transfer.

Socio-economic and cultural considerations

A. *Taking into account* :

(i) socio-economic aspects in implementing sea turtle conservation and management measures.

(ii) cultural aspects of sea turtles interactions in fisheries as well as integration of cultural norms in sea turtle conservation and management efforts.

(iii) sea turtle conservation and management benefits to fishing and coastal communities, with particular reference to small-scale and artisanal fisheries.

B. Promotion of the active participation and, where possible, cooperation and engagement of fishing industries, fishing communities and other affected stakeholders.

C. Giving sufficient importance to participatory research and building upon indigenous and traditional knowledge of fisherfolk

C. Giving sufficient importance to participatory research and building upon indigenous and traditional knowledge of fisherfolk

These modifications in fishing methods significantly help in reducing the capture rate of sea turtles and potentially the post fishing mortality of those that were caught and did not negatively impact the primary target species catch. These mitigation measures have the potential to reduce mortality of sea turtles and other bycatch species worldwide. Better understanding of the links between sea turtles and fishing allows the design of conservation initiatives that reduce their interactions and thereby sea turtle mortality. Better understanding of these links leads, in part, to designing fishing gear, and adopting management practices and methods of fishing that reduce the takes and mortality of sea turtles.

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