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Full Length Research Paper

Sea turtle mortality in fishing gear: a review and Nigerian conservation efforts

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Abstract

Sea turtles are endangered or threatened ancient reptiles according to IUCN red list. They are protected under the endangered species acts of many countries. Their mortality is incidental to fishing practices, including trawling, gilling, long lining, trapping, seining and entangling. This review quantified the unsustainable problem posed by fishing on the population of sea turtle and options for mitigation. The ban on the export of Nigerian shrimp to US for not using the turtle excluder device in shrimp trawl and the subsequent efforts by Nigerian government to develop local TED with weedless and super shooter grids is highlighted.

Keywords: Incidental mortality, Sea turtle, fishing gear, Endangered.

INTRODUCTION

Incidental catch is a widely known major cause of sea turtle mortality. Several gear types, such as, shrimp trawl nets and purse seines, are known sources of injury and mortality. Pritchard *et al.,*(1983) provided three solutions for reducing mortality: restricting fishing activity in areas and during seasons when sea turtles concentrate, hauling trawls and other fishing gear to the surface more frequently, and using excluder devices to release sea turtles from trawls. The description and analysis of the incidental catch challenge to be documented by Pritchard *et al.,*(1983) more than twenty years ago was the most reliable information at that time. Recent knowledge of the solutions to the incidental capture of sea turtles in fishing gear is available, mostly from developed nations. Current information indicates that the major sources of sea turtle mortality by fishing gear worldwide are:

1). Trawling
2).Drift and bottom set long lines
3).Gill/entanglement nets or entrapment gear *(e.g.,* seines, pound nets)
4).Entanglements in buoy or trap lines
5).Purse seine
6).Hooks and lines from recreational and commercial fishing.

The purpose of this review is to summarize the information available on gear that impacts sea turtles, the known or possible magnitude of takes by gear type, and potential solutions to reduce the take. Information on sea turtle in Nigeria is given and recent national efforts to reduce incidental mortality in shrimp trawls are elaborated.

TOWING/TRAWLING GEAR

Trawls are highly efficient gear for catching a variety of marine crustaceans and fish around the world.Different

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types of trawl are in use, with sizes ranging from 3 m head rope length (used by artisanal and recreational fisherman) to massive commercial trawls up to 61.5 m head rope length. Fortunately for sea turtles, massive trawls used in temperate waters where sea turtles are unlikely to occur. But in tropical seas, large numbers of sea turtle are caught in shrimp trawls.

Impact Assessment

There are no reliable estimates of the global extent of trawl fishing in areas where sea turtles occur, but the incidental take of sea turtles in shrimp trawls is widely cited as very significant. Based on worldwide shrimp trawling effort, and making assumptions about the rate of capture, a reasonable estimate of annual mortality of sea turtles in shrimp trawls worldwide is 150,000 metric tonnes (Eckert *et al.,* 1999).Worldwide, the most abundant marine species targeted in tropical waters by trawling is shrimp. Fish are also harvested extensively, not always as a directed fishery with species specific trawls, but incidentally in shrimp trawls. Regardless of the target species, if bottom trawls occur in habitats frequented by sea turtles, turtles will be taken as bycatch. Unable to surface to breathe, many of those taken will drown.

Mitigation options

The uses of excluder devices, reduced tow times, and/or time and area closures are among the options proffered to prevent or reduce turtle mortality. The Turtle Excluder Device (TED), e.g. Thai turtle free or excluder devices has become the standard for reduction of sea turtle mortality from shrimping and, to a lesser extent, from fish trawling. The principle of the TED is simple: a barrier with an opening through which sea turtles voluntarily or involuntarily escape is installed into the trawl codend. Small openings in the TED, either spacing between the metal bars of a grid or large mesh size (20 cm) webbing panels, allow most of the target species to pass through the openings in the rear or the cod end of the net.

Research by the U.S. National Marine Fisheries Service (NMFS), fishermen and universities, has demonstrated that some types of TEDs work more efficiently at both target species retention and a sea turtle release. All TEDs likely lose some target species, either because shrimp, which are weak swimmers, escape out the turtle release opening, or large fish do not pass through the openings in the TED and also escape out the turtle release opening. Despite some shortcomings, to date the TED is the best technical solution to allow turtles to escape from trawls with minimal effect on the target catch. Research and experience confirm that grid-type ("hard") TEDs seem to be the best for both purposes. Mesh webbing("soft") TEDs diverts a greater proportion of shrimp through the exit openings and, due to net stretching create pockets in which turtles can become entrapped.

An oft overlooked part of the shrimp trawl fishery is the use of try nets or sample trawls. Because these trawls are pulled frequently to provide fishermen with an indication of what the large nets are catching, it was believed that they had little impact on sea turtle mortality. (Eckert *et al.,* 1999) reported that in almost 20,000 hours of tows conducted between 1992-1995 in U.S. waters, 41turtles captured in trying nets were recorded by NMFS observers for a calculated catch rate of about 0.002turtles/net hr/try net (average try net size is 4.6 m). By comparison, Henwood and Stuntz (1987)reported a catch rate of 0.0031 turtles/net hr/30.75 m net, for observer data collected from commercial trawls between 1973-1984, While most of these turtles observed, captured in try nets were alive when brought aboard, their ultimate fate is unknown.

Reducing tow times can improve sea turtle survival under certain conditions. However, recent research and review of physiological data suggest that forced submergence of turtles for even a few minutes causes changes in their blood chemistry. Recovery to normal levels is dependent on the length of time submergence is forced, as well as turtle size. For small turtles, recovery from even a few minutes of forced submergence can require as long as 24 hr. Thus, reduced tow times may not be a viable alternative to TEDs where the conservation of sea turtles is the goal.

Drift Longlines

Longlines, used for the capture of pelagic species such as swordfish and other billfish, tunas, and sharks, consist of a surface line buoyed at each end, with lines of smaller diameter (sometimes called ganglions) spaced uniformly from the main line. Baited hooks are attached to the smaller lines which hang vertically in the water column. Longlines can be several miles long, and are deployed from vessels and allowed to soak, usually overnight. The lines are retrieved after the specified soak time, and the catch brought aboard. There is increasing evidence that sea turtles both bite the baited hooks and become entangled in the lines. Swordfish, a major target species, tends to concentrate along frontal zones with high topographic relief and high biological productivity.These are often the same areas where sea turtles concentrate, creating a scenario for incidental take.

Impact Assessment

There are no worldwide estimates of sea turtle bycatch in pelagic long line gear. It is estimated by the NMFS Northeast Fisheries Science Center that in the U.S. Atlantic Ocean swordfish fishery, 1218 sea turtles were

taken in 1992. More than 20,000 sub adult loggerhead turtles is hooked annually by the Spanish long line fleet (in the eastern Atlantic and the Mediterranean Sea) (Aguilar *et al.,* 1995). Additional long line fleets operate in the Mediterranean Sea and eastern Atlantic waters, so this number represents only part of the total take by long lines.

Mitigation Options

Mitigating measures to reduce sea turtle take should include additional research on the distribution and abundance of sea turtles, as well as a reduction of fishing effort when sea turtles occur in concentrations. Alternatives include limiting entrants to these fisheries, modifying fishing quotas, setting seasonal limits based on sea turtle distribution and abundance, and pulling lines more frequently.

Research on gear types can also be undertaken to reduce potential interactions with sea turtles. Alternative gear placement, bait, and hook types and materials can be developed to reduce interaction with turtles. The Japanese are reportedly conducting research on a rubber or plastic iridescent material that turtles supposedly bite in preference to the baited hooks; however, such a solution would not address the twin threat of line entanglement. Research on reducing sea turtle take by long lines is in its infancy compared to technical solutions in the shrimp trawl fishery because the incidental take of sea turtles by long line gear is a problem documented only fairly recently. However, long line fisheries are expanding rapidly throughout the world, and this problem needs to be addressed.

ANCHORED / BOTTOM SET LONGLINES

Bottom long lines differ from pelagic long lines in that they are set on the sea bottom, usually over a reef or other hard bottom. Bottom long lines use the principle of a main or mother line from which smaller diameter lines with baited hooks are evenly spaced. Principal species targeted are reef fish *(e.g.,* snappers, groupers). Evidence of the incidental take of sea turtles on bottom long lines is sparse, but they have the potential to take reef dwelling turtles such as loggerheads and hawksbills *Eretmochelys imbricata*.

Impact Assessment

There are no national or regional data from which to estimate the global extent of sea turtle mortality due to bottom long line fishing effort.

Mitigation Options

Possible measures to reduce sea turtle takes include pulling lines more frequently, setting gear in areas where turtles are not in abundance, and using degradable to hook that would not cause long-term problems for turtles. More research is needed to define the extent of the problem, and to devise potential solutions.

GILL/ENTANGLEMENT NETS

There are generally two types of gill nets used in fisheries around the world. Pelagic (Deep Ocean) driftnets target species such as swordfish and other billfish, sharks, mackerels, and dolphin fish. These large drift nets are an indiscriminate fishing technique that, in addition to the target catch, takes various non-target species of sea turtles, marine mammals, seabirds, and other marine life. On the other hand, coastal gill nets are used around the world to capture coastal fishes .Mesh sizes vary depending on the target species, mainly between 50-70 mm stretch mesh up to the 300-400 mm mesh used in shark gill nets.

Impact Assessment

Because of the indiscriminate nature of gill nets, sea turtles are likely to be captured in both the pelagic and coastal habitats where they occur. As an example, incidental captures of leatherback turtles *Demochelys coriacea* in the swordfish gillnet fisheries of Chile and Peru has been implicated in the recent collapse of the breeding colony on the Pacific coast of Mexico (Eckert and Sarti, 1997).

Until recently, Mexico supported the largest nesting assemblage of leatherback sea turtles in the world (Sarti *etal.,* 1996). Mortality of sea turtles entangled in Chilean gillnets is estimated to be 80% (Frazier and Montero, 1990).In some parts of the world, such as in Brazil, coastal gill nets represent a larger mortality problem for turtles than trawling.

Mitigation Options

Measures to reduce the incidental take of sea turtles in gill nets include setting nets in areas where turtles are unlikely to be present, limiting the length or depth of the nets, reducing the soak time of nets and requiring nets to be attended, establishing quotas or restrictions for target species, and using mesh sizes that are less likely to take turtles.

To reduce the incidental catch problem on Florida's east coast (USA), the State of Florida has limited the size of gill nets to no more than 554 m, established a green turtle conservation zone in the area of greatest take, limited the number of gill nets allowed to one per fisher, prohibited use of trammel nets (which are actually a double gill net of varying mesh sizes), and established a zero soak time

(that is, fishermen were required to begin retrieving their nets as soon as the set was complete) Eckert and Sarti (1997). Shortly before these measures were instituted, the citizens of Florida, through constitutional amendment, banned the use of all gillnets in state waters in November 1996. Fishery managers around the world may take note of the Florida situation, which illustrates that a public outcry can force stringent management measures when less stringent measures are too little or too late.

PURSE SEINES AND OTHER ROUND HAUL NETS

Seine nets are gear types that can be considered small mesh gill nets that are pulled through the water to capture a target species of fish both for food and bait. Usually one end of the net is anchored in shallow water or on shore and the other end carried by boat or wade fishermen out to sea; then brought back to shallow water or shore, entrapping the target species. Purse seines are deployed from vessels or boats.

The target species is encircled by the net and the bottom of the net pursed or closed to entrap the target species. Pound nets employ the entrapment principle, and are generally anchored with stakes forming a pound or net corral. A single length of netting called a lead line stretches perpendicular from the middle of the pound and is used to guide the target species into the pocket of the net. Pound nets are used in coastal bays and sounds where the water is generally calm.

Impact Assessment

All three gear types (haul seines, purse seines, and pound nets) have been implicated in the capture and mortality of sea turtles (NRC, 1990). However, mortality of sea turtles in these gears is probably not significant because turtles are usually not forced to be submerged and the mesh sizes used are usually small enough that turtles are not entangled. However, pound nets with more slack have more potential for accumulation of debris and marine organisms.

Significant mortality of sea turtles captured in seines is likely to be the direct result of fishermen who kill them for meat.

Mitigation Options

Measures to reduce the incidental take of sea turtles in pound nets would include setting the nets in areas where sea turtles are unlikely to occur. However, based on available evidence, few sea turtles are likely killed in pound nets, as long as due care is employed in releasing the animal. The type of lead lines used in some pound net fisheries can be modified, sometimes simply by stretching it tighter to avoid the potential for capture. In the case of haul seines and purse seines, since this gear is continuously tended by fishermen any turtles incidentally captured can be released from the net in a timely fashion.

POT, BUOY AND TRAP LINES

Entanglement of sea turtles in buoy lines from anchor markers, crab pots, lobster pots, and fish traps has been documented in the U. S and elsewhere. Loggerhead turtles feed on spiny lobsters and crabs and have been known to break into traps to reach the crustaceans.
Kemp's ridleys also feed on crabs and have been known to destroy traps in search of prey. In addition to the possible entanglement in buoy lines, some turtles are likely killed by fisherman because of gear damage.

Impact Assessment

There are no national, regional and international data from which to estimate the global extent of sea turtle mortality due to accidental entanglement in pot, buoy and trap lines.

Mitigation Options

Obvious alternatives to mitigate the potential for sea turtle entanglement in buoy/trap lines are reduction of fishing effort, establishment of restricted fishing zones, and requirements to tend fishing gear more frequently. Management actions to conserve spiny lobster and stone crab stocks, instituted at the state and federal levels in the U.S., have included seasonal fishing restrictions, limits on the number and sizes of traps, and the installation of biodegradable panels in traps to limit their fishing life. Some of these measures will reduce the chances of entanglement of sea turtles (Oravetz, 2000).

HOOK AND LONG LINE GEAR

The abundance of fishing gear using hooks and line around the world is unquantifiable. Hooks, and especially discarded fishing line, have the potential to adversely impact all species of sea turtles. Foul hooking and ingestion of hooks are additional problems.

Impact Assessment

There are no national or regional data from which to estimate the global extent of sea turtle mortality due to accidental catch by hook and line gear.

Mitigation Options

There are no obvious or reasonable mitigation measures

Fig 1: Types of sea turtles in Nigeria

to reduce this take, other than a general educational effort. Fishermen should be continually reminded not to discard their fishing gear in the marine environment, and should be encouraged to use hooks of degradable material. Educational efforts should include information on the proper release of turtles. Where feasible, programs should be established to notify the marine resource or protection agencies of turtle takes by hook and line gear. This would at least help ensure proper release of turtles, recording of the incidents, and provide opportunities for tagging and other research.

RESUSCITATION AND RELEASE PROCEDURES

Oravetz (2000) reported that sea turtles that are dead or actively moving should be released over the stern of the boat. In addition, they should be released only when trawls (or other offending gear) are not in use, when the engine gears are in neutral position, and in areas where they are unlikely to be recaptured or injured by vessels. Orayetz (2000) reported that resuscitation should be attempted on sea turtles that are comatose or inactive but not dead by:

1). Placing the turtle on its carapace (back) and pumping its breastplate with hand or foot,
2). Placing the turtle on its plastron and elevating its hindquarter several inches for a period of 1-24 hr. The amount of elevation depends on the size of the turtle; greater elevations are required for larger turtles. Sea turtles being resuscitated must be shaded and kept wet or moist.

SEA TURTLES IN NIGERIA

Solarin *et al.,* (2005) reported that six species of sea turtles, which occur in Nigerian coastal water, belong to two families. The dominant species of sea turtles include Hawksbill *Eretmochelys imbricate* (*Chelonidae*) and Atlantic leatherback *Demochelys coriacea* (*Demochelydae*). Other species include Atlantic loggerhead (*Caretta caretta*), Atlantic green turtle (*Chelonia mydas*), Atlantic ridley turtle (*Lepidochelys kempii*) and Olive ridley turtle (*L. olivacea*) all of which belong to the family *Chelonidae* (fig 1).

Many species of sea turtles in Nigeria are in danger of extinction due to illegal poaching, by-catch, and threats to the nesting grounds. None of these sea turtle species can sustain catches like these. IUCN reported that; Hawksbill turtles are critically endangered; Green turtles are endangered while Olive Ridley turtle are also endangered, all of which are available in Nigerian sea.Sea turtles are protected under the Endangered Acts in Nigeria marine waters, Sea Fisheries Decree (No 17) of 1992 which is being reviewed and makes it mandatory to install Turtle Excluder Devices (TEDs) in shrimp trawl nets (Federal Republic of Nigeria Official Gazette, 1992).

REDUCTION OF SEA TURTLE MORTALITY IN NIGERIA

Among the reptiles only sea turtles have been found to occur in small numbers in Nigerian waters. There is no targeted fishery for sea turtles, but are caught in trawl nets especially shrimp trawl during fishing. In industrial

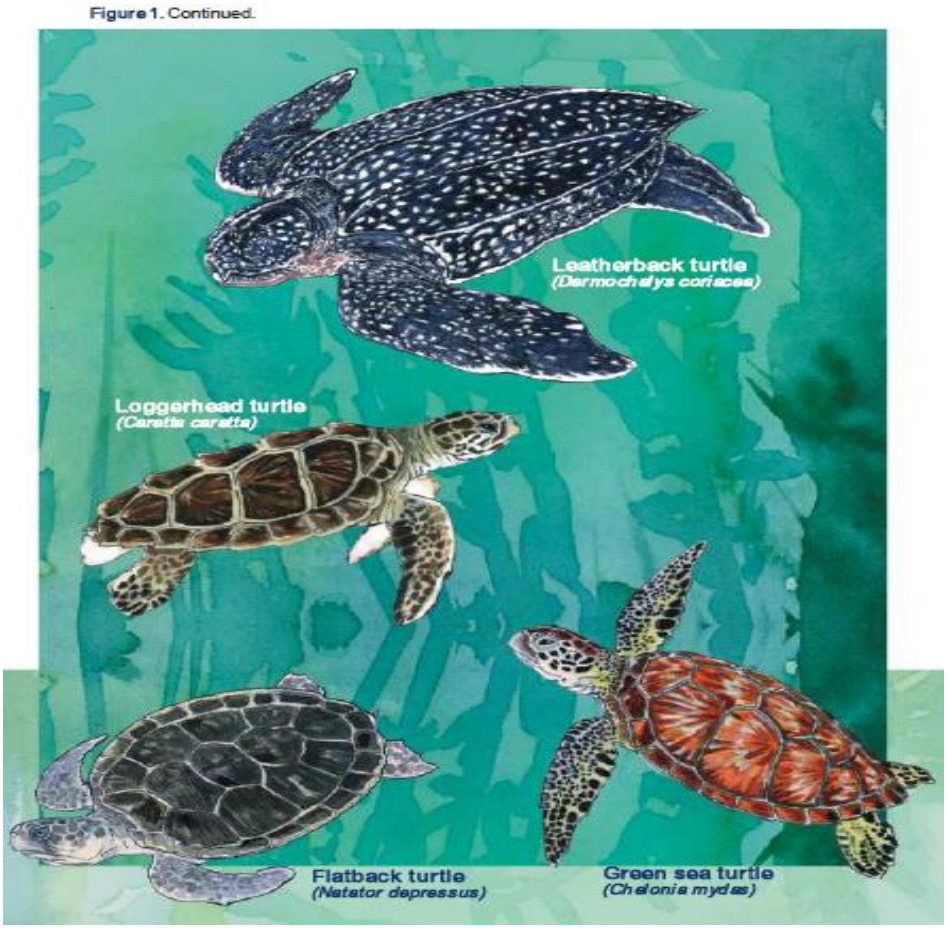

Fig 1: continued

fisheries, sea turtle mortality is reduced in recent years due to mandatory use of TED in Nigeria. The types of turtle excluder device used in Nigeria are the weedless types and super shooter with length and width of 70cm and bar spacing of 10cm and installed at an angle of 45^0. (fig.2)

The latter that has a simple design has been adopted for the industrial shrimp fishery in Nigeria (Solarin *et al,* 2005).In artisanal fisheries, catching of sea turtles is not monitored by Government agencies, hence there is a massive mortality of sea turtles in artisanal fishing gears like beach seine, long lines and beam trawls.

In Nigeria, Solarin and Ambrose (2008) found out that 26 beach seine caught an average of 6 turtles/canoe a year i.e. a total of 156 turtles per year. In addition, 36 long lines canoes caught an average of 10 sea turtles per canoe a year,i.e. a total of 300 sea turtles per year. The total catch estimate was 3428 turtles per year.

In an assessment of fish by-catch species of coastal artisanal shrimp beam trawl fisheries in Nigeria, Ambrose *et al.* (2005) observed that the sea turtles *Eretmochehys imbricate* constitutes 4.40% by weight of the total by-catch sampled in a year.

SEA TURTLE CONSERVATION AND SHRIMP TRADE EMBARGO IN NIGERIA

With effect from May 1, 1996, exports of wild- harvested penaeid shrimps to the United State of Nigeria were embargoed. This action was made necessary by a US court imposed requirement that all such shrimp imported into the US must be harvested by means that protect the endangered sea turtle species. Commercial shrimp trawlers using mechanical means to harvest must use nets equipped with a turtle excluder device (TEDs) in accordance with the US regulations. This embargo also applied to all tropical countries exporting shrimp to the US.

The notice given Nigeria was too short. Nigeria did not have the technology for TEDs. With financial assistance from the World Bank and National Agricultural Research Program, the federal government of Nigeria intervened by developing her local TEDs. The short notice notwithstanding, the awareness of the importance of TEDs has been thereafter created in Nigeria. Literature and audio visual aids on TEDs were obtained from the US and circulated amongst Nigerian fishing companies.

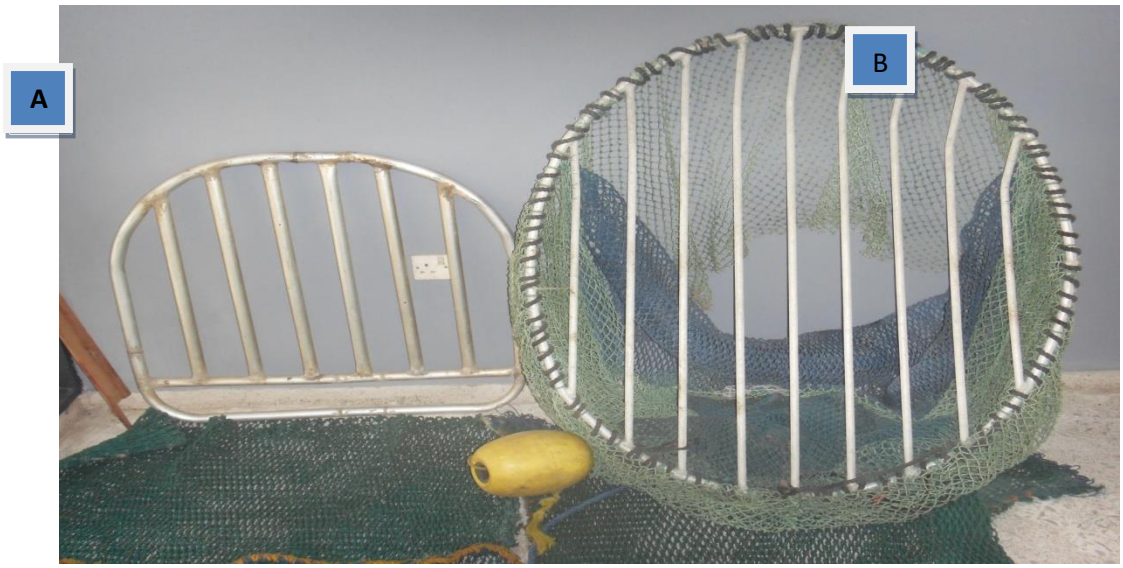

Fig 2. Nigerian models of Turtle excluder Device grids:
A= Weedless; B= Super shooter

About six months after the embargo was placed on Nigeria, there was a stockpile of shrimps valued over seven hundred and fifty thousand United State dollars. Appeals were made to the Nigerian Government to make regulations for the mandatory use of TEDs in trawl nets. Some fishing companies including Allison Fisheries Limited and Intercontinental Fisheries Limited imported prototype TEDs from US, fabricated, tried and put them on sales. Conscious of the importance of protecting the marine turtles, the Nigerian government officially made regulations for the conservation and protection of the sea turtle stocks this was done in accordance with sections 14(h) and 15 of the Nigerian Sea Fisheries Decree (No. 17) of 1992. These sections of the Decree made provisions for the Honorable Minister in charge of Fisheries to make regulations on the conservation and protection of stocks of sea fish including sea turtles. The regulation on sea turtles captioned “Conservation of sea turtles in Nigeria marine waters, sea fisheries decree (1992):mandatory use of turtle excluder devices (TEDs) “was published in the Nigerian Business Times on Monday, October 21, 1996.

The Department of State of US through the US Embassy in Lagos monitored the prompt action taken by the Nigerian fishing industry and the Nigerian Government in putting into place the mandatory use of TEDs. On January 14, 1997 Under Secretary, Joan E. Spero certified to the American Congress that Nigeria fulfilled the requirements of section 609 of 101-162. The export of shrimp’s embargo was on the interim lifted. As part of the renewal of the certification for future exports, the Department of State of America proposes to send to Nigeria a US State –National Marine Fisheries Agency Team. The purpose of the visit was to conduct a workshop for net makers and fishing boat crew in TEDs installation and use. While in Nigeria, the team accompanied government of Nigeria officials, from the Federal Department of Fisheries, Nigerian Navy and Nigerian Institute for Oceanography and Marine Research, which the first author was among to visit shrimp boats to examine TEDs installed in shrimp nets.

CONCLUSION

Sea turtles population is threatened mostly by incidental catch in fisheries, destruction of nesting ground and poaching of eggs in nesting grounds. Modification of fishing gear like trawl to reduce the incidental capture of sea turtle like the use of turtle excluder device is enforced in developed countries. Many developing countries including Nigeria have complied with the U.S regulations, because they control the international shrimp market with the largest market share. In artisanal fisheries, turtle population is impacted by gill net and long line gear operations, there are no monitoring and enforcement; hence turtle mortality is not reported.

ACKNOWLEGMENTS

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