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Impacts of large pelagic fisheries on the survival of sea turtles in Sri Lanka

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Large pelagic fisheries in Sri Lanka are developing rapidly, with an ever-increasing offshore fishing fleet. Over 3000 boats at present are actively engaged in fisheries employing gillnets and longlines accounting for more than 95 % of the total fishing effort. However, both fishing methods have long been cited as major cause for sea turtle mortality. Incidental catch data of sea turtles are somewhat ambiguous to make up a noteworthy representation in the large pelagic catch statistics of Sri Lanka which is collected through port sampling programme. Since all species of sea turtles are protected by law, the turtle encountered in the gear is usually returned to the sea as discards. In complying with the IOTC Resolution 12/04 the conservation of marine turtles, the interaction of sea turtles with fishing gear (separately for gillnet and longline) targeting tuna have been studied at two major landing centers in the west coast; Negombo and Beruwala over one year period via direct communication with fishermen, monitoring of catches, onboard observer programme and stranding data. Between the two fisheries gillnet fisheries have a low sea turtle interaction relative to the longline but relatively higher numbers are reported dead in gillnet fisheries than in longline. Catch and fleet data was used to estimate total number of captures per year at local scale and then at large through a conservative approach. The species of sea turtles recorded in the incidental catch, in order of abundance, were Olive Ridley (*Lepidochelys olivacea*), and Green (*Chelonia mydas*). Number of strategies and measures that can be applied to minimize interactions with sea turtles through modifications to gear and/or current fishing practices while curtailing the impact on the catch rates of the targets species have been discussed. It is highlighted that night fishing with either method would noticeably reduce sea turtle interaction with fishing gear.

Introduction

All seven sea turtle species of the world are threatened or endangered with extinction mainly as a result of many human-related activities (IUCN, 1999). Incidental capture in fisheries is perhaps the greatest threat to juvenile and adult populations of them (Wallace et al., 2013). Fishing gear such as trawls, longlines and gillnets, as well as the ingestion or entanglement in discarded or lost fishing gear, are all cited as major sources of mortality for sea turtles worldwide (FAO, 2010).

Sea turtles regularly carry out long migrations during their life cycle, usually between feeding and nesting areas. Unfortunately, these vast migrations and the tendency to concentrate in highly productive areas often coincide with the majority of fishing efforts, making them vulnerable to incidental capture. The nature and frequency of sea turtle interactions depend on fishing methods and gear characteristics (Lewison *et al*. 2009, Wallace *et al*. 2008, 2010) and also spatial and temporal overlaps between fishing activities and critical habitat for given sea turtle species (Zydelis *et al*. 2011).

Legal protection

Out of seven species of sea turtles recorded in the World five species; green turtle (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*) are regularly visiting the sandy beaches in south, west and southeast in Sri Lanka for nesting. They all are legally protected under the Fauna and Flora Protection Ordinance, No 2 of 1937 and the Fisheries and Aquatic Resources Act, No 2 of 1996. Sea turtles and their eggs, both on land and sea, are completely protected by amendments to the Fauna and Flora Protection Ordinance in 1970 (for the leatherback turtle) and by regulation in 1972 (for the other four turtle species). The punishments meted out to offenders have been increased by the Fauna and Flora Protection (Amendment) Act No 49 of 1993). Under Section 30 of the Fauna and Flora Ordinance (as amended), it is an offence to kill, wound, harm or take a turtle, or to possession a turtle (dead or alive) or any part of a turtle, to sell or expose for sale a turtle

or part of a turtle, or to destroy or take turtle eggs. Further, Sri Lanka has entered into the International Trade in Endangered Species (CITES) agreement in 1979 which prohibits member nations from export or import of turtles and their parts and products.

Objective

The records on the extent of sea turtle by-catch in Sri Lanka are confusing due to their contradictory nature (Jinadasa, 1985; Kapurusinghe and Saman, 2001). There is a need for accurate estimation of the impact of fisheries on sea turtle to address concerns regarding sea turtle interactions with the local fisheries. This is especially crucial given the compulsory adoption of IOTC resolution 12/04. Quantification of the extent of interaction in offshore large pelagic is important to introduce measures to mitigate and minimize interactions with sea turtles while minimizing the impact on the catch rates of the targets species.

Incidental catch data of sea turtles are somewhat ambiguous to make it noteworthy representation in the large pelagic catch statistics of Sri Lanka though which collect through port sampling programme. To address to current data deficient condition this comprehensive study was conducted to obtained the following information;

- identify the fishery types (off-shore) that affect the life of sea turtles
- identify and measure the greatest and harmful fishing method that affect the life of sea turtles
- identify the sea turtle species which is greatly affected
- identify the procedures that can be introduce to minimize the damages and threats on life of sea turtles

Methodology

The present study is a major step forward in providing estimation for the levels of turtle by-catch in Sri Lankan fisheries.

Information for this study was collected basically from primary sources. Two methods were adopted to collect primary data;

- Intensive port sampling (in addition to regular monitoring of large pelagic fisheries by NARA officials)
- Onboard observation
- Interviews of fishermen

Research Assistances and Field samplers of the National Aquatic Resources Research and Development Agency (NARA) and undergraduate students of the University of Sabargamuwa – Sri Lanka participated in data collection.

The study area and the sampling sites in the present study were selected considering well reported sea turtle nesting and feeding grounds around the island (Amarasooriya, 1999). Two major fisheries employed in large pelagic fisheries especially in offshore and high seas were selected for the study as sea turtles are reported to be more vulnerable to these gears (IAC, 2006).

Data for the present study was obtained through intensive port sampling as well as from onboard sampling listed below.

Port sampling programme

Fisheries District	Sampling site	Fishing method	Duration of data collected	Enumerators
Negombo	Pitipana	Offshore large pelagic fisheries – gillnet, longline	January-September 2013	University students NARA samplers
		Offshore large pelagic fisheries –	January 2013 to January	NARA samplers

		gillnet, longline	2014	
Beruwala	Beuwala habour	Offshore large pelagic fisheries – gillnet, longline	January-September 2013	University students NARA samplers
		Offshore large pelagic fisheries – gillnet, longline	January 2013 to January 2014	NARA samplers

Onboard observation Programme

Month	Port	Fishing gear	Trip duration	Fishing days	Fishing area
January- 2013	Negombo	Gillnet + Longline	19	9	Southwest
February	Negombo	Longline	13	7	Northwest
March	Negombo	Longline	17	8	Southeast
April/May	Negombo	Longline	11	8	South
October	Mirissa	Gillnet + Longline	23	11	Southeast
November/December	Negombo	Longline	9	5	Southeast
April/May – 2014	Negombo	Longline	19	11	Southeast

Interviews of fishermen focused on gathering information on fishing experience, traditional knowledge of fishing success, fishermen perception on the turtle by-catch, characterizing practices and frequency of turtle encounter, fishermen awareness and perspective on turtle by-catch and turtle conservation and suggestions to reduce turtle by-catch.

Data collection

During port sampling data was collected by interviewing skippers and crew members and also by administration of a questionnaire. Unfortunately, there may have been some

reluctance to report accurate information because of legal protection of sea turtles. Thus, it took quite a long period for enumerators to develop a good faith and relationship with fishermen. After became friendly they allowed observer onboard their vessels. Thereafter, we expand the scope of the initial progrmme and deployed onboard observation to study sea turtles during fishing operation. Field visits were made twice for the period of January-September 2013 and one a week from October 2013 to January 2014 covering both sampling landing centers.

The format of the questionnaire was standard for both coastal and offshore fisheries. The key questions included:

- Total number of craft landed by gear and craft type
- No. of crafts sampled by gear and craft type
- Fishing rage (distance from the shore)
- Fishing time
- Fishing depth
- Fishing gear used
- Bait used
- No. of hooks or nets employed
- Hook type and size
- Fish catch (kg)
- Incidental turtle catch by species, approximate weight (kg)
- Condition of the turtle (live or dead)
- Action take (released the animal, thrown it to sea, killed onboard brought the flesh, brought the animal to the land)
- Fishermen's observations on the occurrence of turtles in the fishing found

Semi-structured interviews were conducted with fishermen to study the follows;

- To understand the knowledge on the legal aspects
- Attitudes for wild life conservation
- Attitudes for conservation of environment
- Traditional knowledge

Data recording and analysis

Data was stored in Excel spread sheet and was analyzed to study the followings separately for offshore gillnet and long line fisheries;

- Relative impact of offshore fisheries on the survival of the sea turtles
- Most threaten fishing method
- Most vulnerable species
- Management issues related by-catch of sea turtles

Analysis

Catch rate or the entanglement rate of sea turtle was estimated monthly basis separately for gear type.

$E^t = n^t/N^t$

Monthly total catch was estimated as;

$E^t = n^t/N^t*D^t$

Where;

E^t = Average catch rate of gear t (Number per month)

n^t = No. of sea turtle captured by gear t

N^t =No. of boats sampled of gear t

D^t = total No. of boats of gear t landed per month

Average number of fishing days per month for offshore fisheries was taken as 30 days because the landings are made throughout the month. Fishing effort was estimated as catch per boat.

The following fisheries were study studied;

Offshore fisheries	Abbreviation
Tuna longline	TLL
Longline cum large mesh gillnet	GNLL
Large mesh gillnet	LMGN

Fishing methods sampled

Large mesh gillnets

Large mesh gillnets are operating targeting tuna and tuna line fish in the outer range of coastal waters, offshore and high seas. Nylon net is generally made from 6 inches mesh of 24 ply multifilament. It is rigged in 100 meters length panel or piece, and the net is generally consisting about 20-25 such panels. Generally a net is deployed in 2-2.5 m depth from the surface. Nets are shot during the sunset and haul before dawn.

Pelagic longline

Pelagic longline is targeting tuna and tuna like species and thus call tuna longline. It is operate both in coastal and offshore waters. Coastal operation of tuna longline is quite seasonal and confined to limited areas; Kandakuliya-Thalawila (northwest coast) and Trincomalee (east coast) and conduct with small 19-20 ft FRP/OBM boats. Offshore and high sea operation is done with Multiday inboard motor boats of 35-50 ft of length. Coastal longline operation was not studied in this study.

The mainline is the basic part of longline gear and it is made up of units or baskets. The thickness of the monofilament mainline generally is 250 mm, which is made from polyamide. Branch lines are connected to the mainline at appropriate intervals. Each basket consist 5-7 branch-lines, each with a wire leader and a hook. Branch-lines are monofilament of 170-180 mm thickness. Branch line is about 40-45 meter in length in offshore gear and 25-30 meters in coastal gear. Circle hooks of No. 5 are basically used both in coastal and offshore operation. Mainline is suspended using monofilament float-line of 10-30 meter in length and 170-180 mm in thickness. Small boats operating in coastal waters carry 150-200 hooks while in offshore multiday boats

carry 300-400 hooks. Boats equipped with line haulers carry 500-750 hooks. Generally branch lines are stored separately and attached to the main line while casting the line, each hook being baited just before leaving the vessel to the fishing ground. Sardines and flying fish are used as bait in coastal longlining while in offshore *Decapterus sp*., squids, milkfish and trench sardine are used as bait. In the offshore waters generally longline is shot before dawn and hauled with the sunrise.

Sea turtle identification

Species identification based of local names used, diagnostic features, and illustrations,

FAO Fisheries Synopsis No. 125, Volume 11 FAO SPECIES CATALOGUE - SEA TURTLES OF THE WORLD; AN ANNOTATED AND ILLUSTRATED CATALOGUE OF SEA TURTLE SPECIES KNOWN TO DATE was also used to identify species.

Results

Sampling activity

Number of days sampled collectively by NARA officials and the university students during the study period at Pitipana-Negombo and Beruwala-Habour is listed in Table 1

Fishery	2013												2014
	J	F	M	A	M	J	J	A	S	O	N	D	J
Pitipana	8	8	9	7	9	9	8	8	9	5	5	5	5
Beruwala	8	7	8	7	8	8	8	8	8	5	5	6	5

Number of boats sampled collectively by NARA officials and the university students during the study period at Pitipana-Negombo and Beruwala is shown in Figure 1. During the study period 2806 boats were sampled; 1398 boats in Negombo and 1408 in Beruwala respectively.

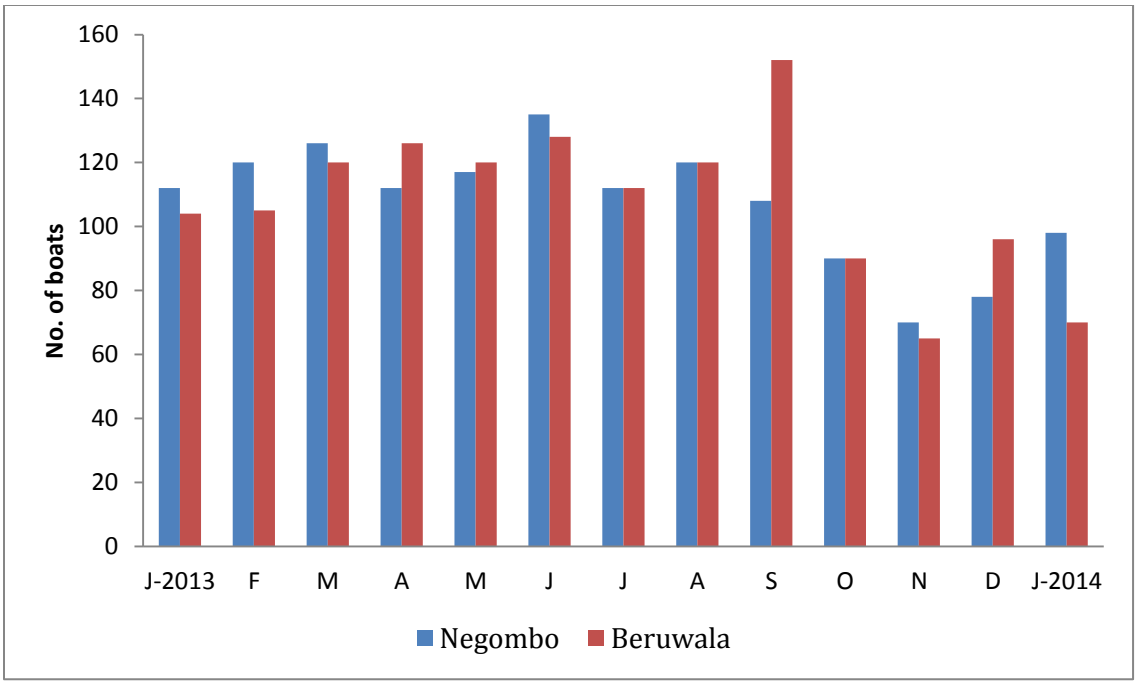
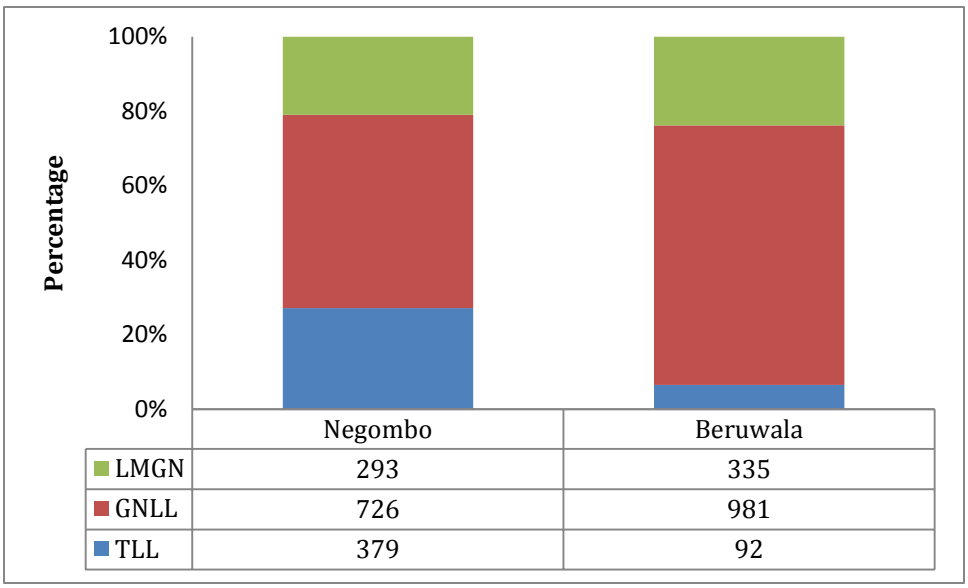


Figure 1: Total number of boats sampled in Naegombo and Beruwala

Random sample of boats employed in different fishing methods is shown in Figure 2. In Negombo 27% of the sample represented tuna longline boats while 52% and 21% represented by gillnet longline combine boats and gillnet boats respectively. In Beruwala tuna longline boats represented only 7% while 70% gillnet longline combine boats and 24% gillnet boats.



	Negombo	Beruwala
LMGN	293	335
GNLL	726	981
TLL	379	92

Figure 2: Total number of boats sampled by gear

Fishing effort

Fishing effort of the day is the total number of boats landed in that particular day. Monthly total fishing effort and the sampled effort is shown in Figure 3.

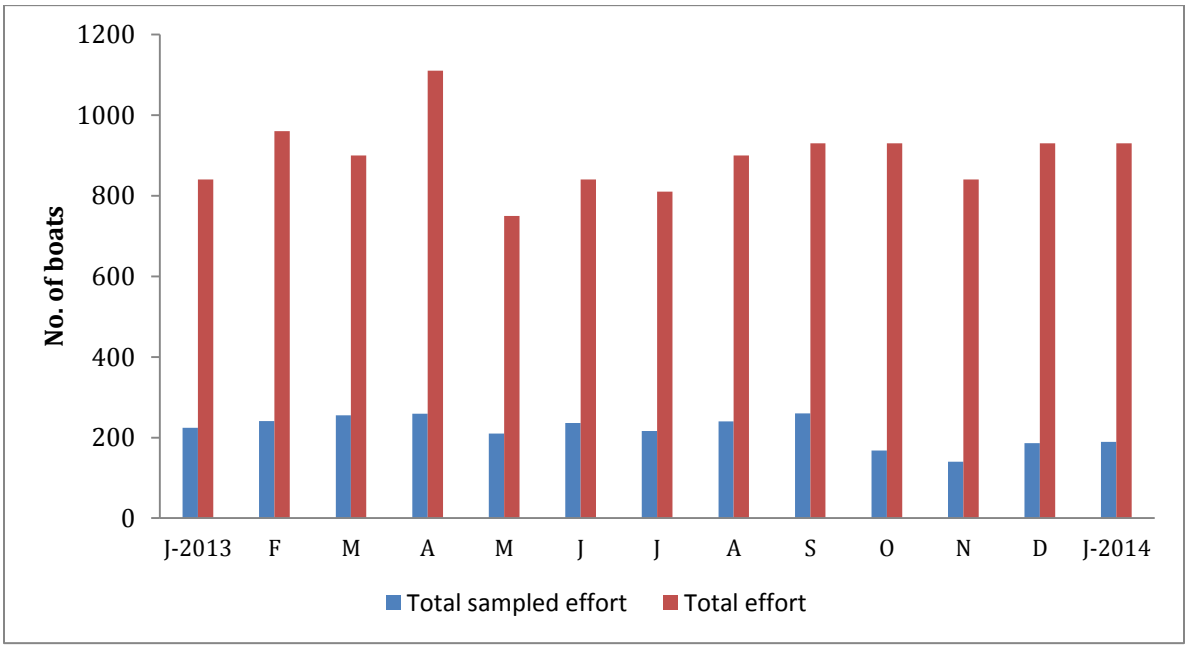


Figure 3: Total monthly fishing effort

Over 25% of the total landed boats was sampled in most moths except from October 2013 onwards.

Interaction of sea turtles in offshore and high sea large pelagic fisheries

Number of boats encountered with sea turtles in the respective sampled days at Negombo and Beruwala are listed in Table 2.

Fishery	2013												2014
	J	F	M	A	M	J	J	A	S	O	N	D	J
Negombo	0	2	0	0	0	0	1	0	0	1	0	0	0
Beruwala	0	0	0	0	0	0	0	0	1	0	0	1	0

A total of four sea turtles at Negombo and two in Beruwala were reported during the sampling days and when it extrapolated to the total landing there was sixteen sea turtles in Negombo while nine in Berueala (Figure 4).

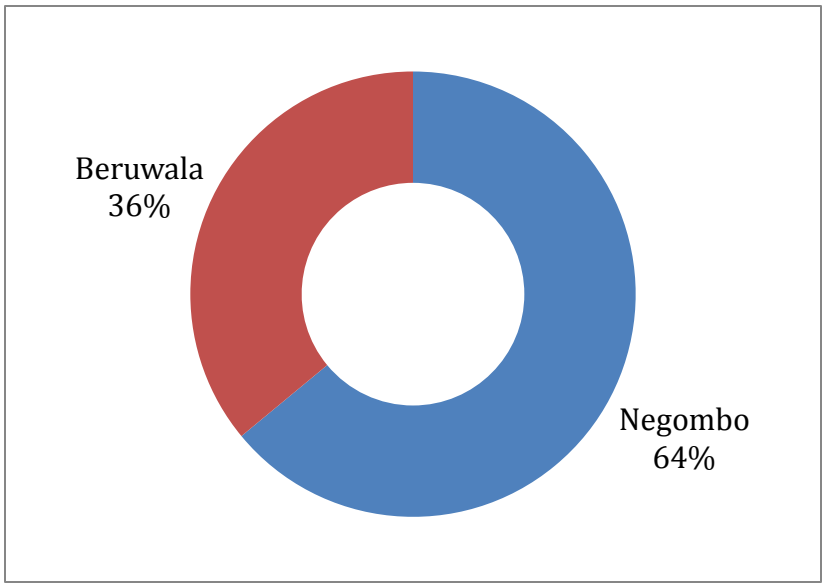


Figure 4: Fisheries interaction of sea turtles

Incidental catch rate

Incidental catch rate (catch per boat) is 0.009 and it is quite low and insignificant. When it extrapolated to the total estimated effort it is about 103 numbers. The most vulnerable fishing gear is tuna longline operating in offshore and high seas (Table 3). Interviews revealed that in the gear combination boat (gillnet and longline) sea turtles were mainly caught in longline.

Table 3: Estimated average incidental catch rate of sea turtle by gear

Fishery	Total No. of boats sampled Jan-2013 to Jan 2014	Total No. sea turtles encountered	Incidental catch rate (No. per boat)
TLL	471	12	0.025
GNLL	1707	10	0.006
LMGN	628	3	0.005

Catch composition

Out of six sea turtles caught by all gears during the study period five numbers represented by Olive Ridley and only one Green turtle (Figure 5). Hawksbill, Logger head and Leatherback were not reported in the present study.

Olive Ridleys are more vulnerable to offshore longline fisheries while Green turtle was reported in gillnet operation (Figure 6).

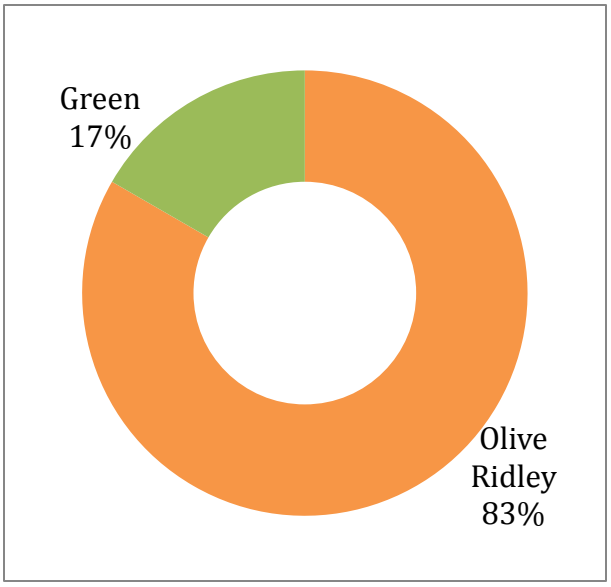


Figure 5: Species composition of sea turtle catch

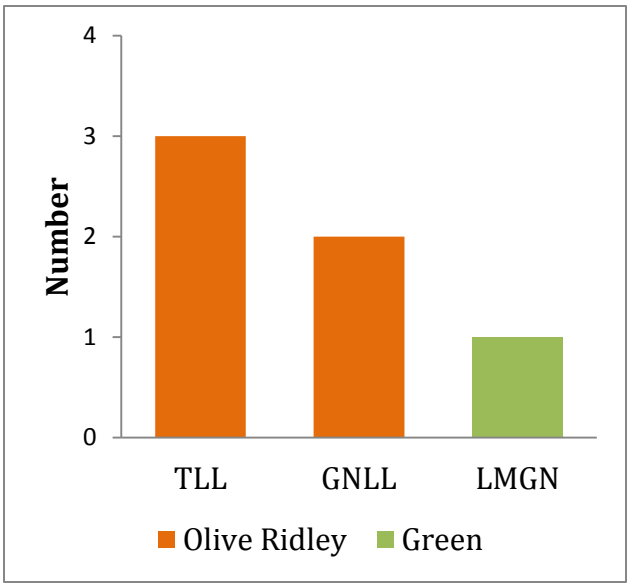


Figure 6: Sea turtle catch by gear

Sea turtle catch status

Of the sea turtles encountered in longline fisheries were reported to be dead when gear was hauling while the Green turtle entangled in gillnet was alive and thus was released..

Effect of hook type

In the longline fishery the most commonly used hooks are circle hook and Japanese tuna hook. These were used only by 18% of the sample studied. Use of Japanese tuna hooks is more popular among Negombo fishermen. 'J' hooks are not used in pelagic longline fisheries. Although interaction of sea turtles in longline is quite low out of five sea turtles

caught in longline fishery four were reported from longline rigged with Japanese tuna hooks. Since the number caught was low it is not possible to make any inference.

Effect of bait type

Many bait species have used in pelagic longline fisheries. However, in tuna longline fisheries mostly use imported bait species especially squids and scomber (*Scomber scombrus*) while in boats operating longline with gillnets are used many types of bait mostly locally available such as milk fish (*Chanos chanos*), flying fish, herrings, scads, Indian mackerel, squids etc, considering the availability in large quantities, not expensive and providing best economic returns. It is noteworthy to further study the situation that all sea turtles reported in longline fisheries during this study were caught at times when imported squid has been used as bait.

Observer reporting

Although there was no sea turtles encountered as an incidental catch in fishing trips made with an observer onboard there were 22 sea turtles free swimming sightings reported when the boat was cursing to and from fishing grounds with in the fishing zone. It was noted that sea turtles show special distribution pattern to some degree (Table 4).

The number of sea turtles sighting were mainly reported from west and southwest coasts and abundance decline gradually towards both direction; south and north.

Table 4: Sightings of sea turtles

Fishing zone	No. of occasion visited	No. of fishing days	No. of sea turtle sighted	Sighting per fishing day
Northwest	1	7	5	0.7
West	1	1	1	1.0
Southwest	2	8	9	1.1
South	3	12	5	0.4
Southeast	4	31	2	0.1

Further, it was noted that their sightings were reported primarily in coastal waters within 50 km from the shore and less number was seen in offshore waters. The observations further revealed that sea turtles show some affinity for floating objects especially plastic bottles. During cruising floating plastic bottles and styrofoam boxes were observed in several occasions especially in the coastal seas of southwest coast and turtles were associated around these objects.

Traditional knowledge

The interviewed commercial fishermen have fishing experience ranging between 5-15 years. The sea turtle encounters reported by respondents were depending on several factors; time of the year, Luna cycle, weather condition, surrounding habitat and the fishing depth. It was noted that fishermen in different fishing zones (areas) had different experiences with sea turtle encounters. A number of fishermen described sea turtles being caught only when the gear was set in shallow waters, in full moon days and at the time of the year when the water was warm. Longline fishermen have experienced that use of squids influence in getting caught of sea turtles.

Fishermen perception

All fishermen interviewed were well aware of the legal protection and conservation status of sea turtles but uncertain about why there is such an interest in sea turtle conservation.

In response to the impact of fisheries on the survival of sea turtles majority of them are of the view that they had not observed decline in sea turtles in the seas that they fish. They may be unconvinced that there is a by-catch problem or simply do not understand the problem. A few respondents strongly believed that that the effort to stop catching sea turtle is meaningless as there are many other greater threats that should be given priority. They identified several aspects which they perceived as threats to sea turtle survival, such as habitat loss, pollution and sand extraction, pouching of eggs. Most of them believed that there are fewer killings of sea turtles at present and some numbers acknowledged that sea turtles may need help. The perception of the majority was that sea turtle by-catch and commercial fishing activities are not an issue for sea turtle conservation and the overall perception that the threats are external to the fisheries.

When questioned about potentially reporting by-catch of sea turtles majority of them regarded it as another plan to stop fishing for larger tuna and others showed distrust and believed this concept was a "double –edged sword". They believe this will also an action as the banning of treasure shark.

Discussion and conclusion

The present study shows that incidental capture of sea turtles in the two major fisheries; gillnets and longline targeting large pelagic fish in the offshore and high seas are quite low and thus impact to the survival of sea turtles is insignificant. Current practice of fisheries such as deploying of gear confined to sunset hours, use of circular hooks, more use of non-attractive fish bait species and also use of multifilament nets may influence in mitigating likely impact of prime fisheries on sea turtle vulnerability. Of the two fisheries; gillnet and longline impact of longline on sea turtles is relatively higher and often carnivores Olive Ridley are likely to get attracted the bait.

All five species of sea turtles species reported in Sri Lanka are considered endangered to local level and even global extinction because of declining numbers. Therefore, it is desirable to gain

information on their interactions in large pelagic fisheries, and to limit their mortality in such fisheries where possible.

Managing fisheries interactions with sea turtles is an international conservation issue. Though sea turtles are legally protected in Sri Lanka no provision covering the interactions of sea turtles with any fishing method. The degree of fisheries interactions with sea turtles in Sri Lankan waters is largely unknown. Mandatory reporting of interactions with sea turtles is limited to that derived from port sampling where no turtle retained onboard due to legal offence. The present study adopted several methods to gather more precise information on fisheries interaction on sea turtles.

The current reporting requirements relating to sea turtles are not widely known by fishers, which may contribute to non-compliance. Reporting of incidental catch is likely to be successful and accurate if fishermen made aware of its objectives and importance in sea turtle conservation and understanding that reporting does not present a threat to their opportunities and way of life, and if it is adopted as voluntary stewardship rather than enforced.

Adopting of co-management arrangement in which responsibilities for the management of incidental catch of highly concern species such as sea turtles, seabirds etc. are shared among government and fishermen through cooperative process and also adopting of cooperative fisheries research would ensure long-term viability and better economic returns from fisheries while meeting conservation objectives. Further, promoting awareness and providing education on sea turtle biology and importance of sea turtle conservation could foster voluntary stewardship and conservation initiatives among fishermen. By engaging fishermen and co-managing the fishery, fishermen would be motivated and empowered to develop, implement and self-monitor mitigation measures in order to minimize incidental catch of critical species.

The National Aquatic Resources Research and Development Agency (NARA), research arm of the Ministry of Fisheries and Aquatic Resources Development of Sri Lanka has made

another step forward in order to ensure sea turtle survival. A sea turtle refugium has been now established at the Regional Research Station in Kalpitiya to give protection to injured and disabled sea turtles.

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