Effect of bait and hook types on pelagic shark by-catch and discards of tuna longline fishery in Sri Lanka

Balawardhana D.G.T.C. [1], Jayasinghe R.P.P.K.[1], Haputhantri S.S.K .[1], Ariyarathna M.M.[2]

1 National Aquatic Resources Research and Development Agency (NARA), Colombo 15, Sri Lanka

2 Department of Fisheries and Aquatic Resources, Colombo 10, Sri Lanka

Abstract

Sharks can be identified as the dominant by-catch of the tuna targeting longline fishery in Sri Lanka. Understanding of the effect of bait type, hook type on catch rate of retained and discarded sharks is a significant factor to be considered to management of the shark by-catch. This study aims to investigate the status of shark by-catch retained and discarded by tuna longline fishing activities of multiday boats in Sri Lanka from January 2020- December 2023, based on the logbook data. Further field surveys were conducted randomly to verify the shark by-catch landings at the fishing harbours. Catch rate (Number/1000hooks) were estimated relevant to the hook type and the bait type. Four types of hook were identified during the survey (J 36, J26, 0 83 and 0 17) and highest CPUE was recorded by J shape hoop type 26 size (0.0889ind/1000hooks) while no records of retaining shark landing by circle shape 17 size hooks. Highest percentage of live released of sharks were recorded by the O shaped 83 size hooks. highest catch rate (0.0836 ind/1000hooks) was recorded by the squid bait followed by the flying fish (Family Exocoetidae) (0.0640ind/1000hooks). Generalized Linear Model resulted the positive effect of J 26 hook type and flying fish bait type on the catch rate while logistic regression model. Flying fish and J 26 hook type combination resulted the highest likelihood of catching sharks (Odd Ratio=4.5, $p<0.00$). Use of circle shape hooks can be recommended to reduce the by-catch but, further investigations should be conducted on the effect of other fishing operations and environmental variables to make proper conclusion. Further studies are recommended to introduce gear modifications to reduce the shark by-catch.

Key words: Pelagic sharks; by-catch; tuna longline; hooks; bait types; Sri Lanka

Introduction

The pelagic longline fishery operating targeting tuna and swordfish in coastal and high seas is an integral part of the commercial fishing industry which contributes significantly to the economy and food security in many coastal nations (Bavliff et al., 2004; Santos et al., 2024). However, the mortality of by-catch species in this fishery has been identified as a critical issue that has caused a significant ecological impact on marine ecosystems (Anderson et al., 2011). Among the most vulnerable species, pelagic sharks are dominant while discarding or retention is being determined due to the market value and the regulations that have been imposed to prohibit retention (Gilman et al., 2017; Jordaan et al., 2020). Since sharks play a vital role as the top predators maintaining the ecosystem balance, this by-catch has significant ecological consequences (Stevens et al.,2000; Fortuna et al., 2024). Pelagic sharks such as the Oceanic whitetip shark (*Carcharhinus longimanus*), Shortfin Mako (*Isurus oxyrinchus*) are particularly vulnerable to the pelagic longlines making them vulnerable to overfishing due to their biological aspects such as slow growth rate, late maturity and low number of offspring produced (Gallagher et al.,2014). As a result of the high mortality rate of the by-catch landing by longline fishery, a significant decline in the shark populations can be expected and this leads to raising concern among conservationists and the prompting the neediness for sustainable fishing practices (Mandelman et al., 2008; Molina & Cooke 2012).

In Sri Lanka tuna longline fishery is one of the key fishing gears which supplies considerable contribution to the total large pelagic fish production in Sri Lanka (PELAGOS). Compared to other oceans, by-catch could be 20%-40% of the total Indian Ocean longline catch including Blue sharks (*Prionace glauca*) and Mako sharks (*Isurus* sp) (Lewison et al., 2004; Liu et al., 2009; Kiszka et al., 2010; Kaplan et al., 2014). Few studies have been carried out to assess the shark by-catch composition in the tuna longline fishery in Sri Lanka due to the scarcity of information and that has been affected directly to the implementation of management measures to prevent the over-exploitation (Hasarangi et al.,2012).

Over the past few decades, research efforts have increasingly focused on minimizing the mortality rate of non-target species caught in longline fisheries. (Swimmer et al., 2020; Santos et al., 2024). One of main factors that affect the shark by-catch of tuna longline fishery is the type of bait used.

Type of bait is the one of most important influential factors in the longline fishery (Coelho et al.,2012; Lokkeborg,2014; Kumar et al., 2016). Different bait types can attract different species and it affects the quantity and the composition of the by-catch. Additionally, the depth and duration for which bait remains in the water are also important factors that determine by-catch. Amorim *et al.*,(2015) and Gilman *et al.*(2016) have noted that the increase by-catch of sharks when using fish baits. Therefore, understanding how bait type affects the shark by-catch is crucial for developing the effective mitigation strategies.

The other main factor that affects the quantity and the composition of the by-catch is the hook type/ shape of the hooks. Commonly used hooks in the longline fishery are J-hooks and circle hooks. J-hooks have been identified as the effective hook that capture target species like tuna with deep hooking which increase the mortality of the by-catch sharks. The circle hooks have been shown to reduce the deep hooking and increase mouth hooking in some pelagic fishes by-catch (kerstetter and graves 2006; important) Even though some studies have been revealed that the circle hooks may reduce the overall by-catch, it is depending on the species and the fishing conditions. According to Ward *et al.* (2009) a significant increase in the blue shark catch rate with circle hooks was observed as compared to J-hooks. Epperly et al. 2012 stated that the probability of boating a dead swordfish, bigeye tuna, or blue shark is increased when caught on a J-hook. The use of circle hooks has been emphasized as the mitigation measure to reduce the by-catch in various fisheries, but the effectiveness in the context of the tuna longline fishery in Sri Lanka has not been assessed.

Since, some combinations of the bait types and the hook types would be more effective and the interaction between the bait types and the hook types may be complex, the combine effect of the bait type and the hook type on shark by-catch should be assessed. Moreover, environmental factors such as water temperature, depth, time of the fishing are important factors to determine the by-catch rates, Therefore, a comprehensive study is needed to develop effective mitigation measures to reduce the shark by-catch in the tuna longline fishery in Sri Lanka.

This study aims to investigate the effect of different bait types and hook types on shark by-catch, including both retained and discards sharks, in the tuna longline fishery in Sri Lanka. By systematically evaluating the combinations of bait and hook types, this study seeks to identify the most effective method to reduce shark by-catch without impacting to the tuna landings. The

findings of this study will have significant implications for developing management measures related to the tuna longline fishery in Sri Lanka.

Materials and Method

primary data for this study was obtained from the logbooks containing gear setting id, quantity and weight by species, retained/discarded, details of the longline including hook type and the bait type used with the fishing locations. An initial assessment has been done to quality control and to ensure the completeness of the data. Summary statistics were calculated including the frequency of use of different bait types and hook types, and the proportion of shark retained and discarded in the catch. Catch rates were calculated as the number of individuals caught per 1000 hooks. Normality and homogeneity of variance were checked by using the Shapiro-Wilk normality test and the Leven's test for catch rates, bait types and hook types. The Generalized Linear Model (GLM) was used to model the relationship between catch rates and hook type, and bait types. Logistic regression was used to model the probability of shark by-catch being discarded and retained with bait type and hook type.

Results

During the study four different types of hooks were identified and those were J 36, J 26, O 83 and O17. Highest average catch rate of sharks was recorded by the J 26 (0.0889ind/1000hooks) hook type followed by J 36 (0.0534ind/100hooks) (Figure 1)

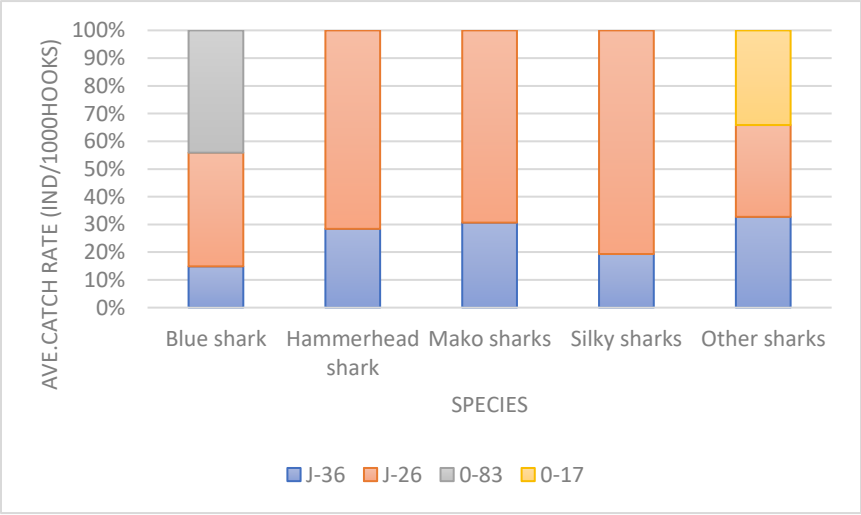

Figure 1: Average catch rate by different hooks types (2020-2023)

Four major categories of bait types were recorded during the study as squids, flying fish (family Exocoetidae), Milk fish (*Chanos chanos*) and others which include scads and artificial baits. The highest catch rate (0.0836 ind/1000hooks) was recorded by the squid bait followed by the flying fish (0.0640ind/1000hooks). Highest catch rate of Hammerhead sharks (*Sphyrna* sp) (0.0208 ind/1000hooks) were recorded when using the Milk fish bait while less catch of Mako sharks (*Isurus* sp) (0.0015ind/1000hooks) could be observed with Flying fish bait. Catch rate of both Silky sharks (*Carcharhinus falciformis*) (0.0114 ind/1000hooks) and Blue sharks (*Prionace glauca*) (0.0101 ind/1000hooks) was higher when using "other" bait type which may include scads and artificial baits.

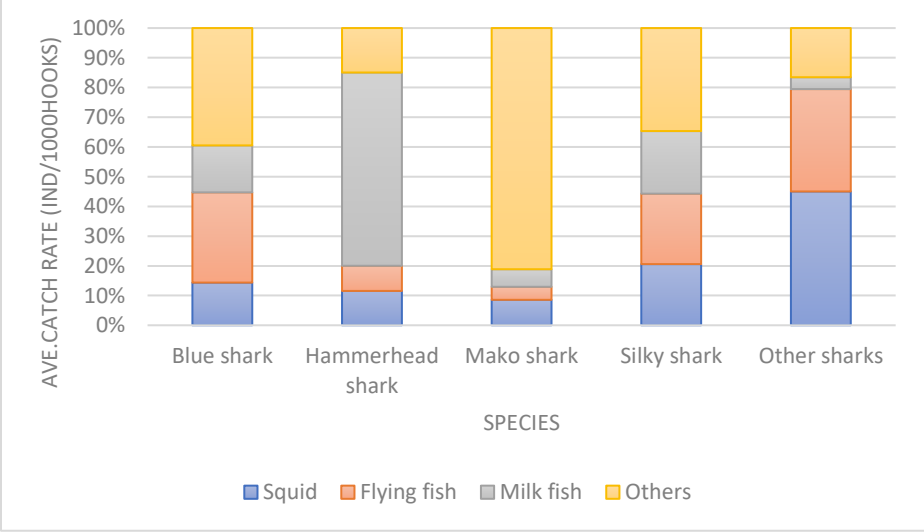

Figure 2: Average catch of sharks according to the bait types.

More than 95% sharks by-catch by tuna longline were retained during the study period and Blue sharks (*Prionace glauca*) and silky sharks (*Carcharhinus falciformis*) showed the highest retaining percentage. Thresher sharks (*Alopias* sp) and Oceanic whitetip shark *Carcharhinus longimanus*) showed the highest live discard percentage () (Figure 3).

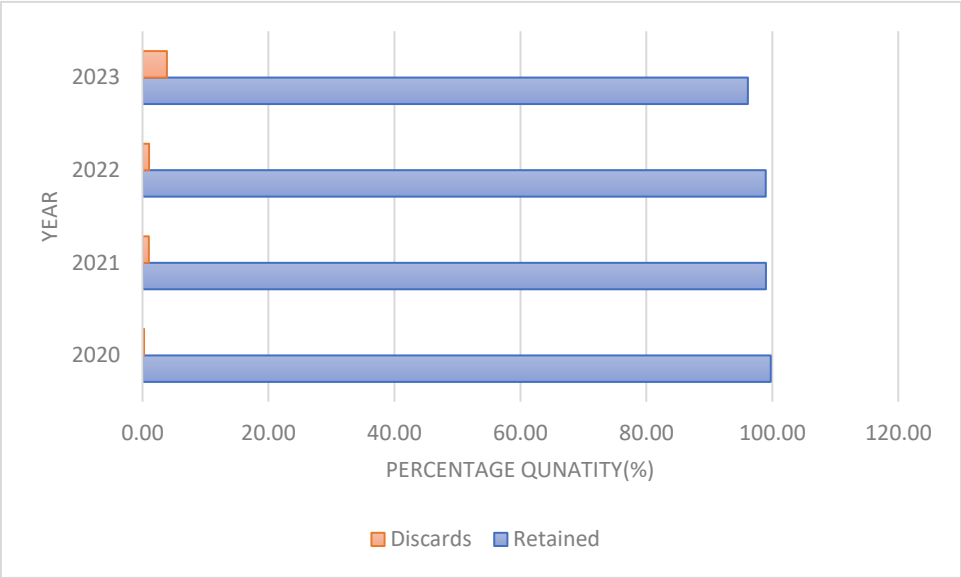

Figure 3: Percentage of retained and discards of sharks by tuna longline fishery (2020-2023)

Based on the results of Shapiro-Wilk normality test (W = 0.74494, p-value = 1.557e-06), the p value is less than 0.005 indicating that the catch rates are not normal distributed while Levene's test for homogeneity of variance, p value is less than 0.001 which indicate the variability of catch rate are not same in all bait types and hooks types. Generalized Linear Model resulted the both bait type and the hook type significantly influence to the catch rate of the sharks ($p<0.005$). The GLM model showed the flying fish bait type significant positive effect on the catch rate (coefficient $\beta=0.25$, p value=0.013) of sharks while J 26 bait type showed the positive effect ($\beta=0.42$, p value=0.006). The interaction between the J 26 hook type and Flying fish bit type showed the positive results also ($\beta=0.45$, $p=0.30$).

The catch probability ratio for the hook types and bait types were estimated from the odd ratio from the logistic regression model. Flying fish and J 26 hook type combination resulted the highest likelihood of catching sharks (Odd Ratio=4.5, $p<0.00$).

Discussion

Tuna longline can be identified as the species- selective, eco-friendly, effective fishing gear that use for targeting large pelagic fishes (Kumara et al., 2016). But, one of major issue related to the tuna longline is the high by-catch rate (Lewison et al. 2004). Since pelagic longlines are being used to targeting mostly tuna and sword fish, incidental entanglement of the pelagic shark species has been identified as the serious concern recently due to the negative impact to the shark populations (Bonfil, 2000). Hook type and the bait type are crucial factors which affect the hooking of by-catch species including sharks and sea turtles . Hence, effect of hook type and bait type on by-catch species by tuna longline have been assessed in most of the studies in different regions.

Since, tuna longline fishery plays an important role in high seas fishing industry in Sri Lanka, and shark by-catch landing has been raising as significant concern recently, it is important to study the factors affecting the hooking of shark by-catch of the tuna longlines. Gunasekara & Haputhantri , 2021 has stated that the there is a significant effect of bait type of tuna longline fishery in Sri Lanka while Bandaranayake et al, 2023 have emphasized the effect of bait type of longlines targeting sword fish in Sri Lanka. Present study provides the evidence of hooking of sharks based on the different bait types. Even though in previous studies conducted in 2016-2019 periods have described the 7 different types of bait types which used in longline fishery, after 2020, bait types have been categorized into the four types as squids, Flying fish, Milk fish and others. The highest catch rate (0.0836 ind/1000hooks) was recorded by the squid bait which showed the high catch rates of target species of tuna by previous studies (Coelho et al., 2012). Highest catch rate was recorded when using the J shaped hook types which specified as J 36 and J 26. J shaped hook is considered as the main hook type which shows the high by-catch rates while circle shape hooks are considered as the lowest catch rates which similar to present study. In the records 4 types of hooks were recorded and no shark catches were recorded by the circle shaped 17 hook type.

Results of the Generalized Linear Model revealed the highest cumulative effect on catch rate by the J 26 hook type and flying fish bait type. Kumar et al., 2016 has stated that the increase of shark catches when use of the fish bait which similar to present study. But study done by Foster et al., 2012 has found that the use of circle hook with the mackerel bait has increased the catch of Blue sharks and Mako sharks. Even though use of Mackerel bait for tuna longline has been recorded by

the several previous studies (Bandaranayake et al., 2023), since, mackerel bait type is included in the "other" bait type category specific analysis was not able to conducted to explain the results of high catch rates of Silky sharks and Blue sharks recorded by the "other" bait category,

Highest discards were recorded from the circle shape hooks. But, significant different of the effect of combination of the bait type and hook type was not found for the live or dead discards. But as a proportion discards were recorded as the low as 5% and Thresher sharks and Oceanic whitetip sharks had been discarded alive.

Shark by-catch rate is largely depending on the fishing operations and the environmental factors such as temperature, fishing depth and time of the day like factors. Study on different environmental factors that affecting the shark by-catch is important. Further studies on fishing locations and other factors mentioned above should be conducted to make the gear modifications like mitigation measures to prevent declining of the shark populations in Indian Ocean.

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