Present Status and Future Developmental Perspectives of Pole and Line Fishery in Sri Lanka

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Received: 15.02.2023 Revised: 20.08.2023 Accepted: 14.08.2023 Online: 15.09.2023

Abstract Pole and line fishery is one of the oldest traditional techniques employed in tuna fishing in the Indian Ocean including Sri Lanka, which is mainly targeted to exploit skipjack tuna. This fishery has fallen to a relatively low level of significance during the past three decades. The potentialities for the expansion of pole and line fishery in Sri Lanka are regained with the possible negative consequences allied with the drift gill net in the region. The present study attempts to understand the factors that hinder the practice of gear progressively in past decades while providing necessary recommendations for the future expansion of the fishery. Scarcity of *Dipterygonotus balteatus* (Redbait), the main live bait species used in the fishery is one of the main reasons documented in the literature. The present findings based on Dr Fridtjof Nansen survey in 2018 revealed that the resource is abundant in the waters but requires an efficient harvesting technique. The impediment factor which hindered the popularization of the fishery is the deficiency of free schools of skipjack tuna where more than 99% of the surface tuna were found to be concentrated beyond the fishing range of existing practices. The commercialization of pole and line fishery in Sri Lanka will be feasible primarily with the modernization of the fishery which includes vessel upgrades, introduction of Fish Aggregating Devices (FADs), forecasting of free tuna schools, and efficient methods to harvest live bait and secondarily through proper awareness and skill development.

Keywords: skipjack tuna, traditional, fishing gear, Redbait, neritic tuna

INTRODUCTION

Tuna is considered as one of the most harvested fish groups in the world and the Indian Ocean accounts for the second-largest tuna production area. It has been recorded that for nearly 20% of the world's commercial tuna catch is from the Indian Ocean (WWF 2022). Skipjack tuna (*Katsuwonus pelamis*) is the most exploited tuna by many coastal countries along the Indian and the Pacific Oceans (Fonteneau *et al.* 2013), and most catches are recorded from the coastal and artisanal fisheries. Further, Novianto *et al.* (2019) stated that during the last few decades, the catches of skipjack tuna considerably declined in the Indian Ocean including Sri Lanka, one of the main countries harvesting in the region. Also, drift gillnets are used as key fishing gear for skipjack tuna, and usage in Sri Lanka has been prominent in recent years. However, pole and line fishing, which is specifically aimed at skipjack tuna has been practiced in Sri Lanka for about 100 years (Amarasiri 1991) and is considered to be the oldest traditional technique employed in tuna fishing in the country (Stequert & Marsac 1989). Pole and line fishing gear have the advantage of being more environmentally friendly with the most effective and selective nature for skipjack (Miller *et al.* 2017). Moreover, the quality of pole and line caught skipjack is also much higher than that of fish caught using other methods, as every fish caught is brought on board alive (Stone *et al.* 2009). Originally, this method was popular amongst fishermen on the southern coast of Sri Lanka and was later expanded to the eastern coast by migrant fishermen with the motorization of the crafts (DFAR 1995). In the early 1960's, the pole and line catch contributed over 40%

to the total tuna production in Sri Lanka. However, presently pole and line fishery has fallen to a relatively low level of significance in the country (Hewapathirana & Maldeniya, 2013). The limited supply of live bait, introduction of drift gill nets and scarcity of surface tuna schools have been identified as the reasons for the decline (Amarasiri 1991; DFAR 1995). Hence, the potentialities need to be addressed. The sporadic nature of the fishery has resulted in limited updated information on this fishery probably due to outliners in the sample. Updated information on the fishery will be crucial not only on the local scale but also on the regional scale as the fishery mainly targets high commercial valued species.

In recent years, drift gill nets have been widely used in skipjack tuna fishery and it has been negatively discussed due to issues of by-catch (MRAG 2012; Anderson *et al.* 2019) as well as environmental sensitiveness (Sala 2015). Hence, more restrictions are being considered in the gill net fishery to mitigate the by-catch (IOTC 2021). Furthermore, it reveals the importance of transformation towards environmentally friendly fishing gear. In consideration of the specificity of target species, quality of fish caught, and minimal environmental damage, the pole and line could be a positive replacement for gill nets. Therefore, it is important to conduct a comprehensive study on the pole and line fishery to understand the potentiality of expanding the fishery as an alternative to increase the market share of the pole and line tuna.

The sustainability of the baitfish is a deterministic factor in small-scale pole and line fisheries. If the live baitfish is scarce or the stock decreases, then the main fishery production will experience a decline (Litaay *et al.* 2021). In Sri Lankan pole and line fishery, *Dipterygonotus balteatus* (mottled fusilier; Family: Caesionidae) Redbait in common is the most preferred species (Sivasubramanium 1972) and during the last two decades, lack of availability of live bait was one of the main reasons for declining of the fishery (Amarasiri 1991; DFAR 1995). Therefore, it is vital to evaluate the abundance and distribution of bait resources in Sri Lankan waters as one of the initial steps for developing the pole and line fishery as a solution for decreasing the usage of drift gill nets. The present study was carried out to address the various aspects of the pole and line fishery in Sri Lanka, such as fishing area, season, and fishing effort in Sri Lanka while understanding the potentialities for the future expansion of the fishery in terms of availability of live bait and free tuna schools.

MATERIALS AND METHODS

A fishery-dependent survey was conducted in two major districts Matara, in the south coast and Trincomalee in the east coast in Sri Lanka, where the pole and line fishery is only being sporadically practiced. Only seven (07) boats belonging to IMUL 1 vessel type category (8.8-9.8 m inboard with insulated fish hold) are being operated for pole and line fishery in Matara while a total of 19 of IDAY vessel type category (8.8-9.8 m inboard without insulated fish hold) in Trincomalee. Data collection was carried out every week from January to June, 2022 which includes the well-known fishing seasons for pole and line fishery in South and East coast in Sri Lanka. The fishing operations were not consistent even during the season and occasional operations could be observed. The sampling coverage was, 55.5% of the total active effort in South and 45.7% in East.

The information related to catch and effort, bait type and fishing seasons and time were collected. The qualitative information such as skills and experience, issues and concerns, and attitudes were also gathered through interviewing fishers those who engaged in fishing in the sampled boats.
Length frequencies were derived based on 171 individuals of skipjack tuna measured for the nearest 0.1 cm. In addition, the distribution and availability of bait species *D. balteatus* in Sri Lankan coastal waters were evaluated using the data of Dr. Fridjof Nansen Ecosystem Survey - 2018 (Krakstad *et al.* 2018).

The distribution of skipjack schools within the Exclusive Economic Zone (EEZ) of Sri Lanka was mapped based on the logbook position data for drift gill net operations from 2016 to 2019. Logbook data were mapped with ArcGIS Pro 3.0.0 (ESRI 2022). Comparing the average and peak catch rates in concerned areas, Total weight lower than 300 kg catch rates was excluded in the maps in consideration of addressing the satisfied concentration of target fish available for a fishing trip.

RESULTS

Present status of the pole and line fishery

The fishing is practiced within 7-10 NM from the coast with approximately 12 hours of true fishing time. The fishing boats depart in early in the morning and arrive in the evening. The barbless hook size used in the fishery is no 16. It was noted that the pole and line fishery in Sri Lanka is being practiced by a limited number of fishermen; 07 in Matara and 19 in Trincomalee, which transfers traditionally, and the art of using technology is not widely popular among the rest. Currently, the fishing effort exerted in the pole and line fishery accounts for only 0.5% of the total fishing effort targeting tuna within EEZ; IMUL 1- 4170; IDAY-860 (MOF, 2021). There are 11 ±2.12 fishermen on board (including live bait collectors) engaged in a fishing trip.

The inter-annual variations of the catch rates of pole and line fishery were remarkable in two regions; Matara and Trincomalee. In Suduwella in Matara District, the average catch rate was 288 kg per boat while the peak catch of 600 kg per boat was recorded in March. In Trincomalee, the average catch rate was 111.6 kg per boat with a peak value of 350 kg per boat in May. However, fishing was not consistently operated even within the season due to multiple reasons such as poor catch rates, lack of free tuna schools, scarcity of bait and fuel crisis. The average active effort in Matara and Trincomalee were respectively 2±1 and 7±2.4 boats per day during the season.

Target species and the length frequencies

The main target species of the pole and line fishery is skipjack tuna (*Katsuwonus pelamis*) which is around 96% of the total pole and line catch. In addition, neritic tuna species; bullet tuna (*Auxis rochei*), frigate tuna (*A. thazard*), and kawakawa (*Euthynnus affinis*) were also recorded as bycatch of the gear. The size range of skipjack tuna recorded during the study ranged between 38 cm to 61 cm (FL) with a mode between 56 and 60 cm (Fig 1). The average lengths recorded in both regions showed that the values were above the length at maturity level as per cited in Froese and Pauly, 2022 (fish base) where the respective value for Trincomalee on the East Coast was 56.4 cm while 49.6 cm in Matara, South Coast. The lengths of the two separate sites further revealed that there was a significant difference between the two regions ($p<0.05$).

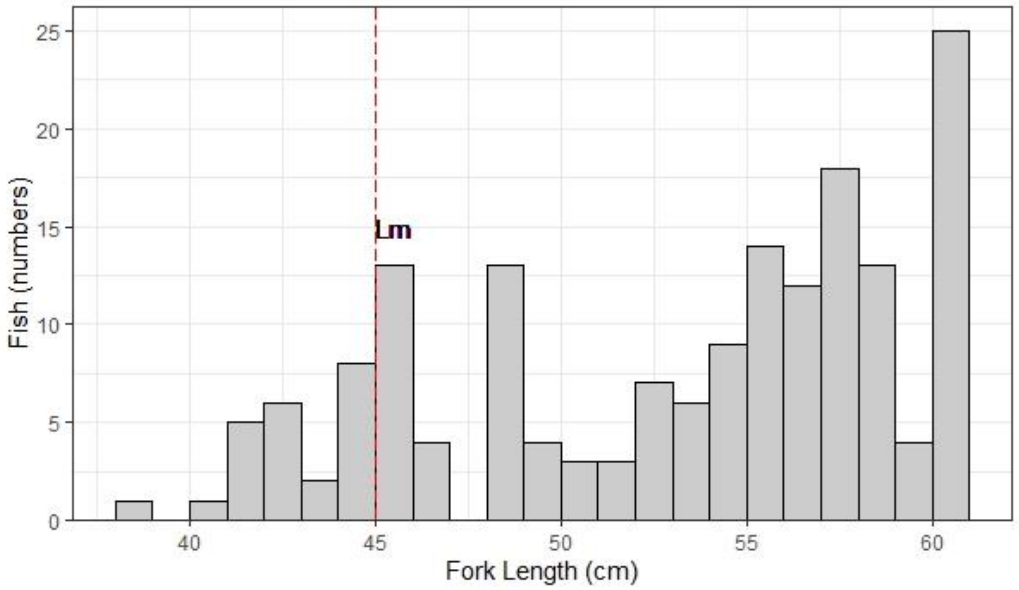

Fig 1 Length frequency distribution of skipjack tuna landings in pole and line fishery, Lm: Length at maturity

Fishing season

It was observed that the well-known fishing season in Matara, South coast (Suduwella) is from December to April while from March to June in Trincomalee, East coast (Sirimapura) which mainly corresponds to the monsoonal impacts in the two regions. Pole and line fishing could not be conducted during the southwest monsoon from May to September on the south coast and the northeast monsoon from December to February on the east coast mainly due to rough sea conditions. Further, the poor water clarity during the monsoon periods impediments the catching of Redbaits.

Bait requirement and distribution of live bait

Dipterygonotus balteatus (Redbait) is the main live bait species used in the fishery. The requirement of live bait per trip is approximately 100 kg and continues to be undertaken as part of the daily tuna fishing operations. Around four members of the crew engage in live bait fishing where they initially dive and search for the availability of fish and then deploy the lift net. This activity is highly dependent on the clarity of water hence, has a great influence on the monsoons. During the Dr. Fridtjof Nansen survey in 2018, *D. balteatus* was recorded abundantly in Sri Lankan waters including the regions where pole and line fishery presently exists (Fig 2). *D. balteatus* was recorded in 31 trawl stations (27 bottom trawl stations and 4 pelagic trawl stations) out of 88 total stations conducted in the survey (Krakstad *et al*. 2018). The majority of habitats for *D. balteatus* were distributed in the depth range of 20 - 100 m of the continental shelf region.

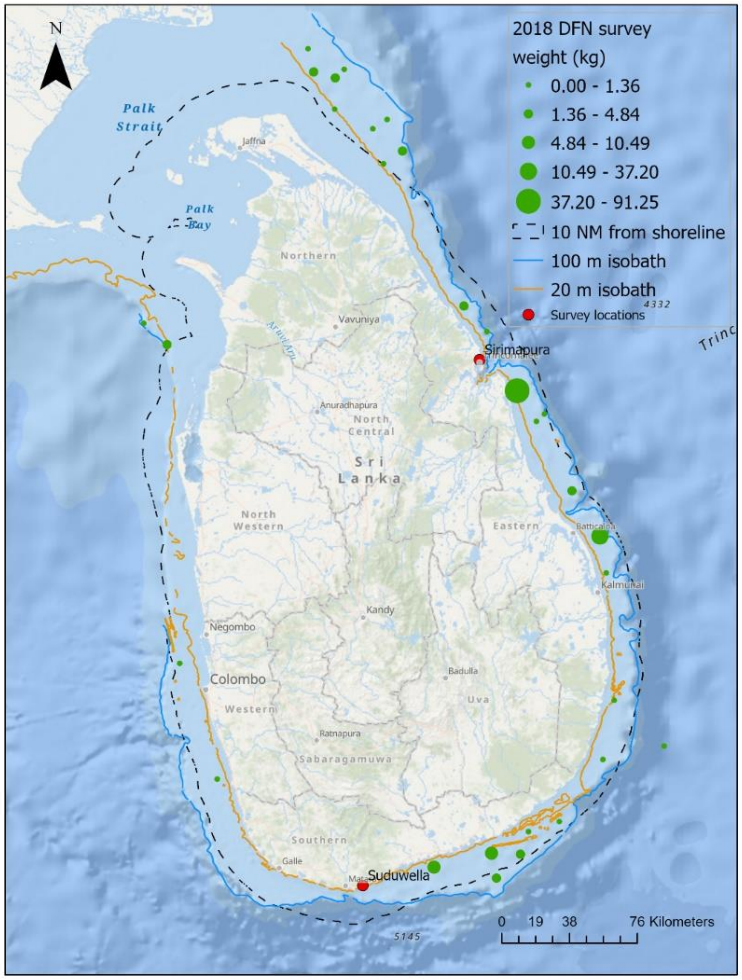

Fig 2 Distribution of *Dipterygonotus balteatus* (Redbait) during Dr Fridtjof Nansen survey in 2018

Skipjack tuna distribution in Sri Lankan waters

Figure 3 exemplifies the monthly distribution of skipjack tuna locations by drift gill net operations (>300 kg per day) over the past years as it reflects the availability of tuna schools for the pole and line fishery around. Skipjack tuna distribution showed that the target fish are abundantly found beyond the 10 NM fishing range where pole and line fishery is practiced. Out of 27,502 fishing operations that had catches greater than 300 kg, only 196 fishing operations (<1.0 %) were found within 10 NM from the shoreline. Further, it was apparent that fishing grounds were concentrated in the east during the northeast monsoon while off the southwest coast during the southwest monsoon (Fig 3). Considering the setting depth of gear, it can be predicted that the occurrence of fish schools would be in between surface to 10m depth, and the live bait in pole and line fishery would have played a critical role in attracting the targets towards the surface.

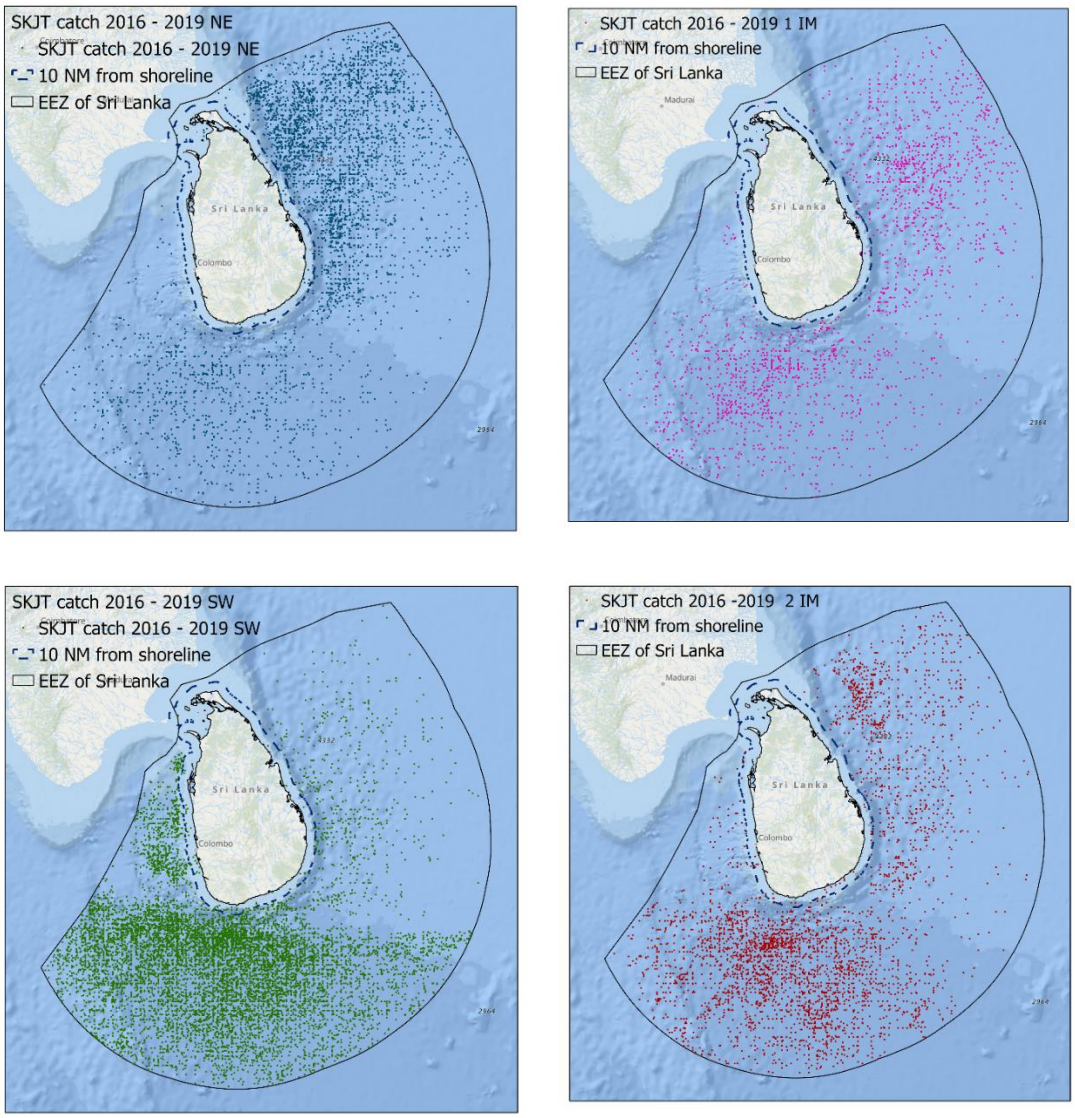

Fig 3 Distribution of skipjack tuna fishing grounds recorded with higher than 300 kg catch per day by drift gill net operations from 2016-2019 (a) Northeast monsoon December -February (b) First inter monsoon from March –April (c) Southwest monsoon May-September (d) Second inter monsoon October-November

DISCUSSION

Pole and line fishery is popular in many countries in the world such as Brazil, Senegal, India, Spain, the United States of America, Portugal, Ghana, South Africa, Namibia, Solomon Islands, Venezuela, Mexico, Ecuador, France, Palau and Cape Verde (Gillett, 2015). The fishery is considered a sustainable fishing practice as they target mainly skipjack tuna and the gear is highly selective with minimal impacts on the marine ecosystems (Jaini & Hisham, 2013; Widodo *et al*. 2016; Miller *et al*. 2017). This fishery around the world is currently being practiced as technologically advanced commercial operations or more artisanal in nature (ISSF, 2022). One of the examples of a successful coastal state-run advanced tuna fishing operation is the Maldives pole and line fishery which accounts for around 20% of the total Indian Ocean tuna catches (Jauharee, 2022) and has yielded impressive socio-economic benefits for the country (Mohammed, 2007). In the Sri Lankan context, pole and line fishery remains traditional and exhausted with an uncertainty about further expansion. While many countries have reached advancements in the pole and line fishery (ISSF, 2022), the introduction and rapid popularity of gill nets in the country have hindered the technological advancements of pole and line fishery in Sri Lanka. Sri Lanka has a major pelagic gillnet fishery, with some 50% of the total fleet (i.e. over 2200 vessels in 2017) using gillnet or multi-gear sets (Hewapathirana *et al*. 2018). However, from a holistic view of the Indian Ocean, the repercussion of gill net allied with the by-catch issues (Anderson, *et al*. 2019; Jayasinghe *et al*. 2019; MRAG, 2012) is one of the main concerns and might be the reason that despite the decreasing trends during last few decades, many nations have taken steps to promote the pole and line fishery (Gillett, 2015). Since, the usage of gillnets are discouraged by the Indian Ocean (Aranda, 2017), Sri Lanka is also able to find alternations for gillnets, where pole and line fishery could be a suitable solution.

However, the findings of the present study revealed that the Sri Lankan pole and line fishery has become very close to extinction and should need to understand the possibilities of restoring this environmentally friendly (Allen, 2022) traditional fishing method.

Before the 1960s, pole-and-line fishing was carried out in 5 to 6 m length sail-propelled dugout canoes with a crew of 5 to 7 men, and during the 1980s, it was by new wooden boats (3-5 t, length 8.5 m) equipped with inboard diesel engines (Stequert and Marsac, 1989). However, no progressive major developments can be observed in the fishery except for the continuous declining trend. Amarasiri (1991) revealed that the effort dropped from 21% in the early 1960s to 7% in the 1990s on the southern coast. The present study further confirmed the prolonged depletion of the fishery with a 0.5% contribution to the total effort.

Insufficient bait supply has been documented as one of the reasons behind the dramatic decline of the fishery in Sri Lanka (Amarasiri, 1991). However, the idea of commercialization of pole and line fishery in Sri Lanka dates back to the 1970s when the Government of Sri Lanka initiated a project for conducting an experimental skipjack fishery for pole and line method and small pelagic fish as live bait using purse seine and lampara nets (Joseph, 1974). Based on the live bait and pole and line fishery survey carried out by 'Seisho Maru-25', 'Kuroshio Maru-70', 'Shinshyu Maru-7', during the early 1970s; Sivasubramanium (1972) contended that if the bait fishing operations had been adjusted in lined with the movements and distribution pattern of the fish, better mean catch rates would have been realized. The sufficient occurrence of live bait was recently confirmed by Dr. Fridtjof Nansen survey in 2018, as it revealed considerably abundant amounts of *D. balteatus* in Sri Lankan waters particularly in the south and east (Krakstad *et al*. 2018) where pole and line fishery currently exists. Hence, it is required to determine an efficient method of harvest them. The *D. balteatus* which is popular among the pole and line fishermen of Sri Lanka as live bait (Joseph, 1974) is still being caught with a special traditional method of lift net. Jauharee *et al*. in 2015 stated that, the Maldivian live-bait fishery has evolved from very labor-intensive daytime fishing to a more efficient method using lights at night as a routine practice. However, the introduction of such efficient techniques for *D. balteatus* such as pelagic trawling or light attraction would be difficult to implement in Sri Lanka with the existing legislation. Moreover, the possibility of utilizing alternative bait types should be evaluated as Maldivian Pole and line fisheries implicit that the

bait fisheries target various species of small pelagic fish such as sprats, anchovies, caesio, or juvenile fusiliers (Stone *et al*. 2009; Jauharee *et al*. 2015, Jauharee, 2022) and sardines (ICCAT, 2008). The availability of these species in Sri Lankan waters mainly in the East and South (Krakstad *et al*. 2018) suggested further research on bait preferences in the fishery. In addition, Rinaldi *et al*. (2019) suggested that Milkfish (*Chanos chanos*) is also an ideal candidate as a live bait. Hence, bait fishery management is also a significant factor in the success of pole and line fishery (Gillett, 2012).

Though the pole and line catch contributed over 40% to the total tuna production in Sri Lanka in the early 1960s, (Amarasiri in 1991), it was evident that throughout the decades, the main constraint continues to remain with the scarcity of free surface tuna schools within the existing fishing range. This would probably hinder the potentiality for the expansion of the fishery. It is found that the fishing grounds of skipjack tuna are freely distributed within the exclusive economic zone (EEZ) but mostly beyond the current pole and line fishing range of 7-10 NM perhaps as a combined result of the immature skipjack tuna caught by ring nets (Ariyarathna & Amarasinghe, 2012; Chathurika and Dissanayake, 2016) and the climate change (Dueri *et al*. 2014; Hsu *et al*. 2021). Therefore, new vessel design is one of the key positive attributes for the expansion of this fishery (Gillett, 2011) which can reach the required distances for free tuna schools. Studies on potential vessel upgrades as a rational approach to increase the production of skipjack, particularly in the range of offshore operations are recommended. It is also advisable to conduct research on the dynamics of fish aggregation and their behaviour with respect to modern fish aggregation devices (FAD) combined with pole and line operations which is a current worldwide practice by many fishers to increase the catchability of tropical tunas (Jauharee, 2022). Moreover, Miller *et al*. (2017) pointed out that, the operation of the fishery is happening in free schools and schools associated with various objects (anchored FADs, drifting FADs, other drifting objects, and seamounts), and these free schools generally consist of a high proportion of large skipjack and less bycatch. Satellite-based potential fishing ground advisories for skipjack tuna to the fishermen which are currently produced by the National Aquatic Resources Research and Development Agency (NARA), Sri Lanka would also be attributed to find free tuna schools (Gunasekera, 2022).

In consideration of the length at maturity estimation for skipjack tuna (40-45 cm) (Froese & Pauly, 2019; Fromentin & Fonteneau, 2001), it was apparent that the pole and line fishery practicing in Sri Lanka mainly targets mature skipjack tuna. The significant difference of the lengths obtained in the two regions could be due to the smaller number of samples, however, it is recommended to conduct future comprehensive biological studies based on spatial differences. Moreover, it is also suggested to conduct quality assurance studies with respect to different infrastructure facilities of boat types engaged in the fishery.

The fish caught from the pole and line fishery has a growing demand from tuna fish processing industries to accept an eco-labeling and eco-certified fishing product because the pole and line fisheries have a better position compared to purse seiners (Widodo *et al*. 2016). Also, Gillett (2010, 2011) mentioned that tuna canning markets in the USA and the UK have special public demands for pole and line fish products. Therefore, the development of pole and line fishery in Sri Lanka would be an investment for the future.

The art of pole and line technology is not very popular especially, among the young generation except those who inherited it traditionally, and has been suggested that attentive technology transfer is a crucial factor in expanding the fishery. However, Gillett (2011) mentioned that the technology behind the pole and line fishery is simpler than the purse seine operations, where local fishers could easily join to extend the country's workforce. Considering the environmental and socio-economical aspects of fishing operations and resources availability (both tuna and baits), it is recommended to establish pole and line fishery in Sri Lanka as a new adventure to harvest tuna resources in addition to the tuna gillnet fisheries which is prominently adopted by the tuna fishing communities in the country. The expansion of pole and line fishery is recommended as a second line phase-out with a proper interim plan.

ACKNOWLEDGEMENT

The financial support provided by the National Aquatic Resources Research and Development

Agency (NARA), Sri Lanka is highly appreciated. Special thanks are due to Mr Laxman Ranawaka and Mr Manoj Wijewikrama for their assistance with the field data collection. Some of the data for this paper was collected through a scientific survey with the R/V Dr. Fridtjof Nansen in Sri Lanka (2018) as a part of the collaboration between the EAF-Nansen Programme of the Food and Agriculture Organization of the United Nations (FAO) and the Government of Sri Lanka. The authors are indebted to the scientific staff and the crew members of the R/V Dr. Fridtjof Nansen for immense support in data collection. Fishers' logbook data provided by the Department of Fisheries and Aquatic Resources (DFAR) of Sri Lanka is acknowledged.

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