Catch Composition and Some Biological Aspects of Silky sharks (*Carcharhinus falciformis*) landed by Surrounding Net Fishery in Sri Lanka.

Balawardhana D.G.T.C[1].,Herath H.L.N.S.[2], Haputhantri S.S.K[1].

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

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

The surrounding net (ring net) fishery in Sri Lanka is responsible for more than 36% of total large pelagic fish landings, while the highest landings are recorded from coastal fisheries (37%). This study was carried out on a monthly basis from January 2019 to December 2021 to investigate the catch composition and reproductive aspects of silky sharks (*Carcharhinus falciformis*) landed as by-catch in the ring net fishery in major fish landing sites in Sri Lanka. Skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacores*), frigate tuna (*Auxis thazard*), and rainbow runner (*Elagatis bipinnulata*) contributed to the by-catch, while sharks contributed quite a small quantity, less than 1% in weight. 82% of the shark by-catch is composed of silky sharks, followed by blue sharks (14%) and *Isurus* sp (2%) A total of 1197 silky sharks were recorded during the study period, and the fork length range was 69–204 cm. The overall sex ratio for males and females was determined at 1:6. The results showed that more than 80% of the silky sharks landed by the purse seine ring net were juveniles. Recorded fishing locations were scattered, but most were confined to the Exclusive Economic Zone. The silky shark can be considered as a highly vulnerable shark species to the ring net fishery in Sri Lanka, and this study provides important information on their reproductive aspects, which will be crucial to the implementation of management and conservation measures.

Key words: Silky shark, Surrounding Net, Ring Net, Sri Lanka

Introduction

The silky shark (*Carcharhinus falciformis*) is a widely distributed and highly migratory elasmobranches species inhabiting pelagic and offshore environments across tropical and subtropical waters, including Atlantic, Pacific and Indian Ocean (Bernard et al., 2016). They are apex predators playing a vital role in regulating marine food webs and excreting significant influence in maintaining the health of their ecosystems (Queiroz et al., 2016). However, these species are frequently encountered with by-catch of long lines, gill nets and the surrounding nets (Gilman et al., 2015; Ita et al., 2010). These fishing gears are caught not only silky sharks but other shark species also (Gilman et al., 2015).

Among the various fishing methods employed in the Indian Ocean, purse seines fishing play a crucial role due to its efficiency in harvesting tuna (Hutchinson et al., 2015). Industrial purse seiners employ encircling nets to capture large schools of migratory fish such as Skipjack tuna, yellow fin tuna and big eye tuna and other fish species that exhibit schooling behaviors near to surface. This fishing method is accompanied by capturing of more than 50 numbers of non-target species including bill fish, sharks, mammals, turtles and sea birds which are collectively referred to as incidental by-catch (Amandè et al., 2008; Gonzalez et al. 2007; Romanov 2002,).

Silky sharks are the most common by catch shark species that represent more than 90% of elasmobranches landing due to the tuna targeting industrial purse seine fisheries using Fish Aggregating Devise (FADs) in Indian Ocean (Gilman.,2011, Poisson 2014). According to the study done by Amandè et al., 2008 silky sharks contributed more than 85% out of all sharks landed by purse seine fisheries in Indian Ocean while catch was dominated by immature individuals. Averagely 85,000 individuals of silky sharks are taken as by-catch annually by Indian Ocean purse seiners (Filmalter et al., 2013).

A range of fishing gears are being used in Sri Lanka to capture tuna and tuna-like species, while long lines, gill nets, surrounding nets and gear combinations are the major fishing gears that contribute significantly to the landings of large pelagic fish in different regions. Ring nets targeting scads are a type of surrounding nets operates encircling floating objects in Offshore and coastal waters in Sri Lanka. These ring nets are found to be lighter and cheaper to use by small boats without haling equipment (Joseph, B. D. L., 1975). Ring nets are responsible for more than

36% of total large pelagic fish landings, while long line and gill nets are responsible for 27% and 22% to total large pelagic landings respectively. According to the Ariyaratne & Amarasinghe, (2012) the Indian scads (*Decapterus russelli)*, rainbow runner, (*Elagatis bipinnulata)* common dolphin fish, (*Coryphaena hippurus*) are dominant in surrounding net fishery and undersized tuna has been recorded as the by-catch. Recently Shark by catch landings by surrounding net fishery in Sri Lanka can be observed. But, data on species composition and catch rates of surrounding net by-catch landings are not available (Sønvisen et al. 2005). This study aims to provide species composition and some biological aspects of silky sharks (*Carcharhinus falciformis*) landed by surrounding net fishery in Sri Lanka.

Methodology

Fish production data submitted to Indian Ocean Tuna Commission (IOTC) by ministry of fisheries and aquatic resources was analyzed to estimate total catch composition of ring net fishery in Sri Lanka. Field data collection was conducted monthly basis from January 2019 to December 2021 in Beruwala, Mirissa, Dondra, Tangalle and Trincomalee fisheries harbors (Figure 1). Ring net operated fishing boats were subjected to data collection while species composition of shark by-catch, weight, fork length, sex and maturity of silky sharks landed by ring nets were recorded.

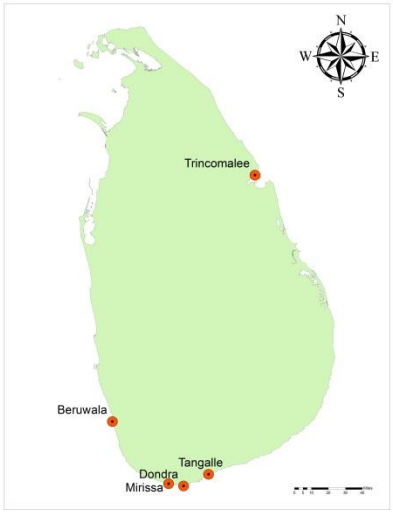

Figure 1: Survey sites of the study conducted during the 2019-2021

Sex was determined according to the presence and absence of claspers. Maturity level of male sharks was determined only from external examinations. The maturity levels were immature (claspers not extending beyond the pelvic fins), maturing (clasper extending beyond the pelvic fin but not calcified completely) and the matured (claspers extending beyond the pelvic fins and rigid structures) (Moore et al.,2012). Apart from this information on fishing effort including gear specifications, fishing time and location were collected by interviewing skippers of the boats.

Results and Discussion

Surrounding net fishery in Sri Lanka contributes more than 37% to total large pelagic fish production in coastal fisheries and 26% and offshore fisheries respectively while long line fishery showed the highest contribution to large pelagic fish production significantly in offshore fisheries (Figure 2).

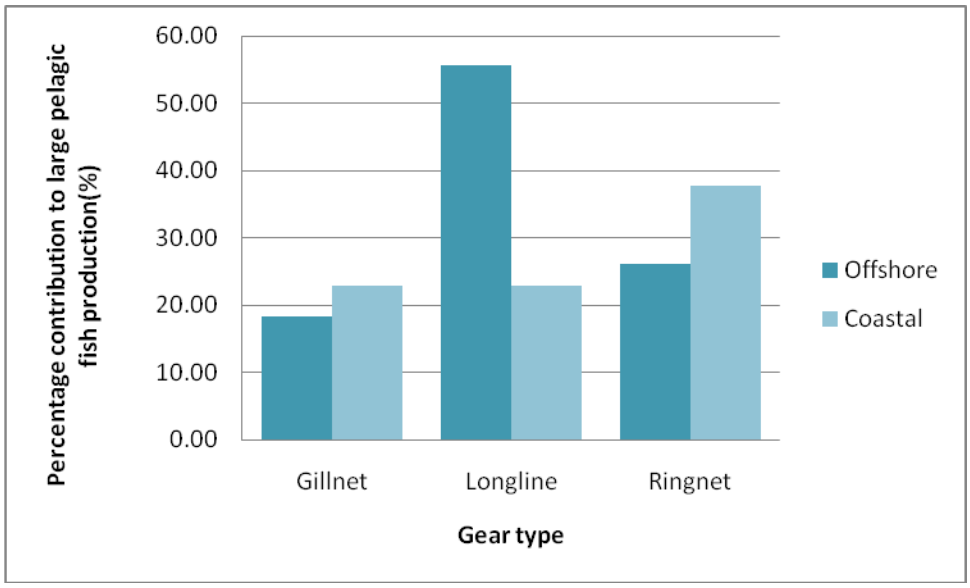

Figure 2: Percentage contribution of by major fishing gears to large pelagic fish production in the EEZ and HS (2019-2021)

In Sri Lanka according to the location that fishing is taken place fishing gears are differentiate and drift nets, ring nets, beach seine, bottom nets are common fishing gears operates in coastal waters apart from long line and gill nets (Gallagher et al., 2023). Surrounding nets (ring nets) which are significantly contribute to landing of Indian scads (*Decapterus russelli*) and mackerel scads (*Decapterus macarellus*) are mostly operate in coastal waters and gears have responsible for the landings of small tuna, sharks and other by-catch species. Tuna targeting purse seiners operates using FADs in tropical waters are responsible for landing of vulnerable species such as elasmobranches and turtles (Dagorn et al., 2012). According to the fish production statistics percentage composition of by-catch landing of sharks by ring net fishery to large pelagic production is less than 1% (Figure 3) in weight.

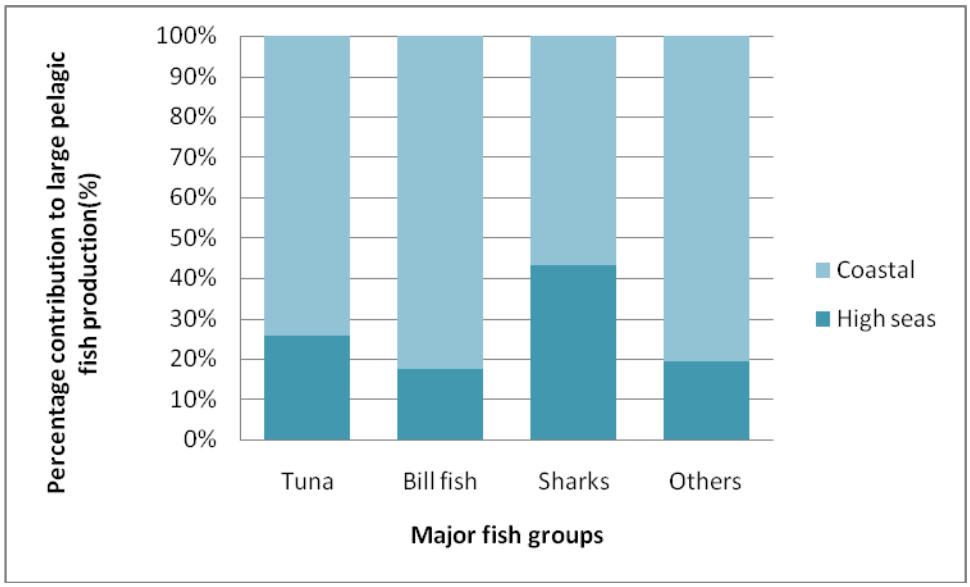

Figure 3: Average percentage composition of different fish groups landed by ring net fishery in coastal and high seas fishery.

But, shark landing by surrounding net fishery is significant and more than 80% of shark landings are consisted from silky sharks followed by Blue sharks (*Prionace glauca*) and *Isurus* sp (figure 4). Previous studies in Indian Ocean region also highlighted the highest catch composition as from family Carcharhinidae dominated by silky sharks by purse seine fisheries (Amande et al., 2008; Romanov, E. V. 2002).

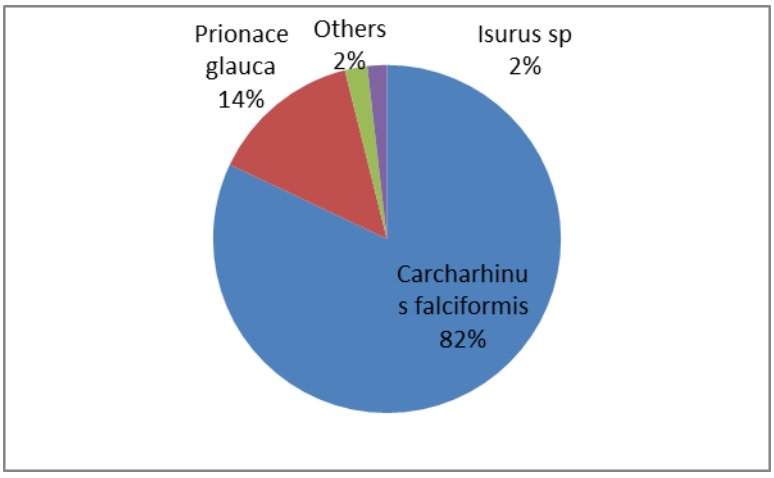

Figure 4: Average percentage species composition of sharks landed by ring net fishery in Sri Lanka from 2019-2021.

A total of 1197 silky sharks were examined during the survey. The fork length range was 69–204 cm. The overall sex ratio for males and females was determined and the ratio was recorded as 1:6 male: female. Imbalance sex ratio for silky sharks also reported from Indian ocean tuna targeting purse seiners by in previous studies also (Dharmadi et al., 2017; Clavareau et al., 2018). The results showed that more than 80% of the silky sharks landed by the purse seine ring net were in immature and maturing stages (figure 5). Since juveniles are found to be highly vulnerable than the adults due to their availability in productive areas because of the nutrient needs (Clavareau et al., 2018). In addition to that significant impact is occurred to the demographic growth due to the large landings of juvenile silky sharks in Indian and Pacific oceanic regions (Hutchinson et al., 2013 & Clavareau et al., 2018). The studies on sex ratio are also crucial (Coelho et al., 2017).

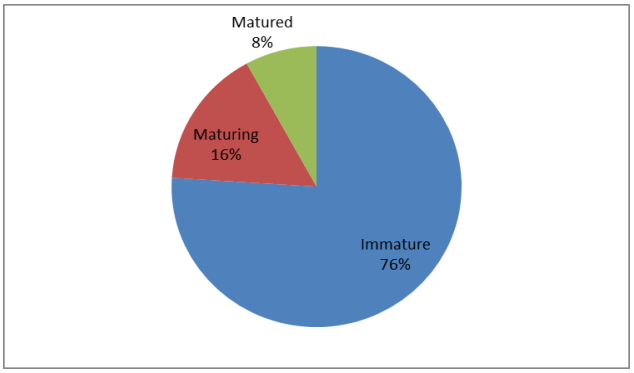

Figure 5: Percentage of maturity levels of silky sharks recorded during the study period.

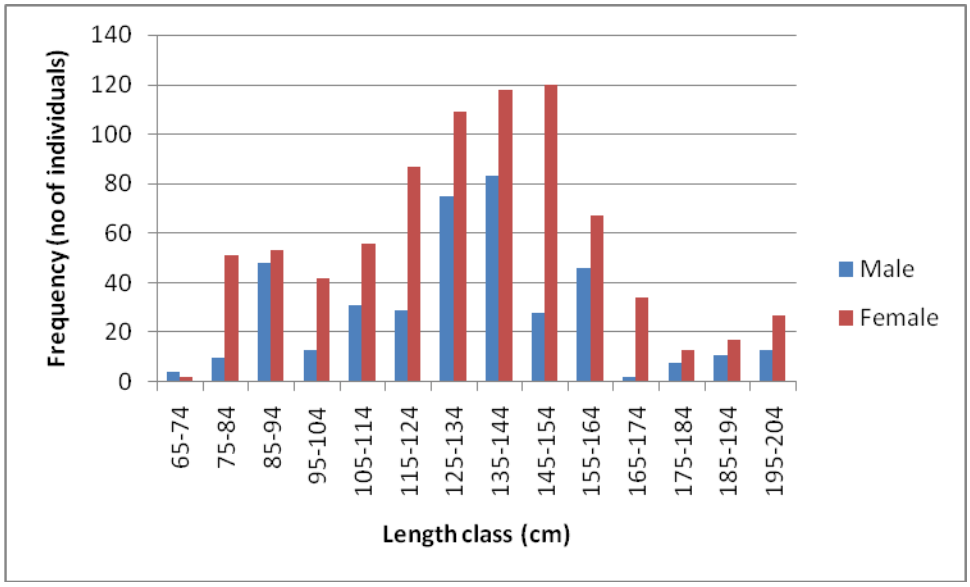

Figure 7: Length-frequency distribution of silky sharks recorded during the study period.

The study found fork lengths of most of the silky sharks landed by surrounding nets during the study period were ranged from 115-155cm. Immature and maturing stages were dominated in the catch. Fork length was ranged from 72-198 cm and 69-204 cm for females and male silky sharks respectively. Higher number of immature silky shark landing can be lead to population decline in Indian Ocean. Survey results showed that most of surrounding nets operations by Sri Lankan fishermen were scattered and scattered from southern to south eastern regions. Therefore, significant proportions of silky sharks landed by surrounding nets were come from the coastal fisheries and tracking fishing locations were difficult. As a result of the fishing gear combinations obtaining precise information on fishing effort is difficult.

Silky sharks are tend to associate with schools of tuna and this is one reason for their vulnerability to long line and purse seine fisheries (Filmalter et al., 2013). According to the previous studies done by Urbina et al., 2018 silky sharks' population in Indian Ocean is subjected to over fishing. Therefore, Dagon et al, 2012 has been necessities of the research to develop the methods are needed to limit the fishing mortality of silky sharks landed by purse seines (surrounding nets). The by-catch of silky sharks by surrounding net fishery raises concern over population declines ecosystem imbalance and potential impacts on fisheries. Since Silky sharks are listed as "vulnerable" on the IUCN red list and listed on the Convention on Migratory Species (CMS) Appendix II mitigation measured should be implemented to ensure the management and conservation. These include setting catch limits, and developing best practices for handling and releasing by-catch sharks.

References

Ariyaratne, M. M., & Amarasinghe, U. S. (2012). A fishery associated with floating objects in the Indian Ocean off Southern Sri Lanka. *Asian Fisheries Science*, *25*(4), 278-289.

Amandè, M. J., Chassot, E., Chavance, P., & Pianet, R. (2008). Silky shark (Carcharhinus falciformis) bycatch in the French tuna purse-seine fishery of the Indian Ocean. *IOTC Proceedings IOTC-2008-WPEB-16: 22p.*

Bernard, A. M., Feldheim, K. A., Heithaus, M. R., Wintner, S. P., Wetherbee, B. M., & Shivji, M. S. (2016). Global population genetic dynamics of a highly migratory, apex predator shark. *Molecular Ecology*, *25*(21), 5312-5329.

Clavareau, L., Sabarros, P. S., Escalle, L., Bach, P., & Mérigot, B. (2018). Elasmobranches bycatch in the french tropical purse-seine fishery of the eastern Atlantic Ocean: spatio-temporal distributions, life stages, sex-ratio and mortality rates. *Collect. Vol. Sci. Pap. ICCAT*, *74*(7), 3740-3753.

Coelho, R., Mejuto, J., Domingo, A., Yokawa, K., Liu, K.-M., Cortés, E., Romanov, E.V., da Silva, C., Hazin, F., Arocha, F., Mwilima, A.M., Bach, P., Ortiz de Zárate, V., Roche, W., Lino, P.G., García-Cortés, B., RamosCartelle, A.M., Forselledo, R., Mas, F., Ohshimo, S., Courtney, D., Sabarros, P.S., Perez, B., Wogerbauer, C., Tsai, W.-P., Carvalho, F., Santos, M.N., 2017. Distribution patterns and population structure of the blue shark (Prionace glauca) in the Atlantic and Indian Oceans. Fish and Fisheries. doi:10.1111/faf.12238

Dagorn, L., Filmalter, J. D., Forget, F., Amandè, M. J., Hall, M. A., Williams, P., ... & Bez, N. (2012). Targeting bigger schools can reduce ecosystem impacts of fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, *69*(9), 1463-1467.

Dharmadi, D., Mahiswara, M., & Kasim, K. (2017). Catch composition and some biological aspects of sharks in western Sumatera waters of Indonesia. *Indonesian fisheries research journal*, *22*(2), 99-108.

Filmalter, J. D., Capello, M., Deneubourg, J. L., Cowley, P. D., & Dagorn, L. (2013). Looking behind the curtain: quantifying massive shark mortality in fish aggregating devices. *Frontiers in Ecology and the Environment*, *11*(6), 291-296.

Gallagher, A., Randall, P., Sivyer, D., Binetti, U., Lokuge, G., & Munas, M. (2023). Abandoned, lost or otherwise discarded fishing gear (ALDFG) in Sri Lanka–A pilot study collecting baseline data. *Marine Policy*, *148*, 105386.

Gilman, E., Chaloupka, M., Merrifield, M., Malsol, N. D., & Cook, C. (2016). Standardized catch and survival rates, and effect of a ban on shark retention, Palau pelagic longline fishery. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *26*(6), 1031-1062.

Hutchinson, M. R., Itano, D. G., Muir, J. A., & Holland, K. N. (2015). Post-release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery. *Marine Ecology Progress Series*, *521*, 143-154.

Joseph, B. D. L. (1975). Purse seining for small pelagic fish around Sri Lanka.

Moore, A. B. M., McCarthy, I. D., Carvalho, G. R., & Peirce, R. (2012). Species, sex, size and male maturity composition of previously unreported elasmobranch landings in Kuwait, Qatar and Abu Dhabi Emirate. *Journal of Fish Biology*, *80*(5), 1619-1642.

Poisson, F., Filmalter, J. D., Vernet, A. L., & Dagorn, L. (2014). Mortality rate of silky sharks (Carcharhinus falciformis) caught in the tropical tuna purse seine fishery in the Indian Ocean. *Canadian Journal of Fisheries and Aquatic Sciences*, *71*(6), 795-798.

Queiroz, N., Humphries, N. E., Mucientes, G., Hammerschlag, N., Lima, F. P., Scales, K. L., ... & Sims, D. W. (2016). Ocean-wide tracking of pelagic sharks reveals extent of overlap with longline fishing hotspots. *Proceedings of the National Academy of Sciences*, *113*(6), 1582-1587.

Romanov, E. V. (2002). Bycatch in the tuna purse-seine fisheries of the western Indian Ocean.

Sánchez-de Ita, J. A., Quiñónez-Velázquez, C., Galván-Magaña, F., Bocanegra-Castillo, N., & Félix-Uraga, R. (2011). Age and growth of the silky shark Carcharhinus falciformis from the west coast of Baja California Sur, Mexico. *Journal of Applied Ichthyology*, *27*(1), 20-24.

Urbina, J. O. D., Brunel, T., Coelho, R., Merino, G., Daniela, R., Santos, C., et al. (2018). *A Preliminary Stock Assessment for the Silky Shark in the Indian Ocean Using a Data-Limited Approach.* Seychelles: IOTC.