

The effect of depth of operation and soaking time on catch rates in the experimental tuna longline fisheries in Lakshadweep Sea, India

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Introduction

Most of the marine fish landings from the Indian waters are from the fishing operations in the coastal shelf area, especially from the shallower region ranging from 5 to 100 m depth (Rao, 2010). Heavy demand for seafood in domestic and international markets underlines the need for increasing the marine fish production. Catch trends indicated that the production from the coastal fisheries is almost stagnant and point towards the need for harvesting unexploited or under exploited oceanic fish resources. Present fleet size of the distant water fishing vessels is very less in spite of India's vast EEZ of 2.02 million sq km and two Islands groups, viz., Andaman, Nicobar and Lakshadweep. The estimated potential

yield of oceanic tuna resources is 2.78 lakh tonnes (Pillai and Jyothi, 2007). Potential of total tuna resources in Lakshadweep Islands is estimated at about 50,000 tonnes (Pillai *et al.*, 2006). A total tuna landing in India in 2010 was 60,512 tonnes along the mainland and 7,883 tonnes in Lakshadweep. The landings trends of these high values fishes indicated a further scope for the expansion of the fisheries. The oceanic tuna fishery of the Indian Ocean is contributed mainly by four species viz., yellowfin tuna, southern bluefin tuna, albacore tuna and bigeye tuna (Joseph, 1972). Longline operations are in its infancy state in India. Surface longline gears can operate at a range of depths, and hooks placed at different depths can have different fishing efficiencies,

depending on the target species and its behaviour. With better knowledge of the relationship between hook depth and foraging behaviour of the targeted fish, catch rates could be improved by placing the majority of hooks at the depth range favoured by the target species. Fishing efficiency of the longline gears are influenced by minor changes in the gear configuration such as type of terminal gear and depth of hooking operations (Broadhurst and Hazin, 2000). Deep setting of the longline gear found to be very effective to reduce the sea turtle bycatch (Shiga *et al.*, 2000; Beverly *et al.*, 2009). Marine mega faunal bycatch is a serious concern in longline fisheries which needs serious attention (Lewison *et al.*, 2004; Diaz, 2005; Garrison, 2007). Major group of animals contributing to the marine mega faunal bycatch are sharks and cetaceans (Gilman *et al.*, 2008; Mandelman *et al.*, 2008; Milian *et al.*, 2008; Mangel, 2010). The depth at which longline fishes is mainly influenced by the gear configuration, primarily by the length of mainline between floats (baskets), sagging rate and parameters such as wind and currents (Suzuki *et al.*, 1977; Boggs, 1992). Tuna shows an aggregation nature near the floating objects which can be effectively utilised by vertical longline operations in the floatsams or FADs (Naeem and Latheefa, 1994). A successful fishing and catch rates greatly depends on the soaking time. The effect of soaking

time on catch rates vary considerably between species to species. Soak time during dusk showed higher overall catch rates (Ward *et al.*, 2004). Experimental longline operations were initiated in the Lakshadweep Sea to tap the unexploited oceanic tuna fishes. This paper discusses the effect of depth of operation and soaking time on the overall catching performance and species selectivity in the longlines operated.

Materials and methods

Fishing operations were carried out from three Pablo boats (7.6 to 8.5 m LOA) modified for longlining in the Lakshadweep Sea around Agatti Island (10°38' - 11°07' N; 70°08' - 72°08' E) (Fig. 1), during 2009-2011. Pablo boats selected for the study were mechanized wooden fishing boats of Lakshadweep Islands ranging from 7.62 m to 8.5 m LOA with engine capacity ranging from 10 to 23.5 hp. Total length of the mainline is 5 km. Mainline and branch lines of the experimental gear were made of polyamide monofilament of 3 mm and 1.8 mm, respectively and float lines were made up of 4 mm dia polyester. Branch lines were 22.5 m long and hooks were deployed in the depth range of 35-100 m by adjusting the length of float lines. Japanese tuna hooks of 3.4 sun with 10° offset were used. The overall depth of the fishing ground ranges from ~ 500 m to ~ 2000m.

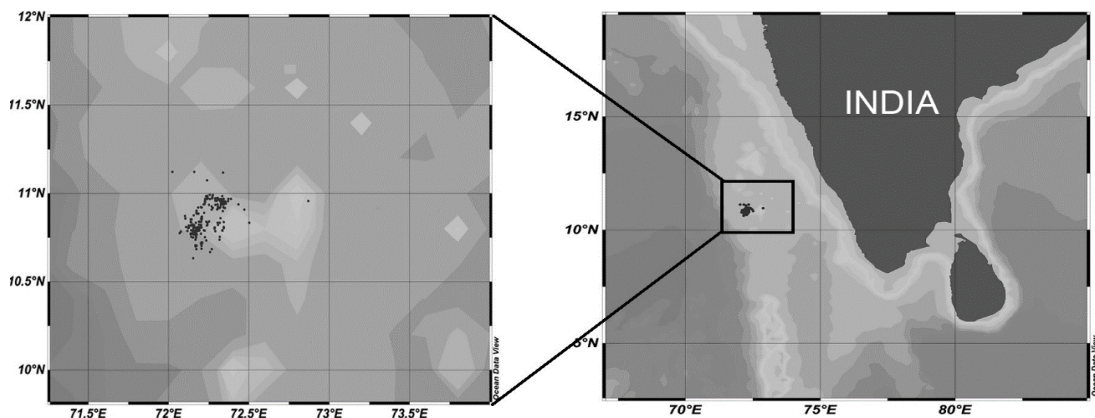


Figure 1: Map showing the fishing area in Lakshadweep waters, Arabian Sea, India ($10^{\circ} 38' - 11^{\circ} 07' \text{ N}$ lat. and $72^{\circ} 01' - 73^{\circ} 18' \text{ E}$ long.) from 16 Nov 2009 to 23 April 2011. The fishing locations are marked as black dots. The depth of the fishing ground ranges from $\sim 500 \text{ m}$ to $\sim 2000 \text{ m}$.

The fishes caught during the fishing operations were grouped into four categories as tuna, sharks, sailfish and miscellaneous fishes for the analysis. The miscellaneous fishes were contributed by lagoon fishes, which include *Lutjanus gibbus*, *Aprion virescens*, and *Epinephelus polylepis*. The study compared the effect of hook depth on the overall catching performance of the longliners. The depth of operation was grouped into four categories viz., 35, 60, and 100 m. The starting and finishing times of both shooting and hauling were recorded to calculate the soaking time of each operation. Soaking time is the duration between completion of setting and the initiation of hauling of the longline. The soaking time has been categorized into three groups for the analysis i.e. Group A (1 to 3 h), Group B (3.1 to 5 h) and Group C ($>5.1 \text{ h}$). During hauling, the parameters such as type of species, size, number, condition (live or dead) were

recorded. The hooking rate was calculated based on the number of fish caught per 1000 hooks.

The statistical tests were performed using SPSS (IBM SPSS Statistics, Version 20). The data collected were compiled and analysed using χ^2 for test of goodness of fit and two factor ANOVA.

Results and discussion

Effect of hook depth on catch rates

The study compared the effect of hook depth on the overall hooking rate and the species composition. The overall hooking rate observed at 35, 60 and 100 m depth were 8.78, 12.96 and 6.89 per 1000 hooks respectively (Fig. 2). No significant association was observed between the overall hooking rate and depth of operation ($\chi^2 = 2.030$, $p > 0.05$, $df=2$).

The study compared the effect of hook depth on the species selectivity in the longline fishing operations (Fig. 3).

At 35 m depth, shark hooking rate was found to be higher (5.56 per 1000 hooks) compared to other group of fishes. Hooking rate of miscellaneous fishes observed at 35 m depth is 1.27 per 1000 hooks followed by tunas and sailfish (0.98 and 0.88 per 1000 hooks). Shark catch was dominated at 60 m depth by contributing 9.4 per 1000 hooks followed by tunas, sailfish and miscellaneous fishes (2.67, 0.51 and 0.38 per 1000 hooks, respectively). Sharks were the dominant group of fishes caught at 100 m depth (4.51 per 1000 hooks), followed by tunas, miscellaneous fishes and sailfish (1.9, 0.47 and 0.24 per 1000 hooks, respectively). Sharks dominated at all the three depths. High tuna hooking rate was observed at 60 m depth. Highest hooking rate for sailfish and miscellaneous group of fishes recorded at 35 m depth.

Effect of soaking time on catch rates

The overall hooking rate was found to be high when the soaking time was 1-3 h (13.23 per 1000 hooks), followed by 3.1-5 and >5.1 h (9.68 and 8.1 per 1000 hooks, respectively) (Fig. 4). Further studies were carried out to understand the effect of soaking time on the species selectivity. Shark catch was observed to be high (8.86 per 1000 hooks) when the soaking time was 1-3 h and low (4.86 per 1000 hooks) when soaking time was >5.1 h (Fig. 5). Tuna catch was found to be high (3.24 per 1000 hooks) when the soaking time was >5.1 h and low (1.17 per 1000 hooks) when it was 3.1 -5 h.

Sailfish hooking rate was found to be high (1.05 per 1000 hooks) when the soaking time was 3.1-5 h and no sailfish was caught when soaking time was higher than 5.1 h. Miscellaneous group of fishes was found to be high (1.09 per 1000 hooks) when the soaking time was 1-3 h compared to soaking time of 3.1 and >5.1 h (0.93 and 0 per 1000 hooks, respectively). Sailfish hooking and miscellaneous fishes hooking rate was found to be zero when the soaking time was higher than 5.1 h. Soaking time failed to show any significant effect on overall hooking rate ($\chi^2=1.335$, $p>0.05$, $df=2$). Soaking time does not show any significant difference on hooking rate of species ($p>0.05$).

Studies were carried out to understand the effect of fishing depth on the overall catching performance and species selectivity in the longline fishing operations in the Lakshadweep Sea. There was no significant relation between the depth of operation and overall hooking rate. The study analyses the species selectivity at three different depths of operations. The results indicated that the depth of operation has effect on the species selectivity. Further studies are needed to understand the effect of depth of operation on the species selectivity beyond 100 m depth. Previous research indicated that the species selectivity of tuna is more evident at deeper depths (Bigelow *et al.*, 2006).

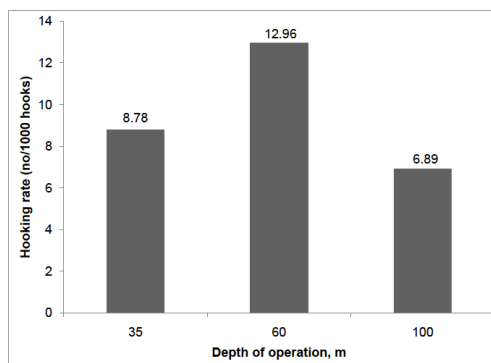


Figure 2: Hooking rate at three different depth levels during the longline fishing operations in Lakshadweep waters from 16 Nov 2009 to 23 April 2011 (the values expressed as number/1000 hooks).

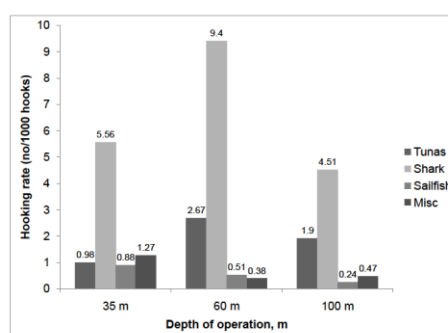


Figure 3: Species wise hooking rate at three different depth levels during the longline fishing operations in Lakshadweep waters from 16 Nov 2009 to 23 April 2011 (the values expressed as number/1000 hooks).

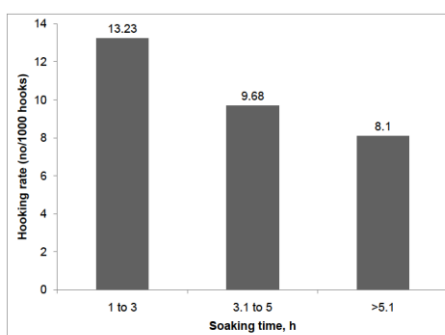


Figure 4: The overall hooking rate reported at three different soaking durations (the values expressed as number/1000 hooks).

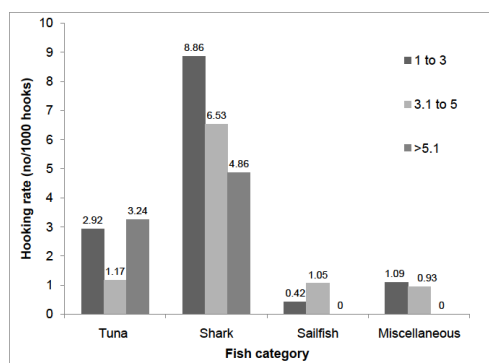


Figure 5: The species wise hooking rate reported at three different soaking durations (the values expressed as number/1000 hooks).

Bigeye tuna was the major group of species caught when the fishing carried out beyond 200 m depth in the Hawaiian longline fishing (Boggs, 1992). Bigelow *et al.* (2006) confirmed the superiority of deeper hooks to catch tunas. The fishing depth for targeting bigeye and yellowfin tunas usually ranged from 100 to 300 m (An *et al.*, 2008). Honamoto (1976) and Beverly *et al.* (2009) opined that the CPUE of bigeye tuna and Bluefin tuna can be improved by deep deployment of the hooks. The deep deployment of the hooks helps to reduce the hooking of the incidentally caught species such as marine turtles, seabirds, sharks and dolphins (Shiga *et al.*, 2000; Francis *et al.*, 2001; Gilman *et al.*, 2008). High billfish hooking rate was noticed in the shallower hooks in the longline fishing operation targeting large tunas (Bigelow *et al.*, 2006). The yellowfin tunas are found to be occupying the surface mixed layer above the thermocline and are restricted to the water temperature no more than 8°C colder than the surface layers (Dagorn *et al.*, 2006).

Vega and Licandeo (2009) opined that the catch rates increase with soaking time. Experiments were carried out to assess the effect of soaking time on the catch rates and the results showed no significant relation between soaking time and catch rates. A trend of decreasing the overall catch rate with soaking time was observed but the differences were not found to be statistically significant. Results are

statistically not significant to establish effect of the soaking time on the species wise hooking rate. Morgan and Carlson (2010) confirmed the correlation of soaking time with the mortality of the sharks caught in bottom longline fishing operations. Previous studies indicated that soaking time can enhance the mortality of the sharks caught in the longline gear (Carlson *et al.*, 2004; Morgan and Burgess, 2007). Further studies at deeper depths from 100 to 300 m have to be carried out to understand the effect of depth of operations on the species selectivity in longline operations in Lakshadweep Sea. The shark catch was found to be decreasing with an increase in soaking time and these results are substantiated with further experiments.

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References

- An, D.H., Kim, S.S., Moon, D. Y., Hwang, S.J. and Kwon, Y.J., 2008. Effect of fishery factors on bigeye and yellowfin tuna catch rates in the tuna longline fishery. Western and Central Pacific Tuna Commission, Scientific Committee Fourth Regular Session, 11-22

- August 2008, Port Moresby, Papua New Guinea.
- Beverly, S., Curran, D., Musyl, M. and Molony, B., 2009.** Effects of eliminating shallow hooks from tuna longline sets on target and non-target species in the Hawaii-based pelagic tuna fishery. *Fisheries Research*, 96, 281-288.
- Bigelow, K., Musyl, M.K., Poisson, F. and Kleiber, P., 2006.** Pelagic longline gear depth and shoaling. *Fisheries Research*, 77, 173-183.
- Boggs, C.H., 1992.** Depth, capture time and hooked longevity of longline caught pelagic fish: timing bites with chips. *Fishery Bulletin*, 90, 642-658.
- Broadhurst, K.M. and Hazin, F.H.V., 2000.** Influences of type and orientation of bait on catches of swordfish (*Xiphias gladius*) and other species in an artisanal sub-surface longline fishery off northeastern Brazil. *Fisheries Research*, 53(2), 169-179.
- Carlson, J.K., Goldman, K.J. and Lowe, C.G., 2004.** Metabolism, energetic demand, and endothermy. In: Carrier, J. C., Musick, J. A. and Heithaus, M. R. (Eds.), *Biology of Sharks and Their Relatives*. CRC Marine Biology Series, Boca Raton, Florida, pp. 203-224.
- Dagorn, L., Holland, K. N., Hallier, J.P., Taquet, M., Moreno, G., Sancho, G., Itano, D.G., Aumeeruddy, R., Girard, C., Million, J. and Fonteneau, A., 2006.** Deep diving behavior observed in yellowfin tuna (*Thunnus albacares*). *Aquatic Living Resource*, 19, 85-88.
- Diaz, G.A. and Serafy, J.E., 2005.** Longline-caught blue shark (*Prionace glauca*): factors affecting the numbers available for live release. *Fishery Bulletin*, 103, 720-724.
- Francis, M.P., Griggs, L.H. and Baird, S.J., 2001.** Pelagic shark bycatch in the New Zealand longline fishery. *Marine and Freshwater Research*, 52, 165-178.
- Garrison, L.P., 2007.** Interactions between marine mammals and pelagic longline fishing gear in the U.S. Atlantic Ocean between 1992 and 2004. *Fishery Bulletin*, 105, 408-417.
- Gilman, E., Clarke, S., Brothers, N., Shugeto, A., Mandelman, J., Mangel, J., Petersen, S., Piovano, S., Thomson, N., Dalzell, P., Donoso, M., Goren, M. and Werner, T., 2008.** Shark interactions in pelagic longline fisheries. *Marine Policy*, 32, 1-18.
- Honamoto, E., 1976.** The swimming layer of bigeye tuna. *Bulletin of the Japanese Society of Fisheries Oceanography*, 29, 41-44.
- Joseph, K.M., 1972.** Some observations on the exploitations of the Indian Ocean tuna resources. *Seafood Export Journal*, 4(8), 11-18.
- Lewison, R.L., Crowder, L.B., Read, A.J. and Feeman, S.A., 2004.** Understanding impacts of fisheries bycatch on marine

- megafauna. *Trends in Ecology and Evolution*, 19(11), 598-603.
- Mandelman, J.W., Cooper, P.W., Werner, T.B. and Lagueux, K.M., 2008.** Shark bycatch and depredation in the U.S. Atlantic pelagic longline fishery. *Reviews in Fish Biology and Fisheries*, 18, 427-442.
- Mangel, J.C., Shigueto, J.A., Waerebeek, K.V., Cacaeres, C., Bearhop, S., Witt, M.J. and Godley, B.J., 2010.** Small cetacean captures in Peruvian artisanal fisheries: High despite protective legislation. *Biological Conservation*, 143, 136-143.
- Milian, G.H., Goetz, S., Dopico, C.V., Gutierrez, J.R., Olea, J.R., Gamundi, J.R.F., Alonso, E.U., Tregenza, N.J.C., Smerdon, A., Otero, M.G., Tato, V., Wang, J., Santos, M.B., Lopez, A., Lago, R., Portela, J.M. and Pierce, G.J., 2008.** Results of a short study of interactions of cetacean and longline fisheries in Atlantic waters: environmental correlates of catches and depredation events. *Hydrobiologia*, 612, 251-268.
- Morgan, A. and Burgess, G.H., 2007.** At- vessel fishing mortality for six species of sharks caught in the northwest Atlantic and Gulf of Mexico. *Gulf and Caribbean Research*, 19, 123-129.
- Morgan, A. and Carlson, J.K., 2010.** Capture time, size and hooking mortality of bottom longline-caught sharks. *Fisheries Research*, 101, 32-37.
- Naeem, A. and Latheefa, A., 1994.** Bio-socioeconomic assessment of the effects of fish aggregating devices in the tuna fishery in the Maldives. Bay of Bengal Programme BOBP/WP/95, Bioeconomics of Small-scale Fisheries GCP/RAS/18/MUL, RAS/91/006.
- Pillai, N.G.K., Vivekanandan, E. and Koya, K.P.S., 2006.** Status of fisheries of Lakshadweep. *Marine Fisheries Information Service*, T&E Series 187, 1-7.
- Pillai, N.G. K. and Jyothi, V.M., 2007.** Bibliography of Tunas, *CMFRI Special Publication* 92, 135P.
- Rao, G.S., 2010.** Current status and prospects of fishery resources of the Indian continental shelf. In: Meenakumari, B., Boopendranath, M.R., Edwin, L., Sankar, T.V., Gopal, N. and George, N. (Eds.) Coastal Fishery Resources of India - Conservation and Sustainable Utilisation. Society of Fishery Technologists, India, pp. 1-13.
- Shiga, M., Shiode, D., Hu, F. and Tokai, T., 2000.** Deep setting of tuna longline hooks using mid-water float system with long float lines to avoid sea turtle bycatch. In: Proceedings of the 3rd International Symposium on SEASTAR 2000 and Asian Bio-logging Science.
- Suzuki, Z., Warashina, Y. and Kisada, M., 1977.** The comparison of catches by regular and deep longline gears in the Western and Central equatorial Pacific. *Far Seas Fisheries Research Laboratory Bulletin*, 15, 51-89.

Vega, R. and Licandeo, R., 2009.The effect of American and Spanish longline systems on target and non-target species in the eastern South Pacific swordfish fishery. *Fisheries Research*, 98, 22-32.

Ward, P., Myers, R.A. and Blanchard, W., 2004.Fish lost at sea: The effect of soak time on pelagic longline catches. *Fishery Bulletin*, 102, 179-195.