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Efficacy of bait species and baiting pattern on hooking rates and bait loss during longline fishing in Lakshadweep Sea, India

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Bait species, baiting pattern and bait loss rates are key factors which determine the success of longline fishing operations. The catching efficiency of three bait species, *viz*., Indian mackerel (*Rastrelliger kanagurta*), Indian oil sardine (*Sardinella longiceps*) and smoothbelly sardinella (*Amblygaster clupeoides*) and its loss rates were evaluated. The effect of baiting pattern (horizontal/vertical) on longline fishing performance were also studied. The results suggest that change in bait species has no significant effect on the overall hooking rate in the longline operations, though variation was observed in catch composition. Changes in pattern of baiting (horizontal and vertical) had no significant influence on hooking rate. The variation in bait loss among three baits tested were not found to be statistically significant. Depth of operation has no significant effect on the bait loss, within the range of 100 m depth. However, the bait loss was observed to increase with soaking time. Scavenging by the small fishes was frequently observed during the study which may increase the rate of drop-off of the bait from the hooks.

[Keywords: Baits, Baiting Pattern, Bait Loss, Longline, Lakshadweep Sea]

Introduction

The main components of the longline fishing system are mainline, branchline, hooks and baits and gear handling equipments such as line setter, line hauler and mainline spooler. Bait is one of the major factors which determines the selectivity and efficiency of longlines. Fishermen use different types of baits based on the traditional knowledge they have acquired over the years. A good longline bait has to be attractive to the targeted fish and should remain on the hook for the entire duration of fishing or until a fish is hooked. Lokkeborg and Bjordal[1] documented the species specific effect of baits. Bait preferences may vary seasonally and are affected by previous diet experiences[2]. Catch rates of longlines depend on type, quality and size of bait, to a large extend[3]. Bait type is a major gear parameter affecting the species selectivity of longlines[4, 5, 6, 1].

Fish bait was found to be more efficient than squid bait to reduce the turtle bycatch[7,8]. Watson et al.[9] documented that use of mackerel bait can reduce loggerhead turtle and shark catch rate by 71% and 40% respectively, compared to squid bait. Squid bait was found to be superior to fish bait in the hook holding properties[10, 11, 12]. Watson et al.[9] and Gilman et al.[13] demonstrated that fish bait with larger circle hook can minimize the turtle bycatch significantly. Previous researches confirmed the effect of bait size in determining the size of the fishes caught in longlines[1, 15, 16]. The effect of bait size has been reported to be stronger in pelagic longlines than bottom longlines[14, 15]. Bait quality is an important factor which affects the catch rates significantly. The quality of bait is also understood as how well it remains on the hook. Physical strength and ability of the bait to remain on the hook throughout the soaking time determines the effectiveness of the bait. Natural bait has been reported to be superior to artificial bait[17,18]. Brothers et al.[19] reported that adding lead sinkers are useful for increasing the sinking speed of the baited hooks and to reduce the sea bird bycatch. Bait tenacity is one of the major factors affecting the catch rate and more tenacious bait would provide a longer effective fishing time[11]. Blue dyed baits are considered as an effective mitigation measure to avoid sea bird bycatch[21, 22] but found to be ineffective in reducing turtle bycatch[8, 23]. The factors like weather, propeller turbulence, bait shape and

thaw conditions have significant effect on the fishing efficiency[20, 24].

The depth at which targeted species are captured is fundamental to understanding the impacts of tuna longline operation on target and bycatch species. Lokkeborg[25] carried out fishing experiments with alternative longline bait constituted by surplus fish products and the results indicated species selective effect[25]. Bait loss is a major factor affecting the longline catch rate and the main factors affecting the bait loss are hook design, hook depth, time of operation and bait species[11, 12]. Loss rate is the number of lost baits divided by the number of baits deployed. Loss rate was reported to be minimum in squid than fish due to the firm nature of flesh[10, 12]. Removal by scavengers or target species, disintegration, and stresses from wave action and longline deployment and retrieval, are the common causes of bait loss[10]. Ward and Myers[12] opined that soak time, bait species and depth had greatest effect on loss rates.

Sea birds are considered as potential cause to the bait loss and it depends mainly on season and fishing ground[11]. Sinking rate of baited hooks have profound effect on seabird bycatch[26]. Partially thawed bait has been reported to sink faster than completely thawed bait[27]. Studies on pelagic and demersal longlines show that bait loss tend to increase with soak time[10, 11, 12]. Bait loss vary depending on bait species and has been found to be higher with increasing water depth[28] Contrary to this finding, Ward and Myers[12] reported that bait loss rate decreases with hook depth and possible reason might be decrease in mechanical effect of surface waves. Authors reported that loss rates were maximum during rough weather. The bait loss has been reported to be high at night[29].

Baiting is carried out manually in smaller vessels and using baiting machines in large vessels. In manual baiting operation, the crew members attach the bait to the hooks by piercing the bait by the hook at the time of casting the branchlines. Before the line is set, the bait should be defrozen or thawed partially before use. Baits that are used by fisherman in India are edible small fishes such as clupeids, small perches, mackerel, mullet, ribbonfish, silverbar, Bombay duck, eels, prawns and cephalopods[30]. Tuna showed quick response to live baits. Balasubramanyan[30] reported that the Indian fisherman use neither salted nor frozen fishes as bait during 1960s. But nowadays, frozen sardine and mackerel are commonly used as baits for tuna longlining in India.

Materials and Methods

Experiments were conducted from 3 Pablo boats (7.6 to 8.5 m L_{OA}) modified for longlining in the Lakshadweep Sea around Agatti Island (10°38' - 11°07' N; 70°08' - 72°08' E), at a depth range of 35-125 m, from 16 Nov 2009 to 23 April 2011. Mainline and branchlines of the experimental gear were made of polyamide monofilament of 3 mm and 1.8 mm, respectively and floatlines were made up of 4 mm dia polyester and were 22.5 m long. Japanese tuna hooks of 3.4 sun with 10° offset were used for the experiments. Data were collected from 19,038 hooks operated during 361 fishing operations. Fishing operations were mostly carried out during the dawn. The duration of soaking time ranged from 1 to 7 h, depending on weather conditions. Shooting and hauling of the lines took approximately 1.30 and 2 h, respectively.

Three bait species, *viz*., Indian mackerel (*Rastrelliger kanagurta*), Indian oil sardine (*Sardinella longiceps*) and smoothbelly sardinella (*Amblygaster clupeoides*) of 10-25 mm total length were used for experimental operations (Fig 1). During hauling, species name, number caught, condition of the fish caught (live or dead), condition of bait (whether bait was retained or not) were recorded. Length and weight of the species were measured onboard. Frozen baits after thawing are used for the fishing operations. The hook holding ability of the bait was determined by counting the percentage of baits which remained on the hook after a given soaking time. The baits which have either detached normally or have been taken away by the fishes were categorized as lost. The condition of the each individual hook retrieved after soaking time was recorded as fish caught, bait remaining (more than 25% of original size remained on the hook), bait lost (less than 25% of the original size remained on the hook), or hook loss[11]. The bait loss is expressed as a percentage of total number of hooks with no fish catch. Two types of baiting, *viz*., horizontal and vertical baiting pattern (Fig. 2) were used to study the effect of baiting pattern on hooking rate.The data collected were compiled and analysed using χ^2 for the goodness of fit and ANOVA using SPSS (IBM SPSS Statistics, Version 20)[31, 32].

Results

Influence of bait species on hooking rates

Details of the fishes caught in the longline gear during fishing operation are given in the Table 1. The species caught during the experimental fishing operation were grouped in to 4 categories, *viz*., tuna, shark, sailfish and miscellaneous fishes.

The miscellaneous fishes included *Aprion virescens, Epinephelus polylepis*, *Lutjanus* spp. and *Caranx* spp. Hooking rates obtained with three different baits, *viz*., Indian oil sardine, smoothbelly sardinella and Indian mackerel were 31, 22.5 and 23.6 per 1000 hooks, respectively (Fig 3). There was no statistically significant difference in the overall hooking rate was observed with three different baits ($\chi^2 = 1.663$, $P>0.05$).

sardine gave superior hooking rate for shark followed by tuna, miscellaneous fishes and sailfish (24.4, 4.1, 1.8 and 0.8 per 1000 hooks, respectively.

Figure 1. Bait species used for experimental longline fishing (A: *Sardinella longiceps,* B: *Amblygaster clupeoides,* C: *Rastrelliger kanagurta)*

Table 1. Species composition of tuna longline fisheries in Lakshadweep Sea

Scientific name	Common name	Number	Total length	Weight (kg)
Tuna				
Thunnus albacares (Bonnaterre, 1788)	Yellowfin tuna	40	15-147	3-40
Gymnosarda unicolor (Ruppell, 1836)	Dogtooth tuna	1	140	27.5
Sharks				
Carcharhinus falciformis Muller & Henle, 1839)	Silky shark	133	50-243	5-98
Carcharhinus amblyrhynchos (Bleeker, 1856)	Grey reef shark	7	114-210	16-41
Galeocerdo cuvier (Peron & Lesueur, 1822)	Tiger shark	4	183-213	31-74
Alopias pelagicus Nakamura, 1935	Thresher shark	2	240-276	50-55
Negaprion acutidens (Ruppell, 1837)	Sicklefin lemon shark	1	256	105
Sphyrna lewini (Griffith & Smith, 1834)	Scalloped Hammer head shark	1	320	130
Sailfish				
Istiophorus platypterus (Shaw, 1792)	Sailfish	14	50-288	1-44
Miscellaneous fishes				
Aprion virescens Valenciennes, 1830	The green jobfish	5	0.3-95	1-9
Caranx spp	Carangids	2	29	5
Epinephelus polylepis Randall & Heemstra,1991	Small scaled grouper	1	No data	4-8
Lutjanus gibbus (Forsskål, 1775)	Humpback Red Snapper	8	61-68	2-6

Hooking rate obtained by using different bait species for sharks, tuna, sailfish and miscellaneous fishes are given in Fig. 4. Shark catch predominates in the smooth belly sardinella bait followed by tuna, miscellaneous fishes and sailfish (12.7, 5, 2.8 and 2.1 per 1000 hooks, respectively). Indian mackerel gave better hooking rate for shark followed by tuna, miscellaneous fishes and sailfish (17.7, 5.6, 0.4, and 0.4 per 1000 hooks, respectively). Indian oil

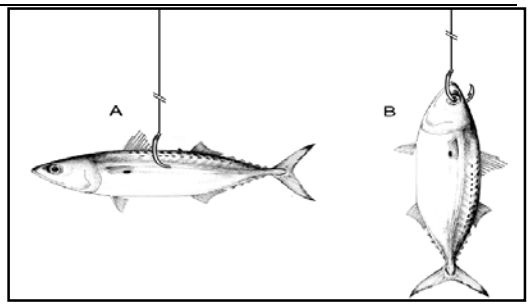

Figure 2. Schematic representation of baiting pattern (A: Horizontal baiting, B: Vertical baiting)

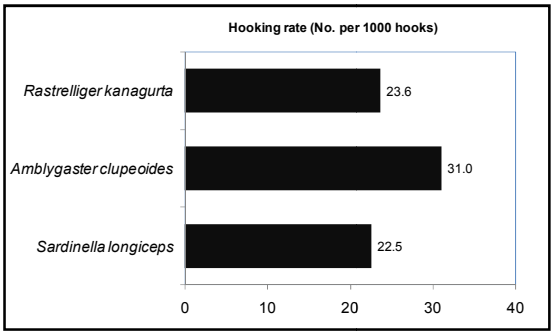

Figure 3. Overall hooking rate using different bait species

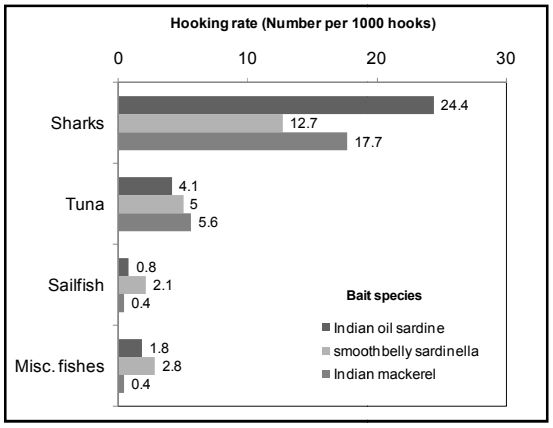

Figure 4. Hooking rates for sharks, tuna, sailfish and miscellaneous fishes, obtained using different bait species

Percentage composition of catch in respect of three bait species used is given in Fig. 5. In all cases, sharks predominated in the catch, followed by tuna. Percentage of sharks were 78.5% in the catch of longline operations conducted using Indian oil sardine as bait, 73.4% when using smoothbelly sardinella and lowest (56.2%) when using Indian mackerel. Percentage contribution of tuna was high (23.2%) when Indian mackerel was used as bait, immediately followed by smoothbelly sardinella (22.1%) and lowest (13.2%) when Indian oil sardine was used as bait. Percentage contribution of sailfish was high (9.3%) when smoothbelly sardinella was used as bait, and between 1.7-2.6% when other baits were used. Hooking rate of miscellaneous fishes was high (12.4%) when when smoothbelly sardinella was used as bait, followed by Indian oil sardine (5.8%) and Indian mackerel (1.7%)

Chi-square test showed that hooking rate of shark was significantly higher with each of the bait is tested.

a. Indian mackerel ($\chi^2 = 33.156$, $P < 0.001$, df = 2)
b. Indian oil sardine ($\chi^2 = 46.768$, $P<0.001$, df = 2)
c. Smoothbelly sardinella ($\chi^2 = 12.540$, $P < 0.01$, df = 2)

No statistically significant difference was noticed in the species selectivity of the three bait species with Chi-square test ($P>0.05$)

a. Tuna ($\chi^2 = 0.233$, $P > 0.05$, df = 2)
b. Sharks ($\chi^2 = 3.767$, $P > 0.05$, df = 2)
c. Sailfish ($\chi^2 = 1.436$, $P > 0.05$, df = 2)
d. Miscellaneous fishes ($\chi^2 = 1.8$, $P > 0.05$, df = 2)

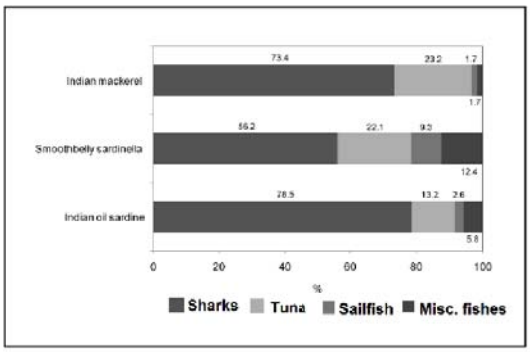

Figure 5. Percentage contribution of sharks, tuna, sailfish and miscellaneous fishes to catch obtained using different bait species

Effect of baiting pattern on hooking rates

Studies were conducted to understand the effect of baiting pattern on the catch rates in longlining. Catch rates in respect of the two baiting patterns are given in the Fig. 6. Hooking rate for horizontal and vertical baiting pattern was observed to be 23.9 and 24.2 per 1000 hooks, respectively. Hooking rate for tuna was better when bait was horizontally baited (5.7 per 1000 hooks), compared to vertical baiting (2.6 per 1000 hooks). Hooking rate was comparatively better when the hook was vertically baited in the case of sailfish (3.9 per 1000 hooks), compared to horizontal baiting pattern (0.7 per 1000 hooks). A similar pattern was observed in the case of sharks, with a

hooking rate of 17.3 per 1000 hooks with vertical baiting, compared to horizontal baiting (14.9 per 1000 hooks). Nearly 87% of the miscellaneous fishes were caught (hooking rate: 2.6 per 1000 hooks) when the hook was horizontally baited, compared to vertical baiting pattern (0.4 per 1000 hooks). There was no significant difference in hooking rate between horizontal or vertical baiting patterns (χ^2 = 0.001, P> 0.05, df = 2).

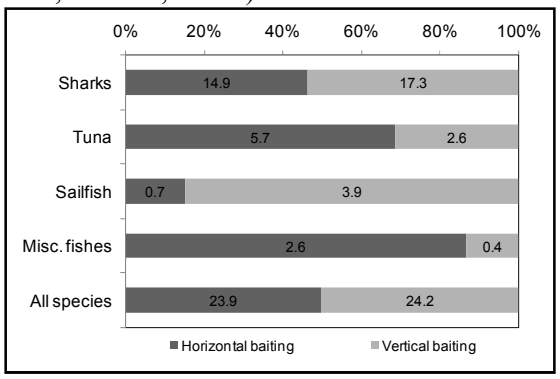

Figure 6. Percentage split of catch obtained using horizontal and vertical baiting (Hooking rate is represented as number per 1000 hooks, inside the bar)

Studies on bait loss

Among the three bait species, bait holding efficiency of Indian oil sardine was better (52%), compared to smoothbelly sardinella (38%) and Indian mackerel (34%) (Fig. 7). However, differences in the bait retention among the three bait species was not statistically significant (χ^2= 4.326, P> 0.05, df = 2).

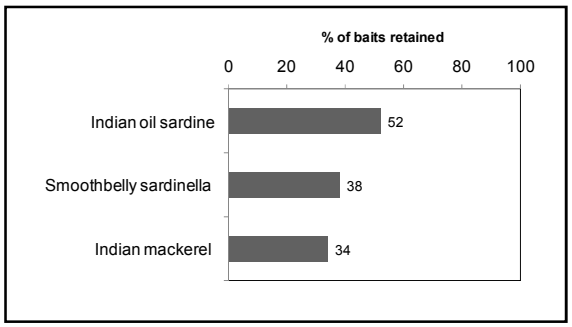

Figure 7. Hook holding efficiency of baits (% of baits retained after fishing operation)

The effect of soaking time on the bait loss is represented in Fig. 8. Soaking time was grouped in to three categories (1 to 3, 3.1 to 5 and 5.1 to 7 h) for the analysis. Bait loss was highest for the soaking time range of 5.1 - 7 h (71%), followed by 3.1-5 h (58%) and 1-3 h (36%). Duration of soaking time has a significant effect on bait loss (χ^2 =7.61, P<0.05, df = 2). The results suggested that bait loss rate increase with soaking time.

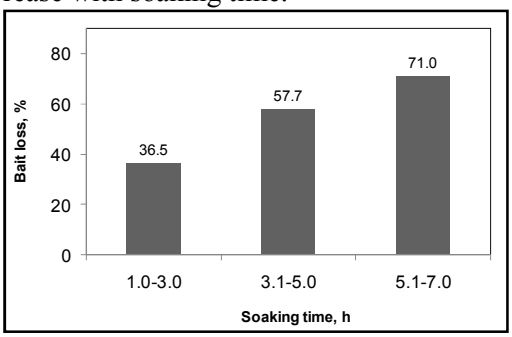

Figure 8. Effect of soaking time on bait loss

The effect of depth of operation on bait loss is represented in Fig. 9. Bait loss observed was highest at 35 m depth (59.5%), followed by 60 m depth (46.7%) and 100 m depth (40.4%). Results indicate that bait loss rate decreases with depth of operation. Statistical analysis showed that the depth of operation has no significant effect on the rates of bait loss (χ^2= 3.874, P>0.05, df = 2) at a depth range of 35-100m.

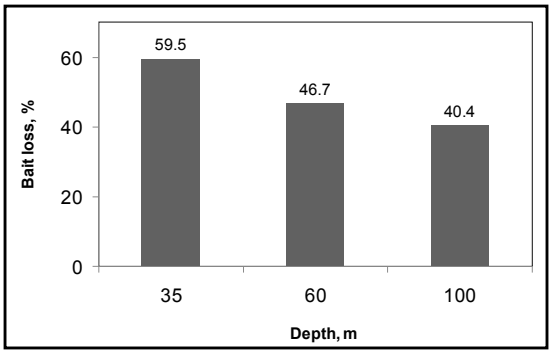

Figure 9. Effect of depth of operation on bait loss

High rate of bait loss was indicated during the period of operations due to scavenging or predation by the small fishes which may increase the rate of drop off of the bait from the hooks (Fig. 10). Scavenging may cause partial or complete spoilage of the baits.

Figure 10. Views of bait loss due to scavenging by small fishes

Discussion

In this study, we have analyzed the influence of three bait species and baiting pattern on hooking rate, and bait loss during experimental longline operations in Lakshadweep Sea. The bait species, *viz*., Indian mackerel, Indian oil sardine and smoothbelly sardinella were selected mainly based on the local availability and as per the prevailing practices of the fishermen.

The results suggest that change in the bait type has no significant effect on the overall hooking rate in the longline operations. The results are in accordance with the findings of the work carried out by Bach et al. and Yokota et al. [3, 8] which indicated that bait species has little effect on the overall hooking rate. Bach et al.[3] opined that change in bait type has no significant effect on improving the hooking responses. Major bycatch species encountered during the longline fishing operations in Lakshadweep Islands were sharks and sailfishes. Bait type is one of the important gear parameters affecting species selectivity[1, 4, 5, 6]. Present study suggests that bait species studied have no significant effect on hooking rates of different categories of catch, *viz.,* tunas, sharks, sailfish and miscellaneous fishes. Shark catch was significantly higher with all three bait species tested. Watson et al.[9] indicated less blue shark catch with Indian mackerel as bait. Watson et al.[9] reported that the catch rate of swordfish was high with mackerel as bait. In the present study, though higher hooking rate for tuna was observed when Indian mackerel was used as bait, compared to Indian oil sardine and smoothbelly sardinella, the differences were not found to be statistically significant. The effect of bait species on the catch rate depend upon many factors like texture and freshness of the bait and it vary seasonally and with previous diet experiences[2, 3, 33].

Previous studies have shown that baiting pattern significantly affects the hooking rate[34]. Our study indicated that the differences observed in hooking rate due to variation in baiting pattern (horizontal and vertical) were not statistically significant. Marquez[34] reported that horizontal baiting pattern showed higher catch rate and higher bait loss. Bait loss is a serious factor which significantly affects the success of fishing operations[11, 12]. Studies by Ward and Myers[34] have suggested that tuna catch rate is significantly affected by the bait loss rates. Hook holding ability of the bait is considered as an important property of the bait. Previous researches indicated that loss rate vary among bait species, depending upon the firmness of the meat and freshness of the fish. The variation observed in bait loss among Indian mackerel, Indian oil sardine and smoothbelly sardinella in the present study were not statistically significant. Removal by the scavenging fishes or target fishes, firmness and tenacity of the bait, disintegration due to wave action have been reported as the main causes of bait loss[10].

Earlier studies have reported that soaking time has significant effect on the bait loss in longline fishing operations[10, 11, 12]. In the present study, we have analyzed the effect of soaking time on the bait loss and results showed that rate of bait loss increased with the soaking time. These results are in agreement with the observations of, Shomura[10] and Pingguo[11], Shepard, et al.[35], Skud[36] which indicated that the loss rate of baits increased with soaking time.

Previous researches confirmed the effect of depth of operation on bait loss. Though the results of the present study suggested that rate of bait loss decreased with depth, the difference was not statistically significant. Ward and Myers[12]] indicated that loss rates from pelagic longlines decrease with hook depth and the explanation they have given are the possible occurrence of Wahoo (*Acanthocybium solandri*) which scavenge on the bait in the shallower waters. Shomura[10] has indicated that the bait loss rate are higher in shallow waters due to the physical stress due to wave action which leads to the drop off of the bait from the hooks. Scavenging by the small fishes was frequently observed during the present study which may increase the rate of drop-off of the bait from the hooks.

Bait species, baiting pattern and bait loss rates are important factors which determine the success of longline fishing operations. In the present study, we have presented results on these aspects, based on experimental longline operations in Lakshadweep Sea. The results suggest that change in bait species, *viz*., Indian mackerel, Indian oil sardine and smoothbelly

sardinella has no significant effect on the overall hooking rate in the longline operations, though variation is observed in catch composition. Dominance of sharks in the longline catch in Lakshadweep Sea is a serious concern. Smoothbelly sardinella and Indian oil sardine may be preferred as the bait species in the longline fishing operations for reducing the shark catch without compromising the overall catching efficiency of the fishing gear. Changes in pattern of baiting (horizontal and vertical) had no significant influence on hooking rate. Bait loss has been considered as a serious issue in the longline fishing operations worldwide which is reported to reduce catch rate and success of fishing operations. The variation in bait loss among three bait species tested were found to be statistically not significant. The soaking time and depth of operation are the two important factors that influence the bait loss in the longline fishing. The results indicated that the depth of operation has no significant effect on the bait loss, within the range of 100 m depth. However, the bait loss was observed to increase with soaking time. Removal by scavengers, disintegration and physical stress from wave action are possible causes for bait loss during the longline deployment. The availability of baits is one of the limiting factors in the fishing operations in Lakshadweep Islands. The development of artificial baits will be useful in this context and further investigations are needed in this direction.

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References

1. Lokkeborg, S. and Bjordal, A. 1992. Species and size selectivity in longline fishing- A review. *Fish. Res*., 13: 311-322.
2. Sutterlin, A. M., Solemdal, P. and Tilseth, S. 1982. Baits in fisheries with emphasis on the North Atlantic Cod fishing industry. In: Chemoreception in fishes (ed. T. J. Hava), Elsevier, Amsterdam, p. 293-305.
3. Bach, P., Dagorn, L. and Misselis, C. 2000. The role of bait type on pelagic longline efficiency, ICES, Copenhagen (Denmark)
4. Shimada, K. and Tsurudome, M. 1971. On the bait for tuna longline- II. On the Saury, Mackerel scad baits for tuna fishing. Mem. Fac. Fish. Kagoshima University, 20: 119-130.
5. Pajot, G. and Weerasooriya, K. T. 1980. Fishing trials with bottom-set longlines in Sri Lanka. Bay of Bengal Program BOBP/WP/6
6. Carr, W. E. S. and Derby, C. O. 1986. Chemically stimulated feeding behaviour in marine animals. *J. Chem. Ecol*., 12: 989-1011.
7. Yokota, K., Minami, H. and Nobetsu, T. 2007. Research in mitigation of the interaction of sea turtle with pelagic longline fishery in the western North Pacific. Proceedings of the 3rd International Symposium on SEASTAR2000 and Asian Bio-logging Science.
8. Yokota, K., Kiyota, M. and Okamura, H. 2009. Effect of bait species and color on sea turtle bycatch and fish catch in a pelagic longline fishery. *Fish. Res.,* 97: 53-58.
9. Watson, J. W., Epperly, S. P., Shah, A. K. and Foster, D. G. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. *Can. J. Fish. Aqua. Sci*., 62: 965-981.
10. Shomura, R. S. 1955. A Comparative study of longline baits. U.S Fish and Wildlife Service, Special Scientific Report- Fisheries No 151, Washington.
11. Pingguo, H. 1996. Bait loss from bottom-set longlines as determined by underwater observations and comparative fishing trials. *Fish. Res.*, 27: 29-36.
12. Ward, P. and Myers, R. A. 2007. Bait loss and its potential effects on fishing power in pelagic longline fisheries. *Fish. Res.*, 86: 69-76.
13. Gilman, E., Kobayashi, D., Swenarton, T., Brothers, N., Dalzell, P. and Kinan-Kelly, I. 2007. Reducing sea turtle interactions in the Hawaii-based longline swordfish fishery. *Biol. Cons*., 139: 19-28.
14. Lokkeborg, S. 1990. Reduced catch of under sized cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) in relation to various sizes of longline bait. ICES Mar. Sci. Symposium., 196: 47-50
15. Lokkeborg, S. 1994. Fish behavious and longlining. In: Fish Behaviour in Capture and Abundance Estimation (eds. A. Ferno and O. Oslen), Marine, Fishing News Books, London.
16. Lokkeborg, S. and Bjordal, A. 1995. Size-selective effects of increasing bait size by using an edible body on longline hooks. *Fish. Res*., 24: 273-279.
17. Januma, S., Kajiwara, Y., Miura, T. Yamamoto, J. and Haruyama, M. 1999. Trial use of artificial bait with tuna longline. Bull. Facu. Fish, Hokkaido University, 50(2): 71-76.
18. Januma, S., Miyajima, K. and Abe, T. 2003. Development and comparative test of squid liver as artificial bait for tuna longline. *Fish. Sci*., 69 (2): 288-292.
19. Brothers, N., Foster, A. and Robertson, G. 1995. The influence of bait quality on the sink rate of bait used in the Japanese longline tuna fishing industry. An experimental approach. CCAMLR Science 2, p. 123-129.
20. Crispin, K. 2003. Sink rate of baited hooks on New Zealand pelagic tuna vessels. DOC Science, Internal series 123, Dept of conservation, Wellington, New Zealand, 9 p.
21. Boggs, H. C. 2001. Deterring Albatrosses from contacting baits during swordfish longline sets. In:

Seabird Bycatch: Trends, Roadblocks, and Solutions. (eds. E. F. Melvin and J. K. Parrish). University of Alaska Sea Grant, Fairbaks: p. 79-94.
22. Cocking, L. J., Double, M. C., Milburn, P. J. and Brando, V. E. 2008. Seabird bycatch mitigation and blue-dyed bait: A spectral and experimental assessment. *Biol. Cons*. 141: 1354-1364.
23. Swimmer, Y., Arauz, R., Higgins, B., McNaughton, L., McCracken, M., Ballestero, J. and Brill, R. 2005. Food color and marine turtle feeding behavior: can blue bait reduce turtle bycatch in commercial fisheries?. *Mar. Ecol. Prog. Series*, 295: 273-278.
24. Keith, C. 2003. Sink rate of baited hooks on New Zealand pelagic tuna vessels. DOC Science Internal Series 123, New Zealand Dept of Conservation, 9 p.
25. Lokkeborg, S. 1991. Fishing experiments with an alternative longline bait using surplus fish products. *Fish. Res*.12: 43-46.
26. Anderson, S. and Mcardle, B. 2002. Sink rate of baited hooks during deployment of a pelagic longline from a New Zealand longline vessels. *New Zealand J. Mar. Fresh water Res.,* 36: 185-195.
27. Brothers, N. 1991. Albatross mortality and associated bait loss in the Japanese longline fishery in the Southern Ocean. *Biol. Cons.,* 55: 255-268.
28. Sullivan, P. J. and Rebert, S. 1998. Interpreting Pacific halibut catch statistics in the British Columbia individual quota program. *Can. J. Fish. Aqua. Sci.*, 55: 99-115.
29. Ward, P., Myers, R. A. and Blanchard, W. 2004. Fish lost at sea: The effect of soak time on pelagic longline catches. *Fish. Bull*., 102: 179-195.
30. Balasubramanyan, R. 1964. On the use of different natural baits for sea fishing in India. *Fish. Tech.,* 1: 41-47.
31. Prince, E. D., Ortiz, M. and Venizelos, A. 2002. A comparison of circle hook and "j" hook performance in recreational catch-and-release fisheries for billfish. American Fisheries Society Symposium 30, p. 66-79.
32. Pacheco, J. C., Kerstetter, D. W., Hazin, F. H., Hazin, H., Segundo, R. S. S. L., Graves, J. E., Carvalho, F. and Travassos, P. E. 2011. A comparison of circle hook and j hook performance in a western equatorial Atlantic Ocean pelagic longline fishery. *Fish. Res.*, 107: 39-45.
33. Atema, J. 1980. Chemical Senses, chemical signals and feeding behavior in fishes. In: Fish Behavior and its use in the Capture and Culture of Fishes (eds. J. E. Bardach, J. J. Magnuson, R. C. May and J. M. Reinhart), ICLARM Conference Proceedings, Manila, p. 57-101.
34. Marquez, D. J. 1976. Comparative Efficiency of Different Types of Baiting Positions in Tuna Longline Fishing. *The Philippine J. Fish.*, 14 (2): 258-270.
35. Shepard, M. P., Robersts, R. F. A., Aro, K. V. and Turner, C. V. 1975. Effect of bait loss on catching power of floating longline gear. *Bull. Int. Pacific Fish. Comm*., 32: 71-77.
36. Skud, B. E. 1978. Factors affecting longline catch and effort: III. Bait loss and competition. International Pacific Halibut Comm. Scientific Report No. 64, Seattle.