

## Research Article

# Effect of offset hooks on catching efficiency and hooking positions of carangids, evidence from the Gulf of Mannar, India

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The efficiency of different shapes of J hooks number 8 (non-offset straight hook, 10° offset kirbed hook, and 10° offset reversed hook) in Carangids longline fishing gears was studied in 15 fishing grounds in the Gulf of Mannar, India, from April to August 2022. For the comparative study, a total of 15 fishing trips were conducted for each experimental gear with a total effort of 6,750 hooks, resulting in a total catch of 176 fishes during the study. Amongst the hook shapes, the kirbed hook had the highest percentage composition of the carangids (43.75 %), followed by the reversed hook (30.68 %), and the straight hook (25.57 %). Furthermore, the overall hooking rate was higher for the kirbed hook than for the straight hook (5.1 % vs. 3 %). Considering the catch rate, the overall Catch Per Unit Effort (CPUE; individual/150 hooks) of the kirbed hook was higher (6.4 vs. 3.75) than that of the straight hook. The percentage of hooking position in the jaw was higher in the kirbed hook than that of the straight hook (55.84 % vs. 37.78 %) and was found to be lower in the gut system (14.29 % vs. 28.89 %). Among the three hook shapes tested, the overall performance of the 10° offset kirbed hook was found to be better than the other 10° offset reversed and non-offset J hook in terms of a catch efficiency, hooking rate, CPUE, and hooking position for carangids (< 0.05).

[**Keywords:** Carangids, Catch Per Unit Effort, Catching efficiency, Hooking rate, Jaw]

## Introduction

The longline is an effective, environmentally friendly fishing gear, operated passively around the world to capture pelagic predatory fishes with the help of lures<sup>1</sup>. Coastal pelagic longlines are currently used in Indian waters by artisanal fishermen to commercially target surface-going and fast-moving commercially important pelagic fish groups<sup>2</sup>. Using highly selective fishing methods, such as longline and gillnet, will help slowly conserve and restore marine ecosystems. Carangids are found in all tropical and subtropical marine waters of the world, and some occur in temperate regions. The carangid fishery is of considerable commercial and economic importance, and as many as 35 species belonging to 21 genera have been observed to support the carangid fishery along the Indian coast<sup>3-6</sup>. In the Gulf of Mannar and Palk Bay, the traditional J-type hook is one of the most commonly used hooks in longline fishing for pelagic fisheries<sup>7</sup>. A non-offset (0° offset) J hook has a point parallel to the hook shank<sup>8</sup>, whereas an offset hook has the point bent sideways (either right or left side), ~5° – 25°, relative to the shank<sup>9,10</sup>. In the Pacific

Ocean, the offset hooks play a major role by influencing the catch and survival rates of targeted and non-targeted species<sup>8,11</sup>. However, hook type, including size and shape, used in isolation or in combination with bait selection, clearly plays a significant role in improving fishing selectivity and reducing the capture of non-targeted species<sup>12-14</sup>. A higher Catch Per Unit Effort (CPUE) was observed in the 18/0 10° offset circle hook than in the non-offset J hook (7.48 vs. 4.77)<sup>15</sup>. Furthermore, no difference in deep hooking rates in striped bass occurs between offset and non-offset hooks<sup>16,17</sup>. However, the kirbed J hook and offset circle have less injury compared with the non-offset J hook in marine predatory fishes and freshwater fishes<sup>15,18</sup>. Kumar *et al.*<sup>19</sup> reported that 27 % of fish caught on Japanese hooks were hooked in the jaw, and no lip hooking was observed. Further, no gear has been developed to exploit pelagic predatory fishes such as Carangids with different J-hook shapes based on hook-point alignment, and the catching efficiency of these hook shapes has not been compared for the pelagic longline in the Gulf of Mannar, India.

### Materials and Methods

The experimental fishing operation was conducted from April 2022 to August 2022 in the Gulf of Mannar region of Ramanathapuram, India (Fig. 1). The experimental fishing gear with different shapes of “J” hook number 8 (Lucana) *viz.*, 0° non-offset, 10° offset kirbed, 10° offset reversed, was designed, fabricated and operated in the Keelamundal region of Valinokkam and Thalaithoppu of the Mandapam region of the Gulf of Mannar using a Fibre Reinforced Plastic (FRP) boat with an overall length of 11 m powered with a double outboard engine of 9.9 hp (Suzuki). The fishing ground was approximately 10 - 40 nautical miles away from the shore. The main lines were made with polyamide monofilament twine, with a diameter of 1.1 mm and a branch line of 0.9 mm. All the branch lines had an identical length of 20 m and were connected to the dropper loops of the main line with the help of swivels. Each experimental longline unit comprised 150 branch lines. Each

branch line had a brass barrel swivel attached 20 m from the main line, which was done to avoid twisting of the branch lines. Swivels weighing 5 g with the commercial trade number 8 (Three Yachts Pvt., Ltd.) were used in the experimental long line. A snood wire with an ideal length of 20 cm was attached with the help of sleeves on one end, and another end attached with a branch line using the Uni-Knot version of Hangman’s Knot. The buoyant forces required for the experimental long lines were standardised by fitting low-density polyethylene (LDPE) floats weighing 10 g in different combinations. The LDPE floats were fitted between each hook interval to facilitate the flotation of the main line. Two 2-L plastic bottles filled with sand, each weighing approximately 1 kg, were tied at both ends of the main line with an HDPE spherical master float to position the experimental longlines firmly on the surface of the water. A total of 15 fishing trials were conducted with each experimental longline to determine its efficiency.

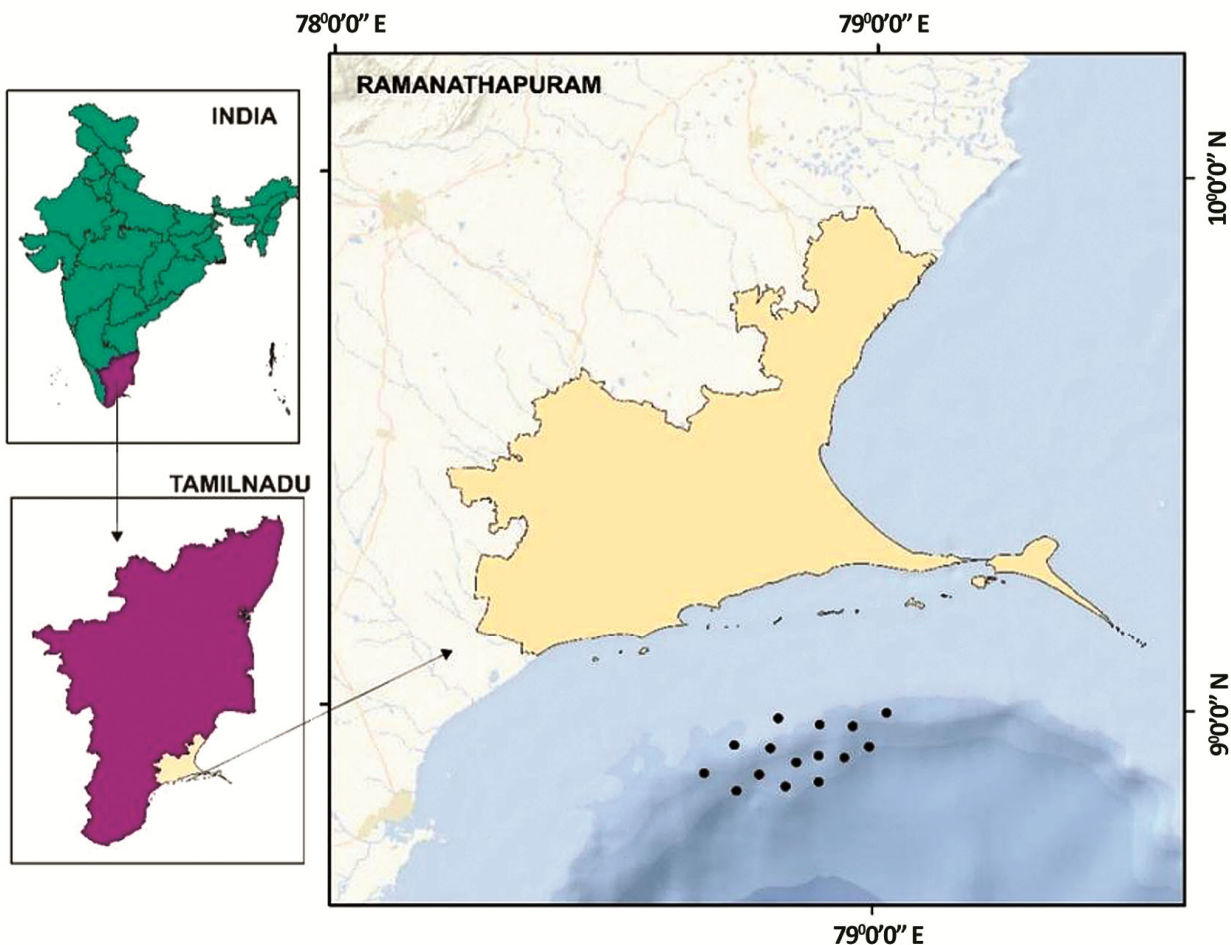


Fig. 1 — Map showing the experimental fishing sites along the Gulf of Mannar coast

Table 1 — Catch composition of modified carangids longlines with different J hook shapes based on the numbers

Sl. Species No.	Straight hook						Kirbed hook						Reserved hook						% Contribution
	Apr	May	Jun	Jul	Aug	Total	Apr	May	Jun	Jul	Aug	Total	Apr	May	Jun	Jul	Aug	Total	
1. <i>A. indicus</i>	3	2	5	4	5	19	3	4	7	6	11	31	3	3	4	5	6	21	71(40.34)
2. <i>C. ignobilis</i>	2	3	2	2	3	12	3	3	3	5	6	20	2	2	3	2	4	13	45(25.56)
3. <i>C. bajad</i>	2	0	2	2	2	8	2	4	3	4	4	17	1	2	3	2	3	11	36(20.45)
4. <i>S. commersonianus</i>	0	1	1	2	2	6	2	0	1	3	3	9	2	2	1	2	2	9	24(13.65)
Total	7	6	10	10	12	45	10	11	14	18	24	77	8	9	11	11	15	54	
% Contribution	25.56						43.75						30.68						

Table 2 — Catch composition of modified carangids longlines with different J hook shapes based on the weight

Sl. Species No.	Straight hook						Kirbed hook						Reserved hook						% Contribution
	Apr	May	Jun	Jul	Aug	Total	Apr	May	Jun	Jul	Aug	Total	Mar	Apr	May	Jun	Jul	Total	
1. <i>A. indicus</i>	7	4.7	11.5	9	11.7	43.9	6.9	9.2	16.1	13.8	25.3	71.3	6.9	6.9	9.2	11.5	13.8	48.3	163.5 (34.43)
2. <i>C. ignobilis</i>	6	9	6	6	9	36.0	9	9	9	15	18	60	6	6	9	6	12	39	135 (28.43)
3. <i>C. bajad</i>	5.8	0	5.8	5.8	5.8	23.2	5.8	11.6	8.7	11.6	11.6	49.3	2.9	5.8	8.7	5.8	8.7	31.9	104.4 (21.98)
4. <i>S. Commersonianus</i>	0	3	3	6	6	18.0	6	0	3	9	9	27	6	6	3	6	6	27	72 (15.16)
Total	18.8	16.7	26.3	26.8	32.5	121.1	27.7	29.8	36.8	49.4	63.9	207.6	21.8	24.7	29.9	29.3	40.5	146.2	
% contribution	25.50						43.71						30.79						

Trials were conducted in the early morning with an average soaking duration of 3 h. First, the main line with bait attached, and the branch line with snood wire and hook, are released one after another until all the hooks are released. At the end of the main line, the spherical float was attached for marking and easy identification. Soon after hauling, the total number of fish caught in each longline unit was segregated by species and counted for each trial. Their total length was measured to the nearest mm, and weight was determined using a top pan balance on board the fishing boat. CPUE was calculated as the number of fish caught per 150 hooks<sup>20</sup>.

$$CPUE = \frac{\text{Number of fish caught}}{\text{Number of hooks deployed}} \times 1000$$

Similarly, the hooking rate was defined as the ratio of the number of successful hooks to the number of hooks deployed<sup>8</sup>.

$$\text{Hooking rate} = \frac{\text{Number of fish caught}}{\text{Number of bites}} \times 100$$

The impact of hook shapes and catch rates of the targeted species on different modified longline units was calculated using the Analysis of Variance (ANOVA) technique<sup>21</sup>. Statistical analyses were performed at a 95 % confidence level (0.05).

**Results**

A total catch of 176 fish belonging to carangidae, the most frequently found family in terms of species,

included four species: *Alectis indicus*, *Caranx ignobilis*, *Carangoides bajad*, and *Scomberoides commersonianus*. *Alectis indicus* (40.34 %) was the most dominant species, followed by *C. ignobilis* (25.56 %), *C. bajad* (20.45 %), and *S. commersonianus* (13.65 %) with regard to the total catch captured during the study period, with 6,750 hooks (Table 1). The kirbed hook ranked first among the hook shapes, with a total catch of 77 fish, followed by the reversed hook (54 fish) and the straight hook (45 fish). The percentage composition among the three hook shapes was as follows: the kirbed hook had a greater composition of fish catch (43.75 %) in terms of numbers, followed by the reversed hook (30.68 %), and the straight hook (25.57 %) during the experimental study (Table 1). Based on weight, the kirbed hook has the highest catch rate (43.71 %), followed by the reversed hook (30.79 %) and the straight hook (25.50 %) (Table 2). While considering the overall hooking rate, the kirbed hook has a higher hooking rate (5.1 %) than the reversed (3.6 %) and straight hooks (3 %) (Table 3).

A total of 176 fish were caught during the experiments, with a total effort of 6750 hooks. The hook shapes influence the species caught on each type of hook. Comparatively, the CPUE of the kirbed hook is higher than that of reversed and straight hooks, 6.4, 4.5, and 3.75 individuals/150 hooks, respectively (Table 4). Species-wise, among four species caught, *A. indicus* exhibited the highest catch rate (CPUE) of

Table 3 — Hooking rate of modified carangid longline with different J hook shapes

Targeted species	Hooking rate					
	Straight	%	Kirbed	%	Reversed	%
<i>A. indicus</i>	19	1.27	31	2.06	21	1.4
<i>C. ignobilis</i>	12	0.8	20	1.33	13	0.86
<i>C. bajad</i>	8	0.53	17	1.13	11	0.73
<i>S. commersonnianus</i>	6	0.4	9	0.6	9	0.6
Total	45	3	77	5.1	54	3.6

Table 4 — CPUE of modified carangid longlines with different hook shapes

Targeted species	Number of fish from 6,750 hooks	CPUE (individuals/150 hooks)			Total
		Straight	Kirbed	Reversed	
<i>A. indicus</i>	71	1.58	2.58	1.75	5.91
<i>C. ignobilis</i>	45	1.00	1.67	1.08	3.75
<i>C. bajad</i>	36	0.67	1.42	0.92	3.01
<i>S. commersonnianus</i>	24	0.50	0.75	0.75	2.00
Total		3.75	6.4	4.5	

Table 5 — Hooking pattern of modified carangid longlines with different hook shapes

Sl. No	Hooking position	Hook shapes						Total number of fishes	Overall hooking pattern (%)
		Straight hook	%	Kirbed hook	%	Reversed hook	%		
1.	Jaw	19	37.78	43	55.84	24	44.44	86	48.86
2.	Throat	17	33.33	23	29.87	17	31.48	57	32.37
3.	Gut	9	28.89	11	14.29	13	24.07	33	18.75
Total number of fishes		45		77		54			

Table 6 — Three-way analysis of variance test result for modified carangid longlines with different J hook shapes

Source of variation	Degrees of freedom	Sum of square	Mean sum of square	F-ratio	F-value 5 %	P-value
Species	3	79.60	26.53	3.95	3.49	$P < 0.05$
Month	4	37.73	9.43	1.40	3.26	$P > 0.05$
Error I	12	80.4	6.7			
Design	2	27.23	13.62	4.88	3.55	$P < 0.05$
Interaction	6	6.50	1.08	0.38	2.66	$P < 0.05$
Error II	18	50.173	2.79			

5.91 individuals per 150 hooks followed by *C. ignobilis* (3.75 individuals per 150 hooks), *C. bajad* (3.01 individuals per 150 hooks), and *S. commersonnianus* (2.00 individuals per 150 hooks).

Hooking position of the total fish hooked were 48.86 % in the jaw, 32.37 % were hooked in the throat system, and 18.75 % were hooked in the gut. In comparison, when using the kirbed hook, 55.84 % of fish caught were hooked in the jaw and only 14.29 % were hooked in the gut system. When using a straight hook, most of the captured fish were hooked in the jaw (37.78 %), followed by the gut (28.89 %); and when using a reversed hook, 44.44 % and 24.07 % of the caught fish were hooked in the jaw and gut,

respectively (Table 5).

The analysis of variances in the impacts of three different hook shapes, such as non-offset 'J' hook, 10° offset Kirbed 'J' hook, and 10° offset reversed 'J' hook on the hooking efficiency of different species of Carangids revealed that there existed a significant difference in catch rate between various species caught, such as *A. indicus*, *C. ignobilis*, *C. bajad*, and *S. comersoninaus* ( $P < 0.05$ ). Furthermore, a significant difference could be observed with respect to the catch rate of three different hook shapes ( $P < 0.05$ ), and there is no significant difference observed between month-wise catch rates ( $P > 0.05$ ) (Table 6).

## Discussion

The present investigation was made on the newly designed carangid longline gears with three different shapes of 'J' hook No. 8. A survey study by Vasanth *et al.*<sup>22</sup> revealed that drift pelagic longline with hooks no. 7, 8, and 9 is extensively used for carangids around the Gulf of Mannar Coast. According to Vinothkumar *et al.*<sup>7</sup>, more than 35 species of carangids were the main resource along the coasts of the Gulf of Mannar and Palk Bay. However, only four species *A. indicus*, *C. ignobilis*, *C. bajad*, and *S. commersonianus* made up the fishery in the experimental longlines along the Gulf of Mannar coast. Table 1 shows that the kirbed hook had the highest catch rate, accounting for 43.75 % of the total fish caught. This was followed by the reversed hook at 30.68 % and the straight hook at 25.56 %. These differences were statistically significant ( $P < 0.05$ ) during the experimental study. A similar result was observed in comparison of the 18/0 10° offset circle hook and straight J hook in pelagic longline fishery in the Bay of Bengal region<sup>15</sup>. Vasanth *et al.*<sup>23</sup> reported a catch composition of 10° offset hook higher than non-offset J hook in Palk Bay region especially for needle fish, and similar studies reported that the catch composition with various hook numbers and shapes did not statistically differ in various waters<sup>8,24,25</sup>. This study found the highest overall hooking rate on the kirbed hook, at 16.74 %, compared with the other two hook shapes. Similar, results were found in various studies conducted in the Atlantic Ocean and Gulf of Mannar, India<sup>11,26</sup>. However, Kumar *et al.*<sup>19</sup> reported that the hooking rate was similar for the Japanese tuna hook and the circle hook.

Various other studies<sup>1,27</sup> have reported that the shape of the hook affects the catch rate of the targeted species. A similar result was observed in the present experimental study, using a different shape of 'J' hook No. 8, where the highest CPUE was found in the Kirbed hook (6.4 individuals/150 hooks), when compared to the reversed hook (4.5 individuals/150 hooks), and straight hooks (3.75 individuals/150 hooks). Further, similar results were observed for the offset circle hook that showed 2.5 times higher CPUE than the non-offset 'J' hook for yellow fin tuna<sup>28</sup>. Prince *et al.*<sup>8</sup>, suggested that the minor offset circle hook (10.25 fishes per day) had higher CPUE than non-offset circle hook (6.35 fishes per day) for sailfish. The 10° offset circle hook showed higher CPUE than the non-offset

J hook (2.23 vs. 1.91) for the targeted species of tuna and swordfish, and the catch rate is higher for the 10° offset 3.8 sun tuna hook compared to the 4.3 and 5.2 sun circle hook for shark<sup>15</sup>. Further, Skeide *et al.*<sup>16</sup>, reported that there is no difference between the catch rate of the straight and Kirbed EZ Baiter hook.

As far as the right type of hooking pattern was concerned, hooking at the jaw was found to be ideal as it did not damage the fish, leading to early death after getting hooked. Among the three shapes of hook, the hooking positions such as hooking at the jaw, throat, and gut, jaw hooking was found to be highly prevalent in the 'Kirbed' hook (55.84 %) followed by the 'Reversed' hook (44.44 %) and the straight hook (37.78 %). Similar results were observed in the experimental study by Kumar *et al.*<sup>19</sup>, on the capture of large predatory fishes in the waters of Agatti Island, Lakshadweep. Further, an offset circle hook was used to reduce the rate of deep hooking and increase mouth hooking in pelagic fishes, such as Atlantic bluefin tuna, yellowfin Tuna, and billfish<sup>8,11,28</sup>. In contrast, straight shank J hooks had a 70 % rate of jaw hooking<sup>24</sup>. Among the three types of hooks tested 'non-offset straight' hook was found to have the highest percentage of hooking at the throat (33.33 %) and gut (28.89 %), which are not proper hooking locations in longline fishing, as hooking at both the throat and gut may lead to high struggle and quick death of hooked fish, resulting in fast degradation in quality. A similar result was seen with the non-offset J hook but not with the offset circle hook<sup>18</sup>. From the present study, the results showed that the offset kirbed hook caught fish in the jaw more frequently than the non-offset straight hooks, whereas the non-offset straight hook hooked fish more often in the throat and gut.

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## Conflict of Interest

The authors would like to declare that there are no conflicts of interest to publish this research papers in the journal.

### Ethical Statement

The evidence used by the authors is from their own original work, which has not been previously published elsewhere. The paper properly credits the meaningful contributions of co-authors. All authors have been personally and actively involved in substantial work leading to the paper and will take public responsibility for its content.

### Author Contributions

KV: Conceptualization of the study, data collection, and data analysis. MK, NM, JVS & VG: Supervision, validation, review, drafting and preparation of the manuscript.

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