Catch rate comparison between circle hooks and ring hooks in the tropical high seas of the Indian Ocean based on the observer data

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Abstract: Based on data collected on board fresh longlining vessels Huayuanyu No.18 and Huayuanyu 19 of Guangdong Guangyuan Fishery Group Ltd，which operated in the tropical high seas of the Indian Ocean (0º47′N～10º16′N，61º40′E～70º40′) from Sep.15th to Dec.12th 2005, this paper did a comparison of the catch rate in term of individuals/1000hooks and the average gilled and gutted weight of Bigeye tuna and Yellowfin tuna between ring hooks and circle hooks at different drifting speed by One-Way ANOVA and T-test. Measurements in situ indicate that drifting speed of the longline in above mentioned area ranged from 0.00 to 0.76m/s, which can be divided into low speed (0.00-0.20)m/s, medium speed (0.21-0.40)m/s and high speed (0.41-0.76m/s). Bigeye catch rate of the ring hooks is relatively stable and affected slightly by drifting speed of longline, while Yellowfin catch rate varied with the drifting speed with the highest catch rate occurred at medium drifting speed. The catch rate of both bigeye and yellowfin tuna of the circle hooks decreased with the increase of drifting speed, but analysis result indicated that no significant differences statistically is found in the catch rate to Bigeye tuna and Yellowfin tuna between ring hooks and circle hooks at the varies drafting speed of longline.

Key words: ring hook; circle hook; catch rate; *Thunnus obesus*; *Thunnus albacares*; tuna longline

Bigeye tuna and yellowfin tuna are the main targeting species by Chinese tuna longline fleet in the Indian Ocean, their catch increased significantly in recent years (Xu Liuxiong etc 2006). Along with the increasing concerns on the responsible fisheries, application of effective mitigation methods are appealed by international communities to reduce the incidental catch of sharks, sea turtles and seabirds in tuna longline fishing (IOTC,2005;SCTB,2003), Scientists have been looking for measures which can reduce the bycatch while keeping the fishing efficiency for the targeting species so that they can be accepted by fishing industries. Many researches have been done on the effect of hook types on the catch rate of targeting species (Laurs,2004;Ariz,2005). Research by Beverly(2004) indicated that increasing the fishing depth of the hooks by adding weight near the float resulted in the reduction of bycatch or incidental catch while increasing the catch of targeting species. Boltan (2001) showed that using large size 18/0 stainless circle hooks resulted in the reduction of the incidental catch of sea turtle. According to Anon (2004), by switching the traditional J-hook with squid bait to large circle hook with mackerel bait, catch rate of leatherback turtles（*Dermochelys coriacea*) and loggerhead turtles（*Caretta caretta*) were reduced by 65% to 90% .

This paper, based on data collected on board fresh longlining vessels Huayuanyu No.18 and Huayuanyu 19 of Guangdong Guangyuan Fishery Group Ltd，which operated in the tropical high seas of the Indian Ocean (0º47′N～10º16′N，61º40′E～70º40′) from Sep.15th to Dec.12th, 2005,

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did a comparison of the catch rate in term of individuals/1000hooks and the average gilled and gutted weight of Bigeye tuna and Yellowfin tuna between ring hook and circle hook at different drifting speed by One-Way ANOVA and T-test.

1 Materials and methods

1.1 Fishing boats, fishing gear and method, operation areas and time

Comparison experiment has been conducted on board the fresh tune Longliners Huayuanyu No.18 and Huayuanyu No.19 of Guangdong Distant water fishing company. The main dimensions of the boats are 26.12m LOA , 150GT, 407kw of main engine. Basic fishing operation equipments on board the fishing boats include one super spool III long line system, one PL-III line reel and one LS-4 line setter.

The component of the tuna longline consists of 3.6 mm diameter monofilament mainline, 360mm diameter hard plastic floats, 22 m nylon float line with 5mm diameter, 16m of branch line. Distance between two consecutive branch lines is 43.5m and there were 25 hooks per basket.

Hooks used in the experiment are 4.5mm ring hooks and circle hooks(15/0) as showed in Fig.2.

Deployment of the longline begins at about 03:00 to 06:00 (local time) at 8 to 8.5 knot of boat speed with the line setting speed of 5.6 to 7.0m/s, the time interval between two successive branch lines was about 7.80s. Hauling back the line starts at 12:00 to 15:00. The setting and hauling process usually lasts for about 5 hours and 10 to 12 hours respectively.

The operation area is at 0º47´N～10º16´N，61º40´E～70º40´(see figure 1) from Sep.15th to Dec.12th 2005. XR-620 submersible Data Logger, and TDR (2050) are used in the experiment.

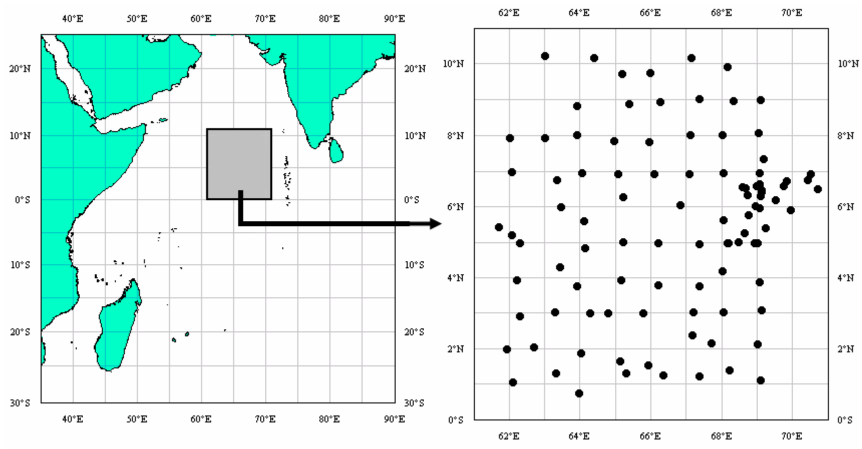

Fig. 1 Operation area during research

Figure 2 Hook types used in the experiment (ring hooks (left), circle hooks (right)

1.2 Experiment design and data record

100 circle hooks and 400 ring hooks were used in every comparison operation, which were successively deployed from the 5-8 baskets to 9-18 baskets respectively. The time and position of setting and hauling the first float were recorded and the difference in time and distance is used to estimate the drifting speed of the longline. Individuals of bigeye and yellowfin tuna hooked by two types of hook were recorded respectively. Their gilled and gutted weight is recorded in kg (±0.1kg). Difference in catch rate of bigeye and yellowfin between the ring hooks and circle hooks are analyzed by one way ANOVA and student T test (Cai Yi-Lin and Yue Yong-sheng 2004)

2 Results

A total of 108 experiments have been made during the research. 1,140 bigeye and yellowfin tuna (21,140kg in weight) was caught during the experiment, among them 624 are bigeye and 516 are yellowfin tuna. In addition, there is 895kg of billfish *Xiphias gladius* and 227kg of Sailfish *Istiophorus platypterus*.

A total of 421 bigeye was measured. Their fork length ranged from 0.73m to 2.06m with average value of 1.253m. The fork length between 1.10m and 1.25m accounts for 43.26%. A total of 336 yellowfin tuna was measured. Their fork length ranged from 0.94m to 1.50m with average value of 1.170m. Fork length between 1.05m and 1.25m accounts for 71.86%.

During this experiment, one leatherback turtle (*Lepidochelys olivacea*) was incidentally caught by ring hook. The turtle was found dead when brought onto the fishing boat.

According to measurements in situ, drifting speed of the longline ranged from 0.00 to 0.76m/s in the operation area, which can be divided into low speed: (0.00-0.20)m/s, medium speed :(0.21-0.40)m/s and high speed : (0.41-0.76m/s). The number of days the above three different drifting speeds occurred and effectively recorded are 28, 21 and 31 respectively.

2.1 catch rate in individuals/1000hooks **between ring hook and circle hook**

Catch rate (individuals/1000hooks) of the ring hooks and circle hooks at three different drifting speeds is showed in Figure 3. It can be seen that bigeye catch rate of the ring hooks is relatively stable and slightly affected by drifting speed of longline. Yellowfin catch rate, however, varied with the drifting speed with the highest catch rate occurred at medium drifting speed. Effect of drifting speed on the catch rate of circle hooks to both bigeye and yellowfin tuna is clearly indicated in Figure 3. The catch rate of both bigeye and yellowfin tuna tends to decrease with the increase of drifting speed.

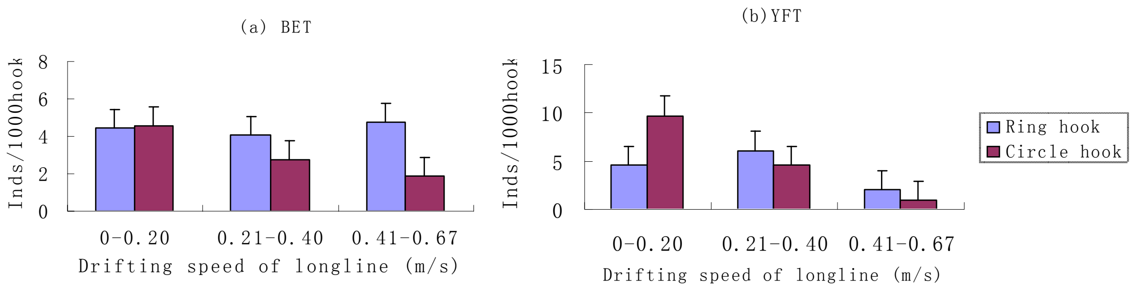

Figure 3 Catch rate between ring hook and circle hook

However according to One-Way ANOVA, there are no significant differences (α＝0.05) in the catch rate of both bigeye and yellowfin tuna between the ring hooks and circle hooks (Table 1 and table 2)

Table 1　One Way ANOVA for catch rate of bigeye tuna

Drifting speed		df	Sum of Sq	Mean Sq	F	Sig.	$F_{(0.05)}$
(0.00-0.20)m/s	Between	1	12.28	12.28	0.22	0.64	4.02
	Within	54	2987.09	55.32			
	Total	55	2999.37				
(0.21-0.40)m/s	Between	1	7.73	7.73	0.42	0.52	4.08
	Within	40	728.72	18.22			
	Total	41	736.46				
(0.41-0.76)m/s	Between	1	84.26	84.26	1.83	0.18	4.00
	Within	60	2759.22	45.99			
	Total	61	2843.48				

Table 2　One Way ANOVA for catch rate of yellowfin tuna

Drifting speed		df	Sum of Sq	Mean Sq	F	Sig.	$F_{(0.05)}$
(0.00-0.20)m/s	Between	1	583.73	583.73	2.66	0.11	4.02
	Within	54	11862.4	219.67			
	Total	55	12446.13				
(0.21-0.40)m/s	Between	1	21.85	21.85	0.13	0.72	4.08
	Within	40	6784.38	169.61			
	Total	41	6806.23				
(0.41-0.76)m/s	Between	1	22.45	22.45	2.34	0.13	4.00
	Within	60	574.55	9.58			
	Total	61	597.00				

2. 2　catch rate in average gilled and gutted weight between ring hook and circle hook

In this analysis, 272 bigeye tuna and 220 yellowfin tuna caught by the ring hooks were sampled with their average gilled and gutted weight 34.4kg and 23.9kg respectively. 23 bigeye tuna and 45 yellowfin tuna caught by the circle hooks were sampled and the average gilled and gutted weight was 38.9kg and was 25.0kg respectively. There are no significant differences ($\alpha = 0.05$) in the gilled and gutted weight of both bigeye and yellowfin tuna between the ring hooks and circle hooks by t-test (sea table 3 and table 4).

Table 3　T-test to the gilled and gutted weight of bigeye tuna

	N	Mean	Std. Deviation	df	t	$T_{(0.05)}$
Ring Hook	272	34.4	15.19			
Circle Hook	23	38.9		22	1.43	2.074

Table 4 T-test to the gilled and gutted weight of yellowfin tuna

	N	Mean	Std. Deviation	df	t	$T_{(0.05)}$
Ring Hook	220	23.9	6.92			
Circle Hook	45	25.0		44	1.02	2.014

3 Discussions

No significant differences in catch rate in term of individuals/1000hooks and gilled and gutted weight between ring hooks and circle hooks from this comparison at least indicates that introduction of circle hooks to replace traditional ring hooks in tuna longline will not affect the catch of the main species, i.e., bigeye and yellowfin tuna to Chinese tuna fleet. In addition, the result also showed that yellowfin catch rate of the circle hook was 5.17ind./1000hooks, higher than that of the ring hook (3.93ind./1000hooks), this will facilitate the application of the circle hooks in tuna longline fishery, especially in the Chinese Indian Ocean tuna longline fleet where yellowfin tuna catch is just following the bigeye tuna.

Though it is indicated that using circle hooks could reduce the incidental catch of sea turtle (Boltan,2001; Anon,2004), there is lack of evidence from this comparative experiment to prove that since only one sea turtle was incidentally caught during three months research when the observers worked on the fishing boats. According to Brett Molony (2005), most turtles spend their time in the upper regions of the water column (less than 120m), so hooks nearby float will have the higher chance to catch sea turtle. Using circle hooks at the two branch lines nearest to the float may protect the sea turtle while increase the catch of yellowfin tuna.

From the view point of pure experiment design, the two types of hook to be compared should be deployed by one basket of comparative hook type immediately followed by a basket of test hook type in order to reduce the possible bias caused by uneven distribution of the main fish species. From practical point of view, however, it is very difficult to conduct the comparative experiment in that way considering the labor and cost involved. Of course, the same number of circle hooks and ring hooks should be used in catch rate comparison next time and considering about 3000 hooks deployed by a fishing boat every day, more circle hooks should be used in doing such the experiment.

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