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# COMPARISON OF CIRCLE HOOK AND J HOOK CATCH RATE FOR TARGET AND BYCATCH SPECIES TAKEN IN THE KOREAN TUNA LONGLINE FISHERY DURING 2005–2006

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# Comparison of circle hook and J hook catch rate for target and bycatch species taken in the Korean tuna longline fishery during 2005- 2006

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NFRDI conducted a circle hook experiment to compare the catch rates of target and bycatch species between J hook and circle hooks in the tuna longline fishery of the eastern Pacific Ocean between 9°13'S~1°36'N and 126°00' ~138°21'W from September 20 to October 23, 2006 (Fig. 1). For this experiment two scientists were deployed on one Korean longliner (416 GRT) fishing for tunas and 4 types of hooks used, size 4.0 traditional tuna hooks (J4) and the offset types of three circle hooks, size 15 circle hooks (C15), size 16 circle hooks (C16) and size 18 circle hooks (C18). In the target species group no significant differences among 4 types hooks were revealed. In the bycatch species group significant differences were found between J4 and C15, and between J4 and C16. Small circle hook (C15) recorded the highest catch rate for tunas and sharks, and traditional tuna hooks (J4) for billfishes, but catch rate of C18 was the lowest. The length frequency of bigeye tuna by hook type showed very similar distribution and slight differences were founded between hook types in the bycatch species. Squid and jack mackerel baits had high catch rate for tuna group and other fishes group, and chub mackerel bait for billfishes and sharks group, but milkfish bait had low catch rate for all groups except tuna group.

Two experiments with circle hooks conducted in 2005 and 2006 showed some discrepencies in the catch rate of target species. This year we will carry out the same type research survey once more in the western central Pacific Ocean and will present results at SC4.

## Fishing method and hooks used

During the 34 days of the experiment, a total of 28 longline sets (one set per day) were monitored. The fishing operations targeted bigeye tuna at the fishing depth ranging from 100 to 300m. The hooks used were of 4 different types: size 4.0 traditional tuna hooks (J-4), and three sizes (C15, C16, C18) of circle hook with 10º offset type (Fig. 2-1). The number of hooks used for each set was 2,240 (560 of each type). The hooks were sequentially set in the order of J 4 - C15 - C16 - C18 ……during

set number 1~14 (A type), and of C15 - C16 - C18 - J 4 ……during set number 15~28 (B type) (Fig 2-2).

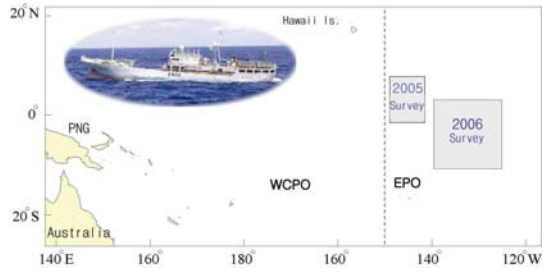


Figure 1. The survey area for circle hook experiment in the eastern Pacific


Figure 2-1. Fishing gear for circle hook experiment. One type (J-4) of traditional tuna hook and three types (C15, C16,C18) of circle hook

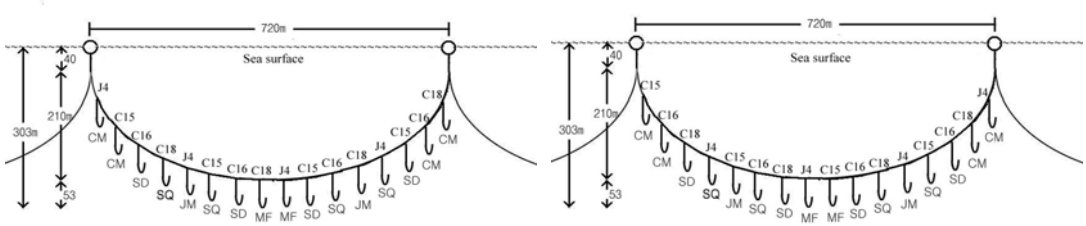


Figure 2-2. Setting type and bait by hook. A type arrayed the hooks in the order of J-4, C15, C16, C18(left) and B type C15, C16, C18, J-4(right). CM: chub mackerel bait, SD: sardine bait, SQ: squid bait, JM: jack mackerel bait, MF: milkfish bait

Longline setting began at around 8:30 am in the morning and finished by 2:00 pm. After about 3 hours of soaking, the longline sets were hauled, continuing until the following early morning and finishing by 7:00 am. Twenty six haulings were started where the setting was finished while two haulings wereas started where the setting started. A total of 62,464 hooks were set in the experiment.

The number of hooks between two floats was 16 and mean length of main line was 135 km. The baits were sardine, jack mackerel, squid, chub mackerel and milk fish.

**Catch in number by species and hook type**

The catches (in number of fish) taken by 62,464 hooks were 824 tunas and billfishes; bigeye tuna was the dominant tuna species accounting for 507 fish (61.6% of the tuna and billfish total), followed by yellowfin tuna of 78 fish (9.5%), and incidental catches of albacore and skipjack tuna (Table 1-1). Incidentally caught billfish were swordfish(8.1%), blue marlin (2.2%) striped marlin (1.0%), shortbill spearfish (3.6%) and sailfish (1.6%). The total number of tunas and billfishes taken on J4 hooks was 195 fish (23.7% of the tuna and billfish total). A total of 221 tuna and billfish (26.9%) were

caught on C15 hooks, 195 (23.7%) on C16 hooks and 212 (25.8%) on C18 hooks. Among the 507 bigeye tuna, those taken on J4 hooks numbered 120. A total of 140 bigeye tuna were taken on C15 hooks, 119 on C16 hooks and 128 on C18 hooks. Of the 78 yellowfin tuna, 15 were taken on J4 hooks, 16 were taken on C15 hooks, 21 on C16 hooks and 26 on C18 hooks.

Table 1-1. Catches in number of tunas and billfishes by hook type. Figures in parenthesis denote the percentage of each species

| Species | Hook type | | | | |
|---|---|---|---|---|---|
| | Total (%) | J4 | C15 | C16 | C18 |
| Bigeye tuna | 507 (61.6) | 120 | 140 | 119 | 128 |
| Yellowfin tuna | 78 ( 9.5) | 15 | 16 | 21 | 26 |
| Albacore | 87 (10.6) | 15 | 24 | 25 | 23 |
| Skipjack | 15 ( 1.8) | 5 | 8 | 1 | 1 |
| Swordfish | 67 ( 8.1) | 15 | 18 | 18 | 16 |
| Blue marlin | 18 ( 2.2) | 7 | 2 | 5 | 4 |
| Striped marlin | 8 ( 1.0) | - | 2 | 2 | 4 |
| Shortbill spearfish | 30 ( 3.6) | 13 | 7 | 4 | 6 |
| Sailfish | 13 ( 1.6) | 5 | 4 | - | 4 |
| Total | 823 (100.0) | 195 (23.7) | 221 (26.9) | 195 (23.7) | 212 (25.8) |

A total of 24 bycatch species (676 in number) were observed during the experiment, among which sharks (43.5%), pomfrets (24.2%) and escolar (16.7%) were most common. Some other fish species were also observed (Table 1-2), especially 8 kinds of incidentally caught sharks. Of the sharks, bigeye thresher shark, blue shark, salmon shark and velvet dogfish were most common. Total fish bycatch numbered 143 fish (21.2%) taken on J-4 hooks, 190 fish (23.1%) taken on C15, 179 fish (21.7%) on C16 hooks and 164 fish (19.9%)on C18 hooks.

Table 1-2. Catches in number of sharks and other species by hook type. Figures in parenthesis denote the percentage of each species

| Species | Hook type | | | | |
|---|---|---|---|---|---|
| | Total (%) | J4 | C15 | C16 | C18 |
| Salmon shark | 17 ( 2.5) | 3 | 4 | 4 | 6 |
| Oceanic white-tip shark | 11 ( 1.6) | 7 | 2 | | 2 |

| | | | | | |
|---|---|---|---|---|---|
| Bigeye thresher shark | 82 (12.1) | 15 | 28 | 21 | 18 |
| Blue shark | 25 ( 3.7) | 4 | 4 | 8 | 9 |
| Crocodile shark | 139(20.6 ) | 13 | 49 | 42 | 35 |
| Velvet dogfish | 14 ( 2.1) | 1 | 5 | 3 | 5 |
| Scalloped hammerhead shark | 2 ( 0.3) | 1 | - | 1 | - |
| Smooth hammerhead shark | 2 ( 0.3) | 2 | - | | - |
| Palagic stingray | 23 ( 3.4) | 7 | 5 | 5 | 6 |
| Manta ray | 1 ( 0.1) | - | - | 1 | - |
| Wahoo | 28 ( 4.1) | 12 | 8 | 5 | 3 |
| Dolphin fish | 3 ( 0.4) | 1 | - | - | 2 |
| Escolar | 114(16.9 ) | 30 | 26 | 36 | 22 |
| Oilfish | 10 ( 1.5) | 7 | 1 | 1 | 1 |
| Longnose lancetfish | 25 ( 3.7) | 9 | 3 | 8 | 5 |
| Pomfrets | 164(24.3 ) | 24 | 52 | 41 | 47 |
| Sharptail mola | 2 ( 0.3) | - | - | 2 | - |
| Slender sunfish | 2 ( 0.3) | 1 | 1 | - | - |
| Great barracuda | 1 ( 0.1) | - | - | 1 | - |
| Opah | 1 ( 0.1) | - | - | - | 1 |
| Rainbow runner | 1 ( 0.1) | 1 | - | - | - |
| Olive ridley sea turtle | 5 ( 0.7) | 3 | 2 | - | - |
| Total | 676(100.0 ) | 143(21.2) | 190(23.1) | 179(29.1) | 164(19.9) |

In this experiment period 5 olive ridley sea turtles were observed taken during the time the fishing gear was being hauled. Incidental catch information for these turtles are shown in Table 2. Sea turtles caught by J hooks were dead but caught by circle were alive. After their body measurements were taken we immediately released them to the sea.

Table 2. Incidental catch information on turtles taken in the circle hook experiment by the Korean tuna longliner in the eastern Pacific Ocean during autumn 2006. Hook no. denotes the setting order position of the hook between two floats

| Species | Date | Location | Carapace (cm) | Hook type (hook no.) | Portion hooked | Condition |
|---|---|---|---|---|---|---|
| Olive ridley sea turtle | 21 Sept. | 2° 7′ N 144° 46′ W | 52 | C15(2nd) | lower jaw | **Alive** |
| | | | 66 | J 4(13rd) | mouth | **Dead** |
| | | | 57 | J 4(16th) | mouth | Dead |

| | | | | | | |
|---|---|---|---|---|---|---|
| Olive ridley sea turtle | 22 Sept. | 2° 24′ N 136°16′W | 73 | C15(16th) | Front flipper (right) | **Alive** |
| | | | 72 | J 4(5th) | mouth | Dead |

**Test for differences in catches by hook type**

Differences in catch in number among four hook types and between two hook types in the same species group were detected using a chi-square ($\chi^2$) test for significant differences. The results for each pair of hook types are shown in Table 3.

In the target species group no significant differences were observed among 4 types hook and between any two hook types. In the bycatch species group significant differences were found between J-4 and C15, and between J-4 and C16, respectively.

Table 3. Catch in numbers by hook type and the $\chi^2$ - test for significant differences in catch frequency among and between hook types for the target and bycatch species groups, NS : non significant (P>0.05), S : significant (P<0.05).

| Species group | Hook type | | | | Among and Between | P value | $\chi^2$ value | Conclusion |
|---|---|---|---|---|---|---|---|---|
| | J 4 | C15 | C16 | C18 | | | | |
| Target species | 195 | 221 | 195 | 212 | J4, C15, C16,C18 | 2.44 | 2.44 | NS |
| | | | | | J 4 and C15 | 0.20 | 1.63 | NS |
| | | | | | J 4 and C16 | 1.00 | 0.00 | NS |
| | | | | | J 4 and C18 | 0.40 | 0.71 | NS |
| | | | | | C15 and C16 | 0.20 | 1.63 | NS |
| | | | | | C15 and C18 | 0.67 | 0.19 | NS |
| | | | | | C16 and C18 | 0.40 | 0.71 | NS |
| Bycatch species | 143 | 190 | 179 | 164 | J4, C15, C16,C18 | 0.06 | 7.35 | NS |
| | | | | | J 4 and C15 | 0.01 | 6.63 | **S** |
| | | | | | J 4 and C16 | 0.04 | 4.02 | **S** |
| | | | | | J 4 and C18 | 0.23 | 1.43 | NS |
| | | | | | C15 and C16 | 0.57 | 0.33 | NS |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | C15 and C18 | 0.17 | 0.91 | NS |
| | | | | | C16 and C18 | 0.42 | 0.66 | NS |

**Catch rate of species by hook type**

Table 4 shows the catch rates for each species in a comparative way. Traditional tuna hooks (J-4) had lower catch rate for all species, 18% lower than small size circle hooks (C15), 10% lower than middle size circle hooks (C16) and 9% lower than large size circle hooks (C18). For the tunas group, J-4 hooks had a catch rate that was 17% lower than C15 hooks and 13% higher than C18 hooks. For the billfishes group the catch rate of J-4 hooks was 19% higher than C15 hooks, 32% higher than C16 hooks and 9% higher than C18 hooks. Also, for the sharks group the catch rate of J-4 hooks was 42~53% lower than C15, C16 and C18 hooks, respectively. The consequence was that 3 types circle hooks had higher catch rate for tunas and sharks and had lower catch rate for billfishes as compared with traditional tuna hooks (J-4).

Table 4. Catch rate (CPUE) of main species caught by hook type

| **Species** | **Hooks no. used** | **CPUE (fishes/1,000hooks)** | | | |
|---|---|---|---|---|---|
| | | **J 4** | **C15** | **C16** | **C18** |
| Bigeye tuna | 15,616 | 7.7 | 9.06.3 | 7.6 | 8.2 |
| Yellowfin tuna | 〃 | 1.0 | 1.0 | 1.3 | 1.7 |
| **Tunas group** | 〃 | **10.0** | **12.0** | **10.6** | **11.5** |
| Swordfish | 〃 | 1.0 | 1.2 | 1.2 | 1.0 |
| Blue marlin | 〃 | 0.4 | 0.1 | 0.3 | 0.3 |
| **Billfishes group** | 〃 | **2.5** | **2.1** | **1.9** | **2.3** |
| Salmon shark | 〃 | 0.2 | 0.3 | 0.3 | 0.4 |
| Oceanic white-tip shark | 〃 | 0.4 | 0.1 | - | 0.1 |
| Bigeye thresher shark | 〃 | 1.0 | 1.8 | 1.3 | 1.2 |
| Blue shark | 〃 | 0.3 | 0.3 | 0.5 | 0.6 |
| Crocodile shark | 〃 | 0.8 | 3.1 | 2.7 | 2.2 |
| Velvet dogfish | 〃 | 0.1 | 0.3 | 0.2 | 0.3 |

| | | | | | |
|---|---|---|---|---|---|
| **Sharks group** | 〃 | **2.8** | **5.9** | **5.0** | **4.8** |
| Escolar | 〃 | 1.9 | 1.7 | 2.3 | 1.4 |
| Longnose lancetfish | 〃 | 0.6 | 0.2 | 0.5 | 0.3 |
| Pomfrets | 〃 | 1.5 | 3.4 | 2.6 | 3.0 |
| **Other fishes group** | 〃 | **6.1** | **6.3** | **6.4** | **5.7** |
| **Olive ridley sea turtle** | 〃 | **0.2** | **0.1** | - | - |
| **Total** | **15,616** | **21.6** | **26.3** | **23.9** | **24.1** |

**Catch rate of species by bait**

The baits used were 5 species : chub mackerel, sardine, squid, jack mackerel and milkfish. The number of bait used in each set was 15,616 for chub mackerel, sardine and squid, and 7,808 for jack mackerel and milkfish, respectively.

Table 5 shows the catch rates for each species by bait type. Jack mackerel and squid of the 5 different showed the highest CPUE for tunas group including bigeye tuna. . For the tunas group the CPUEs (14.5~15.8 fishes/1,000 hooks) of Jack mackerel bait and squid bait were 54~59% higher than for the rest 3 baits. Milkfish bait showed the lowest CPUE for billfishes group, sharks group and other fishes group Also, for the billfishes group the CPUE of chub mackerel bait was 46% higher than jack mackerel bait. and 2~4times higher than the rest 3 baits. For the sharks group the CPUEs of chub mackerel, sardine and squid baits were 19~29% higher than those of jack mackerel bait. For other fishes squid bait showed the highest CPUE, that was 7% higher than jack mackerel bait and 20% higher than sardine bait. In conclusion squid and jack mackerel baits showed higher catch rate for tuna group and other fishes group, and chub mackerel bait for billfishes and sharks group, but milkfish bait showed lower catch rate for all groups except tuna group.

Table 5. Catch rate (CPUE) of species group caught by bait used. Figure in parenthesis denote the numbers of fish observed.

| Species caught | ***CPUE (fishes/1,000hooks) by bait*** | | | | |
|---|---|---|---|---|---|
| | Chub mackerel | Sardine | Squid | Jack mackerel | Milk-fish |
| Bigeye tuna (501) | 4.4 | 5.8 | **11.9** | **12.7** | 7.2 |
| Tuna group (681) | 8.4 | 8.5 | **14.5** | **15.8** | 8.6 |
| Billfishes group (180) | **3.8** | 1.4 | 1.9 | 2.6 | 0.8 |

| | | | | | |
|---|---|---|---|---|---|
| Sharks group (295) | **5.0** | **5.4** | **5.4** | 4.2 | 2.0 |
| Otherfishes group (380) | 5.4 | 6.0 | **7.2** | **6.7** | 4.6 |
| Olive ridley sea tuetle(5) | 0.1 | - | 0.1 | 0.1 | - |
| All species (1,497) | 22.9 | 21.3 | **29.1** | **29.3** | 16.0 |

**Length composition of catches by hook type**

Length frequency data for all species caught by the 4 types of hook were collected. The fork length of bigeye tuna ranged from 51cm to 208cm (mean 135cm), that of bigeye tuna caught by J-4 hooks ranged from 51cm to 200cm (mean 128cm), that by C15 hooks ranged from 51cm to 200cm (mean 135cm) and that by C18 ranged from 72cm to 206cm (mean 141cm). Therefore, the length distributions for bigeye tuna were very similar for the 4 hook types as shown in Figure 3-1.

The fork length of yellowfin tuna ranged from 96cm to 175cm (mean 134cm), that of yellowfin tuna caught by J-4 hooks ranged from 96cm to 163cm (mean 130cm), that by C15 hooks ranged from 118cm to 167cm (mean 135cm), that by C16 hooks ranged from 111cm and 169cm (mean 137cm) and that by C18 hooks ranged from 111cm to 175cm (mean 134cm) (fig. 3-1). Therefore, yellowfin tuna caught by J-4 hooks had slightly smaller length than those by circle hooks.

Length frequency data for billfishes, sharks and other species were compared among the 4 types hook (Fig 3-2). The sizes of swordfish and bigeye thresher shark caught by J-4 hooks were slightly smaller than those for 3 types of circle hooks, respectively, but those of the other fishes were not. There were slight differences in length size between hook types in the bycatch species as shown in Fig.3-2.

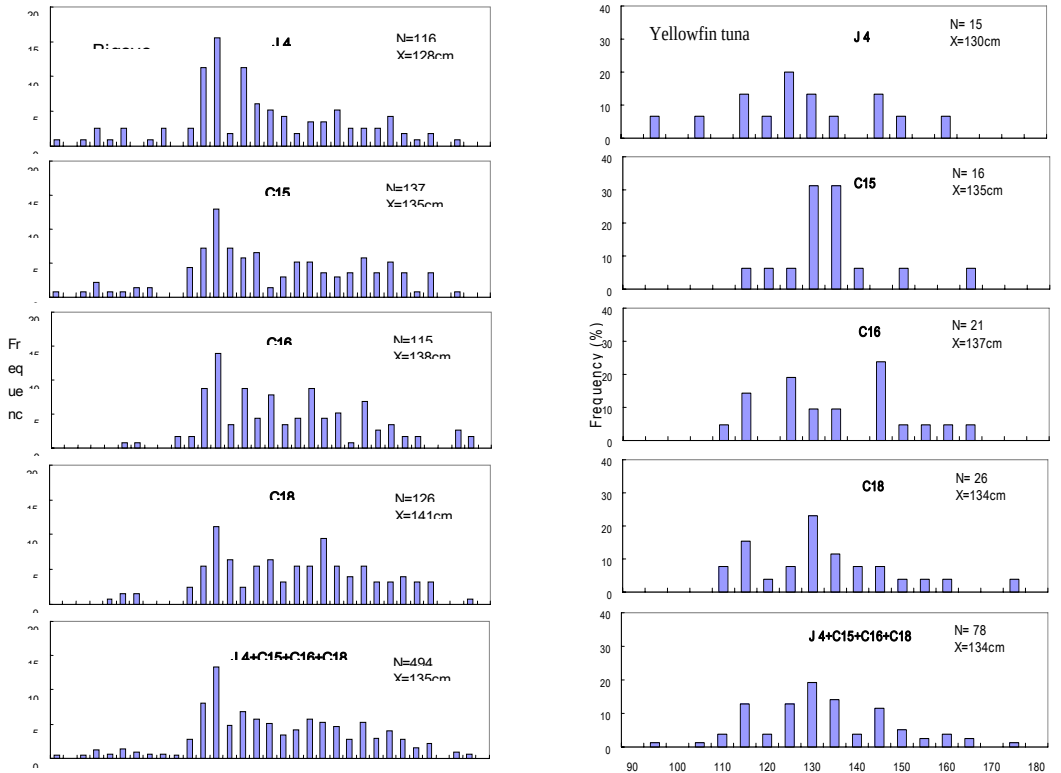

Figure 3-1. Length frequencies of bigeye (left) and Yellowfin tuna (right) by hook type.

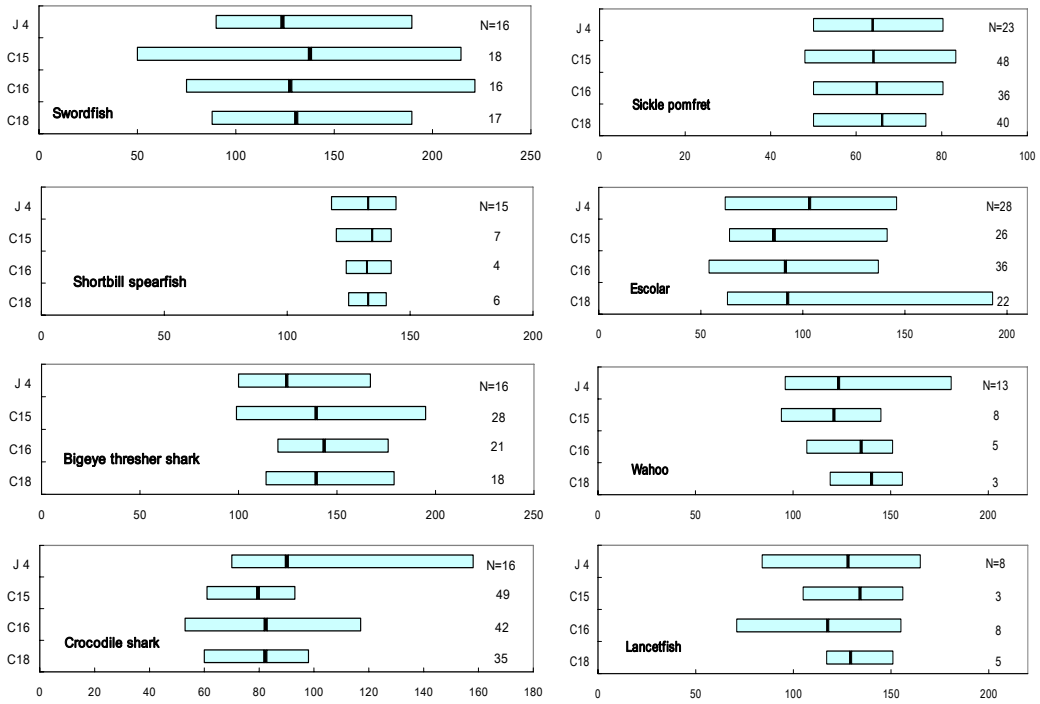


Figure 3-2. Ranges and mean of billfishes and sharks(left) and other species (right) lengths by hook type. (length range : open bar, mean length : filled bar).

**Comparison of the results between the two experiments conducted during 2005 and 2006**

NFRDI conducted the 1st circle hook experiment in the tuna longline fishery of the eastern Pacific Ocean between 1°48'S~7°00'S and 142°00' ~149°13'W from July 15 to

August 12, 2005 using 3 types of hooks, size 4.0 traditional tuna hooks (J4) and the straight types of two circle hooks, size 15 circle hooks (C15) and size 18 circle hooks (C18). The results from the two experiments in 2005 and 2006 showed differences in the catch rate of target and bycatch species by hook types and sea turtle catch rate etc.

In the target species group no significant differences between 4 types hook were observed but in 2005 straight large circle hook (C18) had the lowest catch rate i.e. lower than J4 by about 20% for tunas and for other fishes, and the small circle hook (C15) had lowest catch rate for billfishes and sharks.

Bycatch rate by species was not showing the same trend between the two results. Especially sea turtles were caught by J hook only in 2005 but in 2006 they were caught by both J hook and circle hooks. It is clear that the using of the offset circle hooks did not decrease bycatch of sea turtle but in general increased the survival rate of sea turtle after caught.

At this point it is hard to decide for us to decide the efficiency of circle hooks in bycatch mitigation of sea turtle in tuna longline fishery because of the inconsistency of results in 2005 and 2006. To solve this problem this year we will carry out the same type research survey once more with a mixture of circle hooks (straight and offset types) during August-September in the western central Pacific Ocean and will present the result at SC4.

**Reference**

Kim S. S., D.Y. Moon, C. Boggs, J.R. Koh and D.H. An, 2006. Comparison of circle hook and J hook catch rate for target and bycatch species taken in the Korean tuna longline fishery. J. Kor. Soc. Fish. Tech., 42(4), 210-21