# The Difference of the Tuna Longline Catch by Retrieving Method

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# 다랭이 주낚의 揚繩方式에 따르는 漁獲尾數의 差

朴 丞 源*

다랭이 주낚의 揚繩方式에는 方向의 揚繩(On-tracing retrieve)方式과 逆方向의 揚繩(Back-tracing retrieve)方式의 두가지 方式이 있다. 順方向의 揚繩은 最初에 投繩된 주낚끝에서부타 揚繩하기 시작하여 投繩한 順과 같은 順으로 揚繩하는 것이고 逆方向의 揚繩은 最後에 投繩된 주낚끝에서부터 揚繩하기 시작하여 投繩한 順과 反對順으로 揚繩하는 것이다.

주낚의 操業所要時間을 變更하지 않고 揚繩方式만 變更한다면 주낚의 平均浸漬時間은 變하지 않고 다만 浸漬時間의 分布區間만 變한다.

投繩作業時間을 $\tau_1$, 投繩作業이 끝나고 揚繩作業을 시작하기까지의 待期時間을 $\tau_2$, 揚繩作業時間을 $\tau_3$라고 하면 주낚의 浸漬時間分布範圍는 揚繩方式에 따라 다음과 같이 서로 다르다.

順方向으로 揚繩할 때

$\tau_2$부터 $\tau_1+\tau_2+\tau_3$까지의 範圍

逆方向으로 揚繩할 때

$\tau_1+\tau_2$부터 $\tau_2+\tau_3$까지의 範圍

任意時의 낚시漁獲性能은 $F_0e^{-zt}$ ($F_0$는 初期漁獲性能, $z$는 減少係数, $t$는 投繩後 經過時間)으로 나타낼 수 있고 浸漬時間 $t$인 낚시 $H$개의 漁獲尾数는 $H\frac{1-e^{-zt}}{F_0 \; z}$로 나타낼 수 있으므로 주낚操業에서 낚시수 $H_G$개 이고 浸漬時間이 $\tau_\alpha$와 $\tau_\beta$의 範圍內에 分布하면 漁獲尾数 $C_G$는 다음과 같이 나타낼 수 있다.

$$C_G=\frac{H_G}{\tau_\beta-\tau_\alpha}\cdot\frac{F_0}{Z}\int_{\tau_\alpha}^{\tau_\beta}(1-e^{-zt})dt$$

$\tau_\alpha$, $\tau_\beta$의 값은

順方向의 揚繩에 있어서는 $\tau_\alpha=\tau_1+\tau_2$, $\tau_\beta=\tau_2+\tau_3$,

逆方向의 揚繩에 있어서는 $\tau_\alpha=\tau_2$, $\tau_\beta=\tau_1+\tau_2+\tau_3$.

따라서 다랭이 주낚의 漁獲尾数는 그 揚繩方式에 따라 差가 있고 順方向의 揚繩으로 더 많은 漁獲尾数를 얻을 수 있다.

## INTRODUCTION

A set of tuna longline gear is operated in a sequence of three working steps. The first step is "setting", *i.e.*, laying a set of longline gear in a continuous line. The following step is "waiting", *i.e.*, the gear laid is kept for a while before retrieving. The last step is "retrieving",

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which is hauling up the line aboard with the vessel under way at a slow speed.

The retrieving can be started from either the tail end or the head end (Shimada, 1951). If retrieving starts from the tail end of the line, the retrieving method is called "back-tracing." If it starts from the head end of the line, it is called "on-tracing".

The vessel's skipper usually decide to choose either method in regards to navigation schedules and wind direction during the retrieving operation.

Murphy (1960) established a generalized catch equation that can account for all of the varibles. Hirayma (1969a, b) examined the catches of 167 sets in 24 fishing-days and showed no significant difference in the catch-per-set by so called "counter retrieving" and by "returning retrieving". He remarked that the mean soaking time of a set is equal not withstanding of difference in the retrieving method. Park (1974 a) showed that more catch was expected by on-tracing than by back-tracing. Park (1974 b) evaluated the fishing power of the longline gear and established a catch equation.

This study compares the catch of a longline set by two different retrieving methods: "back-tracing" and "on-tracing".

## METHOD AND RESULT

The fishing power (Beverton and Holt, 1957) of a baited-hook is represented (Park, 1974 b)

$$F_t = F_o e^{-zt} \quad \cdots\cdots (1)$$

Where

$F_t$=fishing power at $t$-hour after set

$F_0$=initial fishing power at the time of settieg

$Z$=decreasing coefficient of the fishing power

$t$=time (hour) after set

Number of fish caught on $H$-hooks in $t$-hours after setting is

$$C = HF_o \int_0^t e^{-zt}\, dt$$

$$= \frac{HF_0}{Z}(1-e^{-zt}) \quad \cdots\cdots (2)$$

Where

$H$=number of hooks

$C$=number of fish caught on $H$-hooks

Suppose the soaking time of a longline set ranges from $\tau_\alpha$ and $\tau_\beta$. Let

$$\tau = \tau_\beta - \tau_\alpha \quad \cdots\cdots (3)$$

Where

$\tau_\alpha$=the soaking time of the hook which is retrieved at first

$\tau_\beta$=the soaking time of the hook which is retrieved at last

The total hooks in a set are distributed in a uniform distribution density in $\tau$-hour (diffeerntial of the longest and the shortest soaking time in a set).

$$H_G = (\tau_\beta - \tau_\alpha) H_i$$
$$= \tau H_i \quad \cdots\cdots (4)$$

Where

$H_G$=total hooks in a set

$H_i$=hooks distribution density in the differential of the soaking time

Then catch in a set is

$$C_G = \frac{H_i F_o}{z} \int_{\tau_\alpha}^{\tau_\beta} (1-e^{-zt})\, dt$$

$$= \frac{H_G F_o}{z}\left(1 + \frac{e^{-z\tau_\beta} - e^{-z\tau_\alpha}}{\tau z}\right) \quad \cdots\cdots (5)$$

In an operation of back-tracing retrieve, the hook which is set at the end of setting and then is retrieved at first, has the shortest soaking time in a set. While, the hook which is set at first and then is retrieved at last has the longest soaking time in a set.

Thus, the equation (5) is fitted to back-tracing retrieve by substituting $\tau_\alpha$, $\tau_\beta$ and $\tau$ with

$$\left.\begin{aligned} \tau_\alpha &= \tau_2 \\ \tau_\beta &= \tau_1 + \tau_2 + \tau_3 \\ \tau &= \tau_3 + \tau_1 \end{aligned}\right\} \quad \cdots\cdots (6)$$

Where

$\tau_1$=time required for setting operation in a set

$\tau_2$=waiting time between setting operation and retrieving operation

$\tau_3$=time required for retrieving operation of a set

Let

$$\left.\begin{array}{l} U_1=e^{-z\tau_1} \\ U_2=e^{-z\tau_2} \\ U_3=e^{-z\tau_3} \end{array}\right\} \quad \cdots\cdots(7)$$

Then, catch by back-tracing retrieve is represented

$$C_G'=\frac{H_GF_0}{Z}\left\{1+\frac{U_1U_2U_3-U_2}{Z(\tau_3+\tau_1)}\right\} \quad \cdots\cdots(8)$$

In an operation of on-tracing retrieve, the hook which is set at first and then is retrieved at first, has the shortest soaking time in a set. While, the hook which is set at last and then retrieved at last has the longest soaking time in a set.

Thus, the equation (5) is fitted to on-tracing retrieve by substituting $\tau_\alpha$, $\tau_\beta$ and $\tau$ with

$$\left.\begin{array}{l} \tau_\alpha=\tau_1+\tau_2 \\ \tau_\beta=\tau_2+\tau_3 \\ \tau=\tau_3-\tau_1 \end{array}\right\} \quad \cdots\cdots(9)$$

Then catch by on-tracing retrieve is represented

$$C_G''=\frac{H_GF_0}{Z}\left\{1+\frac{U_2U_3-U_1U_2}{Z(\tau_3-\tau_1)}\right\} \quad \cdots\cdots(10)$$

Comparing catches by back-tracing and on-tracing retreives

$$C_G'-C_G''=\frac{H_GF_0U_2}{Z^2}\left(\frac{U_1U_3-1}{\tau_3+\tau_1}-\frac{U_3-U_1}{\tau_3-\tau_1}\right)$$

$$=\frac{H_GF_0U_2}{Z^2}\left\{\frac{\tau_1(1+U_1)(1-U_3)-\tau_3(1-U_1)(1+U_3)}{(\tau_3+\tau_1)(\tau_3-\tau_1)}\right\} \quad \cdots\cdots(11)$$

In a practical sense it takes longer for the retrieving operation than the setting operation.

Thus

$$\tau_3=\gamma\tau_1 \ (\gamma>1) \quad \cdots\cdots(12)$$

The equation (11) is reduced to

$$\left.\begin{array}{l} C_G'-C_G''=PQ \\ P=\dfrac{H_GF_0U_2}{Z_2\tau_1(\gamma+1)(\gamma-1)} \\ Q=(1+U_1)(1-U_3)-\gamma(1-U_1)(1+U_3) \end{array}\right\} \quad \cdots(13)$$

In the equation (13) the factors of $P$ are all positive

$$P>0 \quad \cdots\cdots(14)$$

The values of $Q$ are examined by giving $\tau_1$ and $\gamma$ the conceivable values in a practical longline operation in field.

Park (1974 b) evaluated $Z$ in various tuna species: albacore, 0.09 bigeye, 0.205; yellowfin, 0.077; skipjack, 0.014.

Table 1. gives $\tau_1=3-6$ hours and $\tau_3=10-15$ hours.

**Table 1. Fishing process during three steps of a longline operation**

| | First step | Second step | Third step |
|---|---|---|---|
| Operation | Setting | Waiting | Retrieving |
| Longline | Being cast in the sea | Being set | Being retrieved aboard |
| Vessel | Under way in a full speed | Stand by at either end of a set of longline | Under way in a slow speed |
| Duration | $\tau_1$ =3—6hours | $\tau_2$ =3—4hours | $\tau_3$ =10—15 hours |

Let us give $Z$, $\tau$ and $\gamma$ values ranging wider than the conceivable in a practical fishing operation (Table 2. and 3);

$Z$=0.07—0.21

$\tau_1$=3—6 hour

$\gamma$=2—5

**Table 2. Range of the soaking time in sequence of a longline operation**

| | Back-tracing retrieve | On-tracing retrieve |
|---|---|---|
| The direction of progress in retrieving | Reversed to the setting operation | Accordance with the setting operation |
| The hook of the shortest soaking time | Set at last and retrieved at first | Set at first and retrieved at first |
| The shortest soaking time ($\tau_\alpha$) | $\tau_2$=3—4 hours | $\tau_1+\tau_2$=7—10 hours |
| The hook of the longest soaking time | Set at first and retrieved at last | Set at last and retrieved at last |
| The longest soaking time ($\tau_\beta$) | $\tau_1+\tau_2+\tau_3$ =17—25hours | $\tau_2+\tau_3$ =13—19hours |
| The range of the soaking time in a set ($\tau=\tau_\beta-\tau_\alpha$) | $\tau_3+\tau_1$ =13—19hours | $\tau_3-\tau_1$ =6—12hours |

Table 3. The valuss of $Z\tau_1$ for various value of the decreasing coefficient of fishing power ($Z$) and the setting time ($\tau_1$), in a set of longline

| $\tau_1$ (hour) | $Z$ 0.07 | 0.14 | 0.21 |
|---|---|---|---|
| 3 | 0.21 | 0.42 | 0.62 |
| 4 | 0.28 | 0.56 | 0.84 |
| 5 | 0.35 | 0.70 | 1.05 |
| 6 | 0.42 | 0.84 | 1.26 |

The values of $Q$ are all negative for tha conceivable values of $Z_1$ and $\gamma$ in the practical fishing operations as shown in Table 4.

$$Q<0 \quad \cdots\cdots(15)$$

Table 4. The calculated values of $Q$ in the equation (13) for various value of $\tau_1$ $Z$ and $\gamma$

| | $\gamma$ 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| $_1Z=0.21$ | | | | |
| $U_1$ | 0.811 | 0.811 | 0.811 | 0.811 |
| $U_3$ | 0.657 | 0.533 | 0.432 | 0.350 |
| $A=(1+U_1)(1-U_3)$ | 0.621 | 0.846 | 1.029 | 1.177 |
| $B=(1-U_1)(1+U_3)$ | 0.313 | 0.290 | 0.271 | 0.255 |
| $Q=A-\gamma B$ | -0.005 | -0.024 | -0.055 | -0.098 |
| $\tau_1Z=0.56$ | | | | |
| $U_1$ | 0.571 | 0.571 | 0.571 | 0.571 |
| $U_3$ | 0.326 | 0.186 | 0.106 | 0.061 |
| $A=(1+U_1)(1-U_3)$ | 1.059 | 1.279 | 1.404 | 1.475 |
| $B=(1-U_1)(1+U_3)$ | 0.569 | 0.509 | 0.474 | 0.455 |
| $Q=A-\gamma B$ | -0.079 | -0.248 | -0.492 | -0.800 |
| $\tau_1Z=0.84$ | | | | |
| $U_1$ | 0.432 | 0.432 | 0.432 | 0.432 |
| $U_3$ | 0.186 | 0.080 | 0.035 | 0.015 |
| $A=(1+U_1)(1-U_3)$ | 1.166 | 1.317 | 1.382 | 1.411 |
| $B=(1-U_1)(1+U_3)$ | 0.674 | 0.613 | 0.588 | 0.577 |
| $Q=A-\gamma B$ | -0.182 | -0.522 | -0.970 | -1.474 |
| $\tau_1Z=1.26$ | | | | |
| $U_1$ | 0.284 | 0.284 | 0.284 | 0.284 |
| $U_3$ | 0.080 | 0.023 | 0.006 | 0.002 |
| $A=(1+U_1)(1-U_3)$ | 1.181 | 1.254 | 1.276 | 1.281 |
| $B=(1-U_1)(1+U_3)$ | 0.773 | 0.732 | 0.720 | 0.717 |
| $Q=A-\gamma B$ | -0.365 | -0.942 | -1.604 | -2.304 |

$$Q=(1+U_1)(1-U_3)-\gamma(1-U_1)(1+U_3)$$

$$U_1=e^{-\tau_1 z},\ U_3=e^{-\gamma\tau_1 z},\quad \gamma=\frac{\tau_3}{\tau_1}$$

From the equations (13). (14) and (15).

$$C_G'-C_G''<0$$

$$C_G'<C_G'' \quad \cdots\cdots(16)$$

Thus the more catch is obtainable by on-tracing retrieve than by back-tracing retrieve.

## FIELD DATA ANALYSIS

Fishing power $F_t$ was evaluated through 87 sets of operations (Park, 1974 b), representing the number of fish caught on 1,000 hooks per hour at a given time after setting;

albacore, $F_t=4.389\ e^{-0.09t}$ $(4\leq t\leq 20)$

yellowfin, $F_t=0.779\ e^{-0.077t}$ $(4\leq t\leq 20)$

The operation time of three working steps in a set was:

$\tau_1=3.8$ hour

$\tau_2=4.0$ hour

$\tau_3=12.2$ hour

All the retrieving operations were done by back-tracing. The shortest soaking time($\tau_\alpha$) and the longest soaking time ($\tau_\beta$) in a set are:

$\tau_\alpha=\tau_2=4.0$ hour

$\tau_\beta=\tau_1+\tau_2+\tau_3=20.0$ hour

If all the retrieving operations were done by on-tracing retrieve without changing the operation time of three working steps, the shortest and the longest soaking time in a set are:

$\tau_\alpha=\tau_1+\tau_2=7.8$ hour

$\tau_\beta'=\tau_2+\tau_3=16.2$ hour

Total number of hooks, $H_G=122,733$.

Thus catches calculated by the equations are:

By back-tracing retrieve,

albacore 3,756

yellowfin 717.

By on-tracing retrieve,

albacore 3,889

yellowfin 739.

Observed catches in the experimental fishing operations by backtracing retrieve were:

albacore 3,572

yellowfin 689.

## LITERATURE CITED

Beverton, R. J. H. and S. J. Holt, (1957): On the Dynamics of Exploited Fish Populations. Fish. Invest. 2(19), 89~96. Her Majesty's Stationary Office, London.

Hirayama, N., (1969 a): Studies on the fishing mechanism of tuna long line-Ⅲ. The difference of catch by retrieving methods. Bull, Jap. Soc. Sci. Fish., 35(7), 629~634. (in Japanese.)

________. (1969 b): Studies on the fishing mechanism of tuna longline-Ⅳ. Theoretical analysis of fishing effectiveness of the gear. *ibid.*, 35(7), 635~640. (in Japanese).

Murphy C. I., (1960): Estimating abundance from longline catches. J. Fish. Res. Bd. Canada, 17(1), 33~40.

Park, S. W., (1974 a): The fishing efficiency of the tuna longline-2. The fishing efficiency dercease by soaking time. Bull. Pusan Fish. Coll., 14(1), 1~11. (in Korean).

________. (1974 b): Fishing power and diurnal variation of catchability of tuna longline. Publ. Mar. Lab. Busan Fish. Coll., 7, 51~76. (in Korean).

Shimada, B., (1951): Japanese tuna-mothership operations in the Western Equatorial Pacific Ocean. Commercial Fish. Rev., U. S. Dept. Interior., 13(6), 1~26.