Size selectivity of tuna purse seine nets estimated from FAD sets data

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Abstract

Mitigating small tuna by-catch in FADs fishery is an urgent task for sustainable fishery. Although using large mesh net might reduce small tuna catch, its impact is unknown as very few studies has been done on the size selectivity of purse seine nets. To obtain quantitative information on the size selectivity we compared the catch composition from two different mesh size nets. The catch of small mesh showed more catch of smaller fish of 25-35cm FL. The result suggests possible escape of small fish from large mesh openings.

Introduction

The Fish Aggregating Devices (FADs) attract fish including small Bigeye tunas. This nature results in by-catch of small bigeye tuna in purse seine fishery and causes negative impacts to its stock status. Effective method to mitigate the small tuna by-catch is necessary.

Generally, enlarging mesh size of nets can reduce bycatch of small fishes. In purse seine fishery, however, there have not been clear evidence that shows the size selectivity of the gear. We tried to compare the catch composition of two nets with different mesh sizes and to estimate the size selectivity curves for tune purse seine nets.

Materials & Methods

(1) Sampling

Two tuna purse seiners were used for the study; Taikei-maru No.1 and Koyo-maru No.88. Two vessels have nets with different mesh size; smaller mesh (240mm) for Taikei-maru and larger mesh (300mm) for Koyo-maru. To make a comparison with uniform conditions, we used data of the sets from same area (eastern Indian Ocean) and from same period (Nov-Dec,2016). Also, only the data for FAD sets were used. Research scientists on board both ships measured the three-major species (Skipjack, Yellowfin and Bigeye tunas) to estimate the size composition of each catch. Spill sampling method were used to collect sample.

The size data from 14 sets with small mesh and from 28 sets with large mesh were summed up for each net and were used for the analysis.

(2) Estimation of size selectivity curves

We estimated the size selectivity curve of the large mesh net using estimated split model of the SELECT method (Millar and Walsh1992, Tokai & Mitsuhashi 1998).

For selection function of the large mesh net, the logistic curve $\mathrm{r}(l)$ is applied.

$$\mathrm{r}(l) = \frac{\exp(a+bl)}{1+\exp(a+bl)}$$

The "split parameter" *p* of the estimated split model is the relative fishing intensity of the large mesh net. In case of this study, for a fish caught, its probability of being caught in large mesh and small mesh net is *p* and 1 – *p* respectively.

Consequently, for a fish of length *l*, its probability of being caught in large mesh is $p * r(l)$. Similarly, its probability of being caught in small mesh is 1 – p under the assumption that small mesh net captures all size classes. Then the probability that a fish of size *l* is caught in large mesh net is described in the following function.

$$\phi\,(l) = \frac{p * r(l)}{1-p+p*r(l)}$$

$$= \frac{p * exp(a+bl)}{1-p+\exp(a+bl)}$$

The number of fish caught in large mesh net can be modelled as binomial distribution. The likelihood function L , that is multiplied over all length classes, is

$$\mathrm{L} = \prod_{l} \frac{n_{L+}!}{n_{Ll}!\,n_{Sl}!}\ \phi\,(l)^{n_{Ll}}[1-\ \phi\,(l)]^{n_{Sl}}$$

where n_{Ll} and n_{Sl} denotes the number of fish of length *l* caught in the large mesh and small mesh nets respectively. n_{L+} is the total number of fish of length *l* ($n_{L+} = n_{Ll} +\ n_{Sl}$). The log-likelihood function is

$$log_e L = \sum [n_{Ll} log_e\ \phi\,(l) + n_{Sl} log_e(1-\ \phi\,(l))]$$

The parameters a, b and p that maximize the $log_e L$ were estimated using Excel solver.

Results

Figure 1 shows the size composition of skipjack, yellowfin and bigeye tunas caught with two nets. For each species, the catch number of 25-35 cm size classes were generally larger in sample from small mesh net compared to that from large mesh. This suggests possible escape of smaller fish through mesh openings.

Figure 2 shows the fits of the estimated curves to the observed proportions of catch of large mesh net to total catch for the three species. Figure 3 shows the preliminary result of size selectivity curve estimation for the three species. Size selectivity curve of skipjack tuna showed steeper selectivity than that of yellowfin and bigeye tunas.

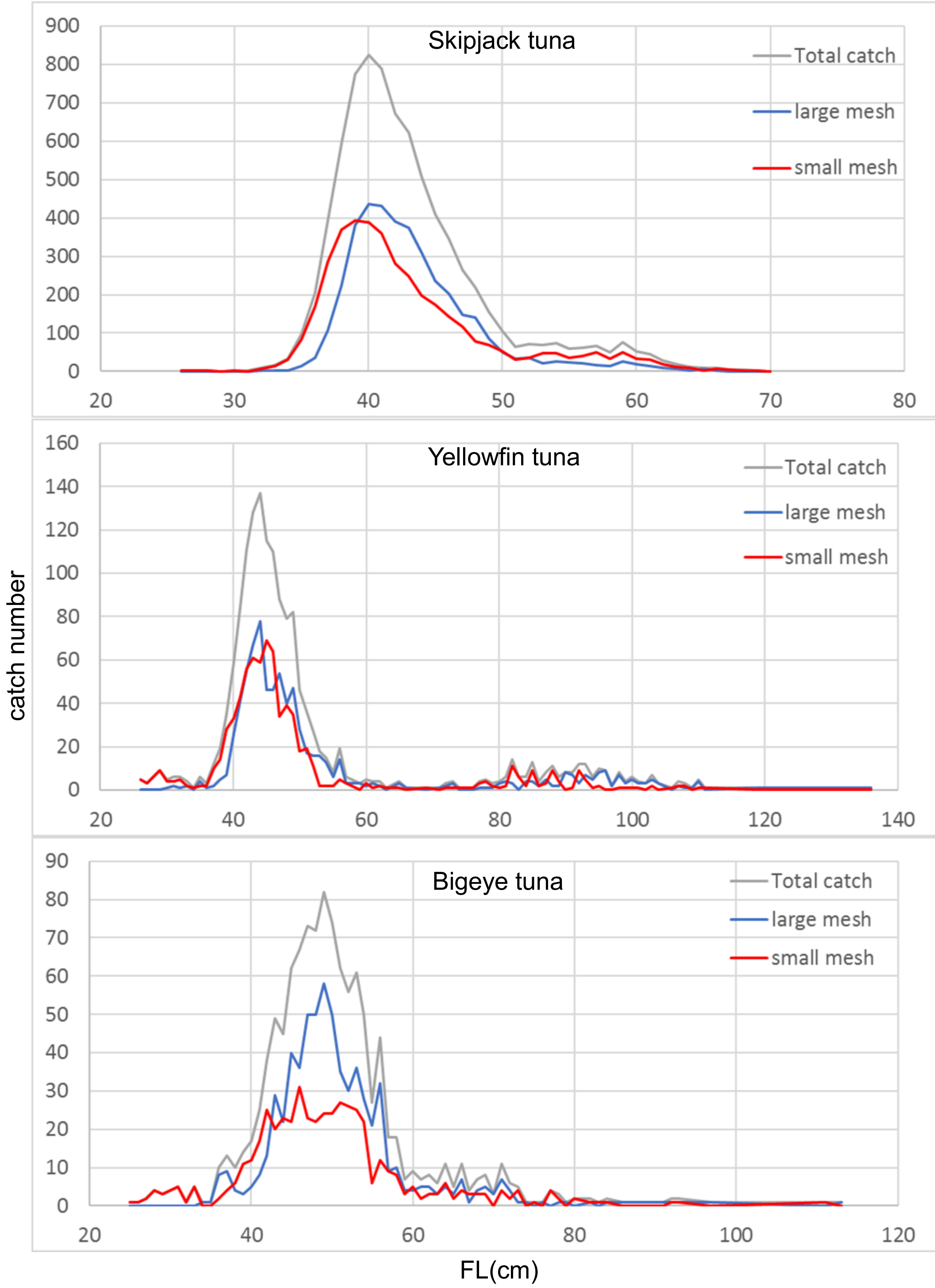

Fig.1 Size composition of skipjack, yellowfin and bigeye tunas caught with two nets

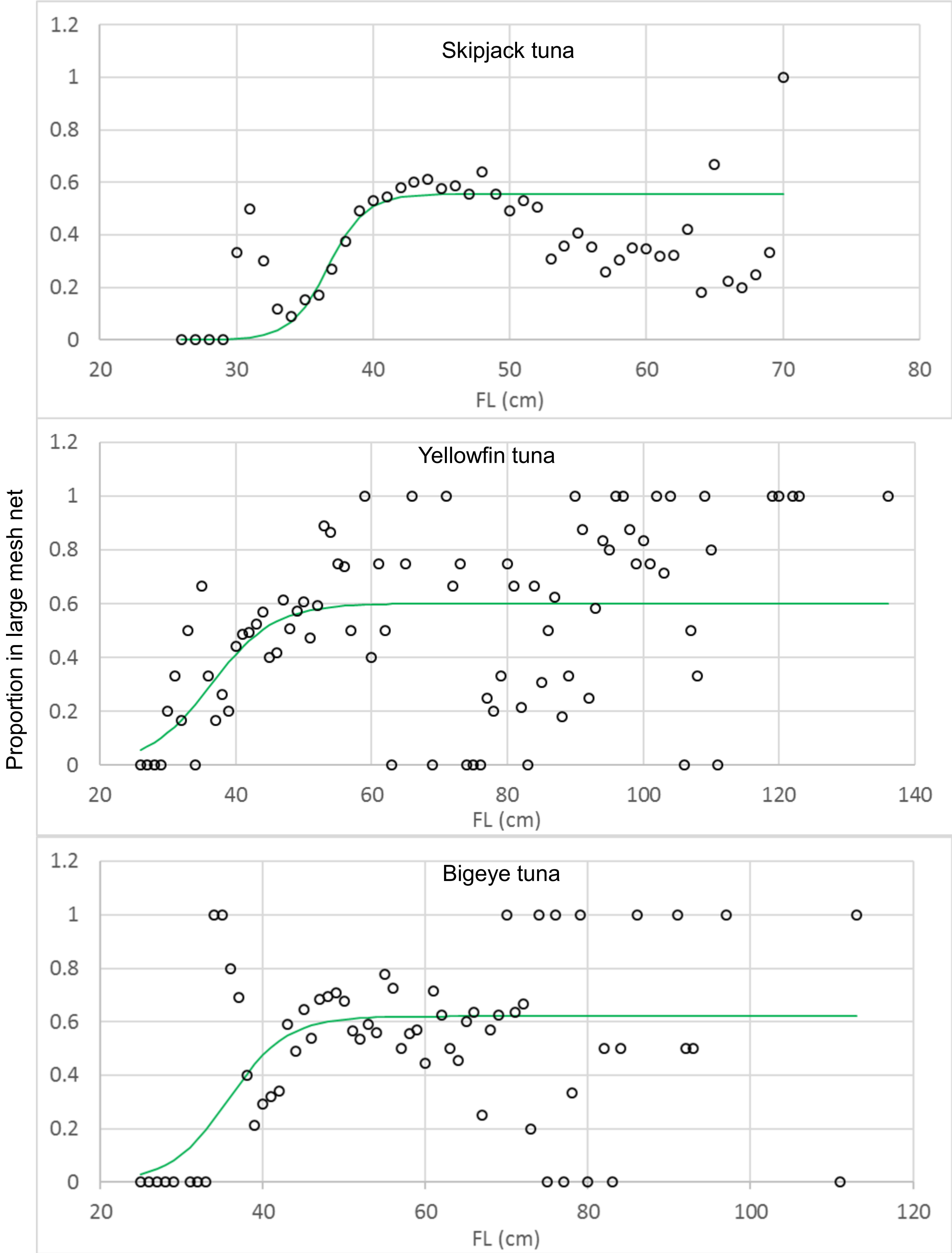

Fig.2 Fits of the estimated curves to the observed proportions of catch of large mesh net to total catch for the three species

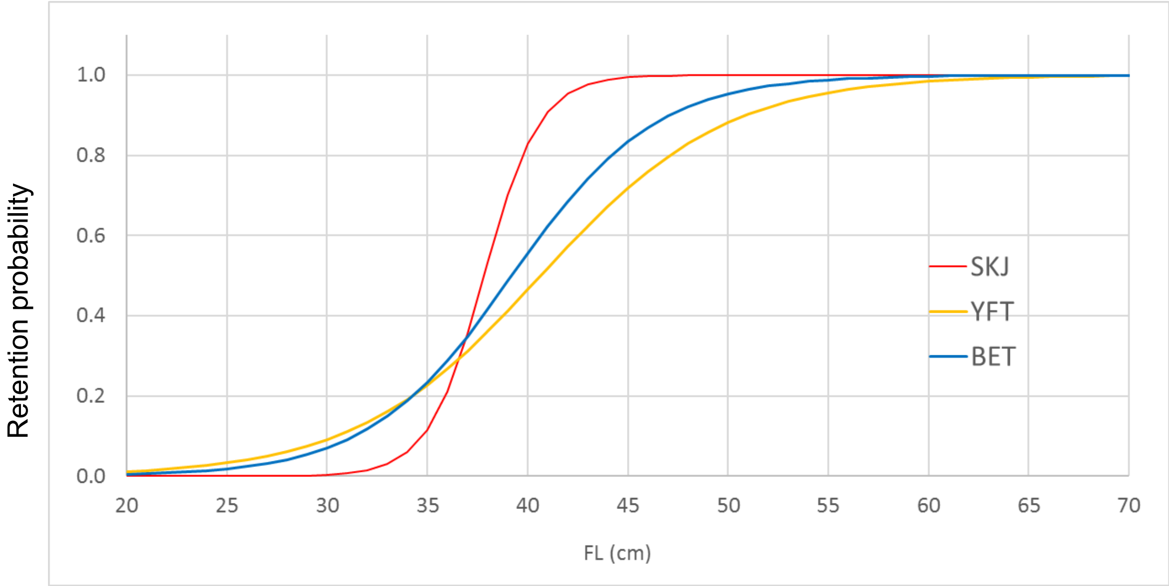

Fig.3 Preliminary result of size selectivity curve estimation for the three species; Skipjack (SKJ), Yellowfin (YFT) and Bigeye (BET)

Discussion

The large-scale field study showed, for the first time, clear difference in size composition between two mesh size nets in tuna purse seine fishery. Although the mesh size ratio was only 1.25 times, the catch of smaller tunas differed significantly.

As for the selectivity curve estimation, the result should be considered preliminary because the small mesh we used was not small enough that some part of smaller fish might have escaped through the mesh. Authors are planning to conduct another comparison study with nets with 150 and 300 mm mesh size.

For purse seine fishery, it is presumed that another factors such as time of the day (light condition) or the current speed affect the escaping of fish through mesh openings. Those factors should also be considered in further analysis.

References

1) Millar and Walsh 1992. Analysis of trawl selectivity studies with an application to trouser trawls. Fisheries Research, 13(1992) 205-220.
2) Tokai & Mitsuhashi 1998. SELECT Model for Estimating Selectivity Curve from Comparative Fishing Experiments. Bulletin of the Japanese Society of Fisheries Oceanography 62(3) 235-247 (in Japanese).