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FULL PAPER

Effects of net depth reduction to Bigeye tuna (*Thunnus obesus*) catch

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ABSTRACT

Analysis on the catch of Bigeye tuna (*Thunnus obesus*) from purse seine and ring nets of various net depths was conducted to assess the effect of reducing net depth as a compatible measure the Philippines has implemented and reducing the catch of Bigeye in its internal waters and the Exclusive Economic Zone (EEZ). The study was based on observer reports from ring net and purse seine fishing vessels operating in internal waters and EEZ as well as from group seine operations in the high seas pocket 1. Nets were classed by depth to determine and compare variations on the catch of Bigeye, catch rates and relative proportion, species composition, and fishing grounds. Results indicated that the catch of Bigeye is correlated with the depth of net, with a significantly higher catch of Bigeye in deeper nets. The result of the study is consistent with other studies elsewhere, and in consonance with the implementation of Fisheries Administrative Order 236 limiting the depth to 115 fathoms for ring net and purse seine operating in Philippine internal waters and the EEZ as a compatible measure to reduce the catch of Bigeye.

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1. INTRODUCTION

Tuna fishing significantly contributes to the country's fish production contributing about a quarter of the total marine fish production annually. There are eleven tuna species reportedly caught in the country that include Skipjack (*Katsuwonus pelamis*), Yellowfin tuna (*Thunnus albacares*), Bigeye tuna (*Thunnus obesus*), Albacore (*Thunnus alalunga*), Longtail tuna (*Thunnus tonggol*), Striped bonito (*Sarda sarda*), Pacific bluefin (*Thunnus orientalis*), Frigate tuna (*Auxis thazard*), Bullet tuna (*Auxis rochei*) and Eastern little tuna/kawa-kawa (*Euthynnus affinis*). The Philippine total tuna production was 443,713 MT comprised of frigate/bullet, yellowfin/bigeye, skipjack, and kawa-kawa. The bulk of the contribution came from commercial fisheries with 32.5% while municipal fisheries contributed 9.7% or a total of 9.1% contribution to the total fisheries production of the country (BFAR 2012). The bulk of oceanic tuna caught in purse seine and ring net vessels operating in internal waters and Exclusive Economic Zone (EEZ) of the Philippines was composed of 49.6% Skipjack, 18.2% Yellowfin and 1.9% Bigeye tuna (Ramiscal et al. 2014).

The sustainability of Bigeye tuna in the Western and Central Pacific Ocean (WCPO) is under threat with assessments indicating spawning stock biomass below the limit reference point with the level of catch unlikely to be sustainable (Davies et al. 2011). The Western Central Pacific Commission (WCPFC) has introduced measures to rebuild the stock of Bigeye, among which is the FADs closure, which prohibits purse seining with FADs in the high seas and EEZ (WCPFC 2008). Schaefer and Fuller (2002) and Matsumoto et al. (2006) determined the influence of gear characteristics to catch composition and depth layering of different species around FADs.

The Philippines has implemented Fisheries Administrative Order No. 236 (FAO 236) that requires all purse and ring net fishing vessels operating in internal waters and the EEZ to reduce the net depth to 115 fathoms or less as a compatible measure to reduce the catch of Bigeye tuna. The monitoring of this measure had been annually reported to the Science Committee (SC) of WCFPC. This study consolidates data from observers to further validate catch of Bigeye tuna with various net depths and to evaluate current measure. Further, this study aims to validate Bigeye tuna reduction in High Seas Pocket 1 where net depth is not restricted.

2. METHODOLOGY

2.1 Net Depth Inspection/Validation

Net depth and length were determined based on the annual fishing gear inspection conducted by the Fisheries and Regulatory and Quarantine Division (FRQD) either at company yard or compound when the vessel is docked in port or at a fishing ground as verified by fisheries observers. The hanging rate was not considered a factor affecting the actual hanging depth of net since General Santos - based tuna fisheries have similar hanging ratio.

2.2 Catch Estimation

Catch estimate was based on the degree of fullness of fish hold and its capacity estimated by the captain of the carrier vessel or the fisheries observers using a standard estimate on brail capacity, brail fullness, and number of brails.
In the brailing capacity, estimation was based on the following formula:

Volume = π r2 h

Brail Capacity = Volume x 80% where

π = 3.1416

r = brail radius

h = brail height with load

The volume of fish catch displaced was approximately 80% of brail volume to account 20% of air and water space. Based on the formula, it was observed that a margin of +/- 2% difference with the actual catch landing in port (Dela Cruz 2010).

2.3 Data Collection

Data used in this study were from the reports of fisheries observers deployed onboard Philippine-flagged vessels in the country's internal waters and the EEZ, as well as from the group seine operations in the high seas pocket 1. Compilations of data were done by the technical staff from Fisheries Observer Program Management Office (FOPMO).

2.4 Catch Sampling and Species Identification

Samples were taken randomly from the catch either by scooping from the brail or the fish hold. Another method was using tub with ropes on both ends and putting it inside the fish hold before pouring off the brail, and in 2014 onwards spill sampling method was introduced. As needed, sub-sampling procedures were conducted.

Samples were sorted according to species, weighed to the nearest 0.1 kg and measured in cm (fork length for tuna and other large pelagic species, and total length for other small pelagic species).

Morphological evaluation of the unique external characteristics of Yellowfin and Bigeye tunas was considered to differentiate the two species. Species identification manual was also provided to observers as reference.

2.5 Data and Statistical Analysis

Depths of the net were stratified at 20-fathom intervals. Comparison on average nominal catch (t/set) of Bigeye tuna was done by net depth class/interval across fishing grounds (i.e. internal waters/EEZ and HSP1). Analysis of Variance (ANOVA) and Covariance (ANCOVA) using Statistical Package for the Social Sciences (SPSS) version 15 was used to compare nominal Bigeye catch by net depth class/interval and by fishing ground.

There were nets deeper than 115 fathoms in the past before the implementation of FAO 236. However, data on their operations were not monitored and recorded until the 5% observer coverage (FAD closure). Thus, linear regression analysis on the catch by net depth class/interval was used to estimate the relative reduction of Bigeye across net depth class.

3. RESULTS and DISCUSSION

3.1 Internal waters and EEZ

Table 1. Distribution of observed sets by net class/interval and fishing grounds.

Net depth	CEL	PAC	SS	WPS	Total
101-120	835	661	86	86	**1,668**
81-100	628	110	34	156	**928**
61-80	38				**38**
Total	**1,501**	**771**	**120**	**242**	**2,634**

Observer data covered 2,634 sets between 2010 to 2016 from four (4) fishing grounds that include the Mindanao/Celebes Sea (CEL), Pacific Seaboard (PAC), Sulu Sea (SS), and West Philippine Sea (WPS). The distribution of observations by net depth class and fishing grounds is presented in Table 1.

3.2 Catch Variation by Net Depth

Analysis on the catch of Bigeye tuna across net depth class/interval indicated a direct correlation of Bigeye catch with the depth of net, with the highest average catch in deeper nets (101-120 fathoms). With this, the Bigeye catch under current net depth regulation of 115 fathoms maximum (100-120 depth class) indicate a decrease by 28.3% when compared to the predicted catch (by linear regression) for next higher net depth class (121-140 fathoms) as shown in Table 2 and Figure 1.

Analysis of Variance (ANOVA) also suggests a significant difference on the average catch of Bigeye by depth of net across all fishing grounds (Table 3), which signifies significantly lower Bigeye catch in shallower nets. Further, environmental factors such as physico-chemical parameters might affect the presence of Bigeye tuna in different fishing grounds. Results are consistent with the study of Lennert-Cody

Table 2. Average Bigeye catch by net depth class, internal waters/EEZ

Net Depth (fathom)	Midpoint	BET_catch	%Reduction
121-140	130	0.283*	
101-120	110	0.203c	28.3
81-100	90	0.114b	43.8
61-80	70	0.039a	66.1

*predicted by linear regression
Different superscript are significant at $p < 0.05$

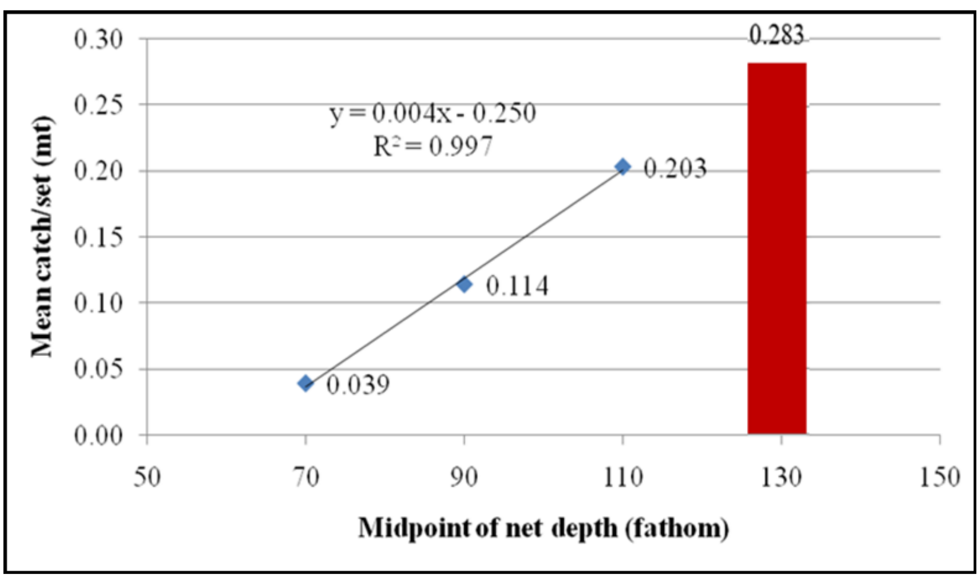

Figure 1. Average Bigeye catch by net depth class (121-140 was predicted by linear regression).

Table 3. Analysis of variance on the average Bigeye catch by net depth class and fishing ground.

Depth (fathom)	Celebes Sea	Sulu Sea	West Phil. Sea	Phil Pacific Seaboard	Across all fishing grounds
61 – 80	0.039 a	-	-	-	0.039 a
81- 100	0.119 b	0.118	0.011	0.233	0.114 b
101 - 120	0.241 c	0.08	0.074	0.187	0.203 c
significance	p < .01 highly sig	p > .05 not sig	p < .01 highly sig	p > .05 not sig	p < .01 highly sig

Table 4. Distribution of observed sets in high seas pocket 1 by depth of net.

Net Depth	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
>140	38	94	138	144	387	801
121-140	50	361	795	971	1,225	3,402
101-120	98	782	1,482	1302	982	4,646
81-100	25	115	253	18	49	460
Total	211	1,352	2,668	2435	2,643	9,309

et al. (2008) which also showed that Bigeye tuna are likely caught with net depths extending to 260 meters (142 fathoms), while set locations also influence Bigeye tuna catch.

Similar annual assessments on the catch of big-eye tuna also indicated a reduction of Bigeye catch on shallower nets (Ramiscal et al. 2011) as basis for the implementation of FAO 236.

3.3 High Seas Pocket 1 (HSP1)

In High Seas Pocket 1 where no regulation for net depth is being implemented, variations of Bigeye tuna catch by net depth class was clearly observed. A total of 9,309 sets were conducted by a total of 46 purse seine and ring net vessels operating from 2012 to 2016.

Table 5. Average Bigeye catch by net depth class, HSP1.

Net Depth (fathom)	n	BET catch (mt/set)	% Reduction
>141	801	0.540 b	
121-140	3,402	0.305 a	43.5
101-120	4,646	0.286 a	6.2
81-100	460	0.230 a	19.6

Different superscript are significant at $p < 0.05$

3.4 Catch Variations by Net Depth

Using the same net depth class applied above, data showed a decreasing catch of Bigeye by 43.5% when net depth class is reduced from >141 to 121-140 fathoms. A further reduction to 100-120 fathoms resulted in a decrease of 6.2%. Analysis of Variance (ANOVA) also showed a significant difference in the average catch of Bigeye in different net depths. Further tests within groups also revealed the significantly higher catch of Bigeye tuna when the net depth is more than 140 fathoms (Table 5, Figure 2).

4. CONCLUSION

Based on the preceding, the reduction and limiting the depth of net for purse seine and ring nets fishing vessels operating in Philippine internal waters and EEZ is consistent with the objective of reducing the catch of Bigeye and can be considered as a compatible measure with current CMMs to reduce the catch of Bigeye.

Adjusting the depth of net has also been suggested elsewhere to reduce the catch of Yellowfin and Bigeye. Similarly, the behavioral study of Matsumoto et al. (2006) on oceanic tunas suggested that it is possible to reduce the catch of Yellowfin and Bigeye tunas

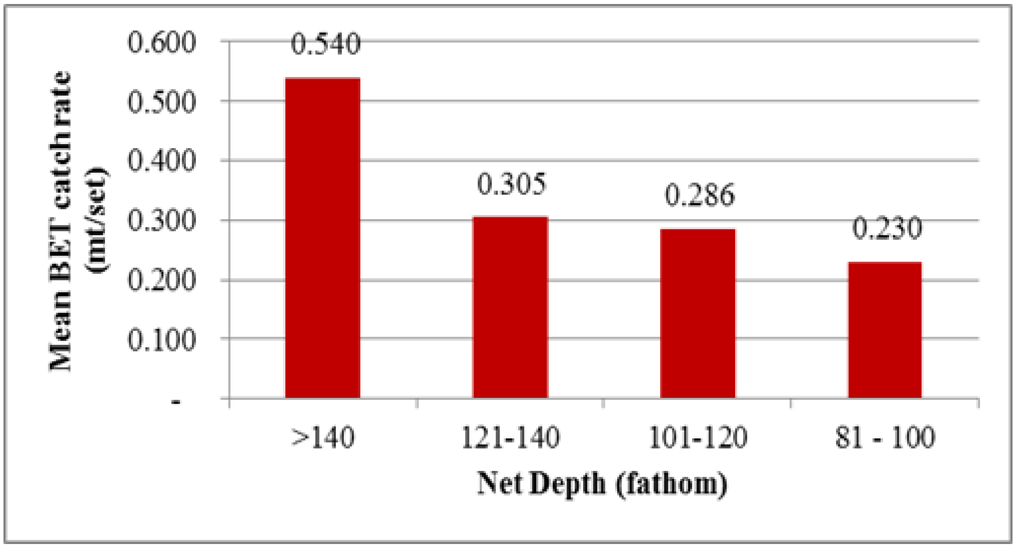

Figure 2. Average catch of Bigeye by net depth, HSP1.

to some extent by adjusting the depth of the net.

The study showed that FAO 236 is a compatible measure in reducing the catch of Bigeye tuna, and it is recommended to maintain the following considerations:

a.) Strengthen fishery law enforcement. Enhanced patrolling and visibility of enforcement units in major fishing grounds to non-compliant vessels conducting Illegal, Unreported and Unregulated Fishing (IUUF).

b.) Continue assessment of the measure through the Observer program and the National Stock Assessment Program (NSAP) and adapt and adjust the current measures to reduce Bigeye as maybe be necessary.

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