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Examining a management measure of key purse seine vessels for recovering bigeye tuna stock in the western and central Pacific Ocean

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Title
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Abstract
SC11 noted that around one-third of the purse-seine catch of bigeye is taken by a small component (~10%) of the fleet (key purse seine vessels). To identify the effective management options for the bigeye tuna stock, a future projection using TUMAS ver. 2.2 was conducted to evaluate a management measures for bigeye catch of the key purse seine vessels. The examined management measure is reducing the key vessel's higher bigeye catch ratio (12% of the total annual tuna species catch) to the average value (4%) of the other purse seine vessels. The future projection revealed that the simple management option resulted in substantial positive impact to recover the bigeye tuna spawning biomass. We invite SC12 to consider the management options regarding to purse seine fishery including the key purse seine vessels issue, and to request SPC to conduct related analyses including precise future projections using the vessel-level purse seine data.

Introduction
Harley et al. (2015) reported that for the specific 27 vessels bigeye tuna comprise 12% of their total tuna catch (i.e., all set types) versus 4% for the rest of the fleet (237 vessels) (**Table 3** of Harley et al. 2015). This report also invites the WCPFC-SC11 to suggest any other specific analyses which they feel would be of value to the Commission's consideration of bigeye tuna management. SC11 noted that around one-third of the purse-seine catch of bigeye is taken by a small component (~10%) of the fleet (key purse seine vessels) and also SC11 recommends that further research on the various issues identified by the paper be undertaken, and that WCPFC12 takes note of this paper (paragraph 474 of the SC11 report). During the WCPFC12 a CMM mentioned that about 10% of all purse seine vessels are responsible for approximately 30% of the total bigeye purse seine catch based on this analysis (Harley et al. 2015) and requested analyses for various combinations of FAD set limits and longline bigeye catch limits (paragraph 321 of the WCPFC12 report). At early July 2016, just before SC12, we can find a document of WCPFC-SC12-MI-IP-07 which could be successive analysis of Harley et al. (2015), however the document is assigned as information paper. Thus we are afraid that there is no discussion about the key purse seine vessels issue during SC12.

The effect of CMM2014-01, which is substantially equivalent to CMM 2015-01, was evaluated by future projection (SPC, 2015; WCPFC12-2015-12_Rev1). The results, including four scenarios of combinations of fishing mortality by longline and purse seine, revealed that only under the optimistic scenario achieved the CMM objectives by 2032, with F less than FMSY. Thus, an exploration into alternative management option is common and useful if it can achieve the objectives achieved in shorter period or even under pessimistic fishing mortality.

The aim of this study is to facilitate discussion of a purse seine management option for the key purse seine vessels with higher bigeye catch percentage during SC12. We conducted a future projection using TUMAS ver. 2.2 was conducted to evaluate a management measures for bigeye catch of the key purse seine vessels. The measure is reducing the key vessel's higher bigeye catch ratio (12% of the total annual tuna species catch) to the average value (4%) of the other purse seine vessels.

Martials and methods
We conducted a future projection to evaluate only one management option which is reducing the 27 key purse seine vessel's higher bigeye catch ratio (12.098 % of the total annual tuna species catch) to the

average value (4.297 %) of the other purse seine fleet (237 vessels) using TUMAS ver. 2.2[1] based on the bigeye tuna stock assessment in 2014. The last year of the stock assessment is 2012, so the period for the future projection is from 2013 to 2022. The actual implementation for the management option is simple (**Table 1**), that is, we assigned the catch scalar of four FAD (associated) fisheries as 0.79. The catch scalar is catch ratio for the future projection period relative to the average catch from 2010 to 2012 (see also in foot note of **Table 1**).

The future projection software (TUMAS) for MULTIFAN-CL was updated at June 27th 2016 by SPC and implemented the bigeye and yellowfin tuna stock assessment results in 2014. The projection was based on the average recruitment in recent ten years (2002-2011) and the reduced constant FAD catch mentioned above. In addition, at the time TUMAS ver. 2.2 can allow one recruitment option in recent 10 years.

Table 1 Implementation for the management option (reducing the 27 key purse seine vessel's higher bigeye catch ratio (12.098 % of the total annual tuna species catch) to the average value (4.290 %) of the other purse seine fleet (237 vessels))

		Key vessels (27 vessels)	Rest vessels (237 vessels)	Total
From Table 3 of Harley et al (2015)	Annual total tuna catch (mt)	119,719	702,227	
	Annual total bigeye catch (mt)	14,484	30,131	44,615
	Bigeye proportion of total tuna	12.098 %	4.290 %	
Target bigeye catch (t)	bigeye catch (t) assumed bigeye proportion of the rest vessels (4.290%)	5,135.9 (=119,719*4.290/ 100)	30,131 (=702,227*4.290/ 100)	35,266.9
	Corrected bigeye catch by factor*			52,300.8 (=35,266.9 * 1.483)
Catch scalar of four FAD fisheries** for TUMAS				**0.79** (=52,300.8 / 66,204.8)

* 1.483 (Total bigeye catch (t) from 2010-2013 is 66,204.8 t (Table 8 of WCPFC-SC11-2015/ST IP-1), the bigeye catch used Harley et al (2015) is 44,615 t, thus the conditional factor is 1.483 (=66,204.8 / 44,615).

** The bigeye catch of purse seine in Harley et al (2015) contained the catch of both school types (FAD (associated) and unassociated), nonetheless the catch scalar is assigned only for the FAD fisheries. Because there was no detail information about the catch ratio by school types in Harley et al. (2015) and the percentage of bigeye catch by school type is dominated by the FAD (associated) set (89.5% in average from 2010 to 2013). Harley et al. (2015) mentioned that "*We examined what differences might exist between those `top' vessels with high bigeye tuna catches versus the rest of the fleet. There was no strong difference in the regions of the WCPO fished*", thus the catch scalar (catch ratio for the future projection period relative to the average catch from 2010 to 2012) for the four FAD fisheries were assigned as 0.79. The four FAD fisheries were S-ASS All 3 (region 3), S-ASS All 4 (region 4), S-ASS

[1] http://distribute.spc.int/OFP/tumas/releases/2.2/TUMAS-2.2-setup-x64.exe

All 8 (region 8) and S-ASS All 7 (region 7). The fishery definition is same for the Multifan-CL fishery definition in 2014 assessment.

Results

Trends in spawning biomass (**Figure 1**), total biomass (**Figure 2**), total biomass / total biomass $_{F=0}$ (**Figure 3**) were presented for the projection period (2013-2022). The spawning biomass and total biomass of bigeye tuna (**Figures 1 and 2**) showed increasing trend after 2017 and 2015. Small bigeye tuna, which survive the purse seine FAD fishery, can grow and increase its biomass after three years implementing the management measure, and the biomass of matured bigeye will increase after five years. The total biomass / total biomass $_{F=0}$ (**Figure 3**) is considered as some proxy of the limit reference point (20% spawning biomass / spawning biomass $_{F=0}$) and showed increasing trend after 2015 and reached to 0.36 in 2022 which is similar to the level of the late of 1990s. In addition, there is no direct output of TUMAS related to the limit reference point.

Discussion

There are many rooms for improvement of the future projection in this study. First, the recruitment for the projection period was based on the recruitment in recent 10 years (2002-2011), which is higher than the historical average, thus the future projection doesn't consider uncertainty in the case of the low recruitment. Secondly, the future projection is based on the bigeye stock assessment conducted in 2014, thus the effect of the FAD management implemented after 2014 is not considered. Thus the relationship between the already implemented FAD closure and the assumed measure in this study is not clear. The third, although Harley et al. (2015) mentioned that there was no strong difference in the regions of the WCPO fished between the key vessels and the rest vessels, the uniform reducing catch scenario in this study could be inadequate. Because it is well-known that the bigeye CPUE of FAD fishery in the eastern part of WCPO is higher than those in the western area, so the key vessels seem to operate in the eastern part of WCPO. If the understanding is correct, the future projection scenario considering area-specific management option using vessel level data is adequate and should lead to more realistic results. The vessel level data also allow the future projection for the bigeye catch limit by vessel, which is already suggested in Harley et al (2015). The Forth, the purse seine catch by school type should be considered.

As mentioned above the future projection in this study is not definitive, however it revealed that the management option (reducing the key vessel's higher bigeye catch ratio (12% of the total annual tuna species catch) to the average value (4%) of the other purse seine vessels) resulted in substantial positive impact to recover the bigeye tuna spawning biomass. It is surprised that the key purse seine vessels comprised only 10% in vessel number of the fishery. We invite SC12 to consider the management options regarding to purse seine fishery including the key purse seine vessels issue, and to request SPC to conduct related analyses including precise future projections using the vessel-level purse seine data.

References

Harley, S., L. Tremblay-Boyer, P. Williams, G. Pilling, and J. Hampton (2015) Examination of purse-seine catches of bigeye. SC12-MI-WP-07

SPC Oceanic Fisheries Programme (2015) Evaluation of CMM 2014-01 for bigeye tuna. WCPFC12-2015-12_Rev1

Acknowledgement

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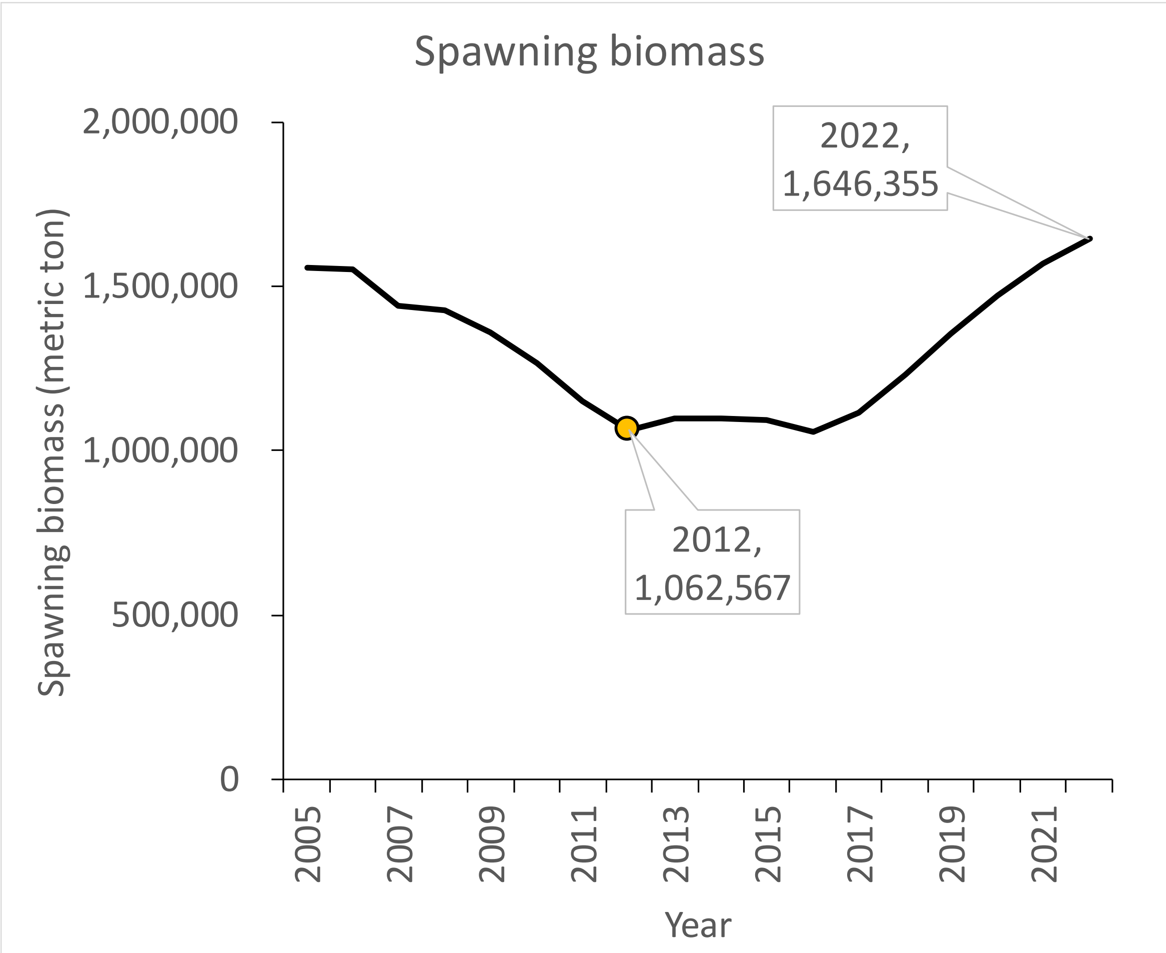

Figure 1. Spawning biomass of bigeye tuna in the western and central Pacific Ocean, including projection period from 2013 to 2022. The projection is based on the average recruitment in recent ten years (2002-2011) and the constant FAD catch (0.79 times relative to the average catch from 2010 to 2012), which is assumed to be equivalent to the condition reducing the 27 key purse seine vessel's higher bigeye catch ratio (12.098 % of the total annual tuna species catch) to the average value (4.290 %) of the other purse seine fleet (237 vessels).

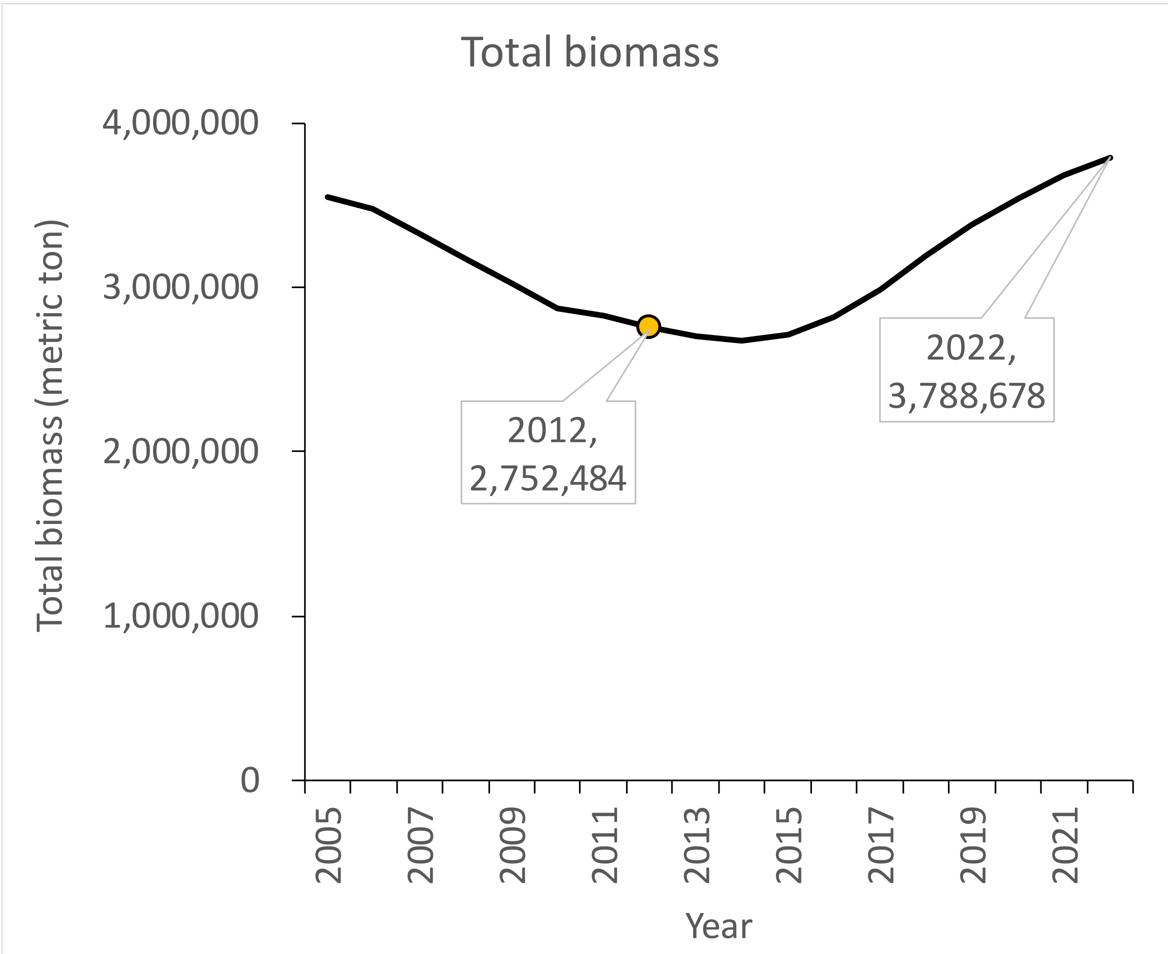

Figure 2. Total biomass of bigeye tuna in the western and central Pacific Ocean, including projection period from 2013 to 2022. The projection is based on the average recruitment in recent ten years (2002-2011) and the constant FAD catch (0.79 times relative to the average catch from 2010 to 2012), which is assumed to be equivalent to the condition reducing the 27 key purse seine vessel's higher bigeye catch ratio (12.098 % of the total annual tuna species catch) to the average value (4.290 %) of the other purse seine fleet (237 vessels).

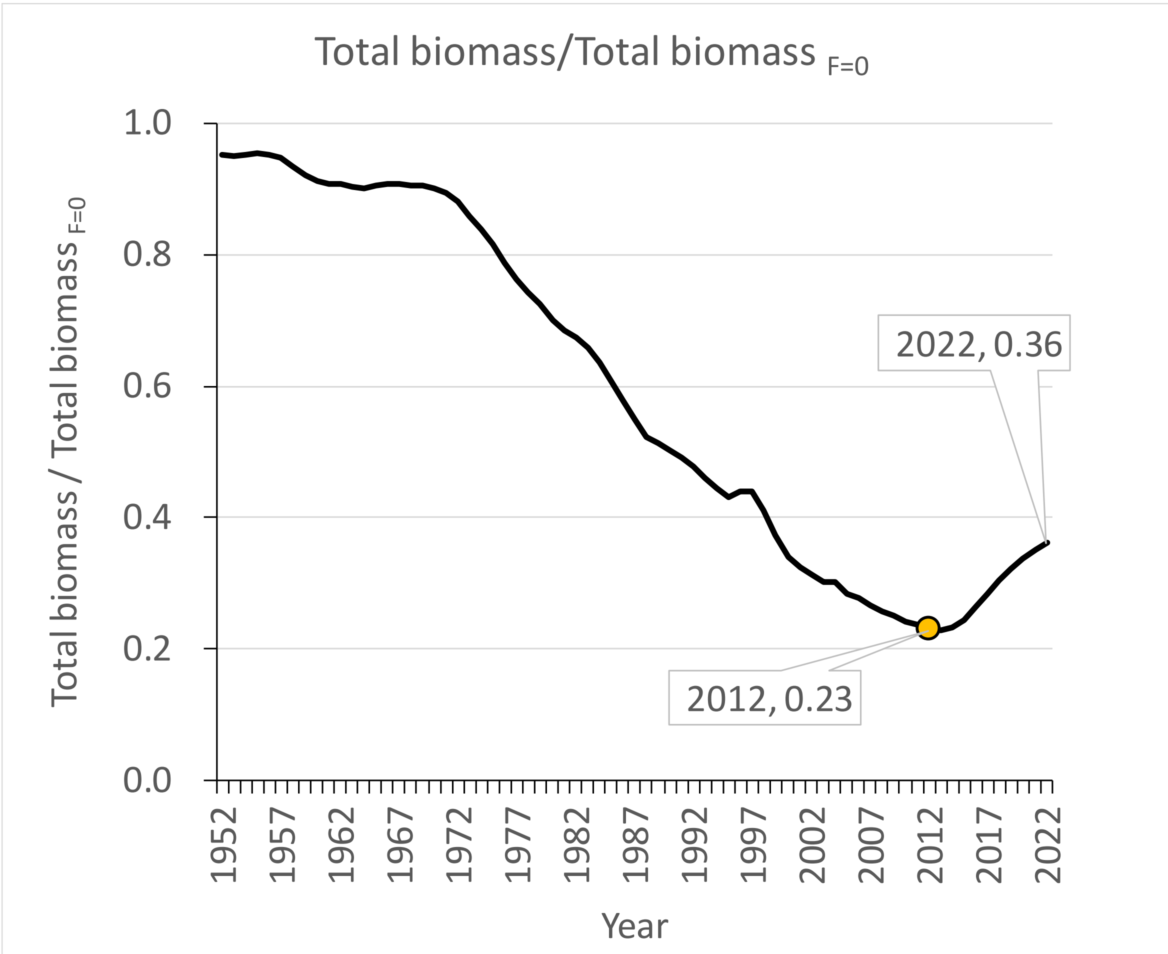

Figure 3. Total biomass ratio (total biomass / total biomass $_{F=0}$; the ratio of the current total biomass to that of the unfished stock) of bigeye tuna in the western and central Pacific Ocean, including projection period from 2013 to 2022. The projection is based on the average recruitment in recent ten years (2002-2011) and the constant FAD catch (0.79 times relative to the average catch from 2010 to 2012), which is assumed to be equivalent to the condition reducing the 27 key purse seine vessel's higher bigeye catch ratio (12.098 % of the total annual tuna species catch) to the average value (4.290 %) of the other purse seine fleet (237 vessels).