SCIENTIFIC COMMITTEE
THIRD REGULAR SESSION

13-24 August 2007
Honolulu, United States of America

Spatio-temporal patterns of purse seine catches of skipjack and juvenile bigeye and yellowfin tuna caught in association with floating objects

WCPFC-SC3-SA SWG/WP-04

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INTRODUCTION

Last year, the Scientific Committee (SC 2) of the WCPFC noted that overfishing of bigeye tuna was occurring and recommended a 25% reduction in total fishing mortality on bigeye tuna in the Convention Area. Similarly, the 2006 assessment also indicated that overfishing was occurring in the yellowfin tuna fishery and SC 3 recommended a 10% reduction in total fishing mortality.

Following SC 2, additional analyses were undertaken to investigate the range of potential fishery-specific effort reductions that could be implemented to reduce current fishing mortality rates to the level that would achieve Maximum Sustainable Yield (*MSY* – achieved at the F_{MSY} level of fishing mortality) (Langley & Hampton 2006a). This analysis revealed that large effort reductions in either the longline fishery or the associated purse-seine fishery would be required to achieve the F_{MSY} target for bigeye tuna. For example, to achieve F_{MSY} for bigeye tuna solely by reductions in effort in the purse–seine fishery would require a 75% reduction in the level of effort on associated schools (i.e. log, drifting FAD, and anchored FAD sets).

Langley & Hampton (2006a) also noted that any management measure implemented to achieve F_{MSY} for bigeye tuna would also achieve the same target for yellowfin tuna, with the exception of measures that resulted in a large increase in unassociated purse-seine sets; for example, a large transfer in effort from associated to unassociated sets (WCPFC 2006).

Previous stock assessments of yellowfin and bigeye tuna have identified that increased yields would be potentially available from the stock if fishing effort on associated schools was reduced (Hampton et al. 2005). This is achieved through the reduction of fishing mortality on small (40–70 cm FL) tuna and the corresponding predicted increase in longline catches and longline CPUE.

On this basis, there has been consideration of various management measures that could be implemented to achieve a reduction in the level of fishing on associated schools, principally through time and area closures for the purse-seine fishery (WCPFC 2006). However, members of the WCPFC have expressed concern regarding the potential economic impact on the purse-seine fishery of a reduction in the level of associated sets, particularly the reduction in the catches of skipjack tuna.

Arguably, management measures formulated to reduce catches of small bigeye should be focussed on those areas that yield the largest bigeye catch in absolute terms and as a proportion of the total catch. Management measures (such as temporal closures) targeting these areas would be most likely to yield the greatest reduction in bigeye catch while minimising reduction in the total catch of skipjack and the catch of yellowfin from unassociated sets.

A preliminary analysis of catch and effort data from the purse-seine fishery revealed seasonal and spatial variation in the proportion of bigeye and yellowfin in the total purse-seine catch (Langley & Hampton 2006b). The purpose of the current paper is to further the previous analysis, using revised bigeye catch statistics, to identify areas of proportionally high bigeye catch and quantify the potential reductions in bigeye and total purse-seine catches that may result from the closure of these areas to fishing by associated purse-seine sets. The paper does not specifically promote the closure of these areas, rather it serves to identify the areas where the catches of small bigeye are greatest and, thereby, identify key areas for future management initiatives to be focussed.

DATA ANALYSIS

Total reported catch and effort data were available from the WCPFC purse-seine fleet aggregated by vessel flag, purse-seine set type, month, and 1° latitude/longitude. Effort was expressed as the number of days fishing (including searching) and catches were available for the three principal tuna species: skipjack, yellowfin and bigeye. Bigeye catch estimates were derived either directly from country estimates (Japan) or calculated as a proportion of the bigeye catch in the combined yellowfin and bigeye catch estimated from observer data (Lawson 2007). The latter approach has been recently refined to account for spatial variation in the proportion of bigeye in the composite bigeye/yellowfin catch (see Lawson 2007 for details).

Data were extracted for the purse-seine fleets operating within for the equatorial region, excluding Indonesian and Philippines; latitude 10°S–10°N, longitude 130°E–150°W. The period of the analysis was limited to the 2000–05 years.

The average annual catch of skipjack, yellowfin and bigeye was determined by set type (associated and unassociated) for each 1° latitude/longitude. The bigeye purse-seine catch was plotted against the combined skipjack catch (associated and unassociated) and yellowfin catch from unassociated sets.

The analysis identified a number of latitude/longitude cells that had a high catch of bigeye and also a high proportion of bigeye relative to the combined skipjack (total) and yellowfin (unassociated) catch (red points) (Figure 1). There was a further group of cells that had a moderate level of bigeye catch and a higher than average level of bigeye catch relative to skipjack (total) and yellowfin (unassociated) catch (blue points) (Figure 1).

The remainder of latitude/longitude cells can be grouped into two further categories; (i) a low average annual catch of bigeye tuna (less than 30 mt) or (ii) a high catch of skipjack and unassociated yellowfin catch and a low–moderate catch of bigeye tuna.

The areas of highest bigeye catch, in absolute and proportional terms (red cells), are principally located within the Bismarck Sea and Solomon Sea (Figure 1). These areas both include a high proportion of purse-seine sets associated with anchored FADs. The associated purse-seine fishery in these areas has accounted for 16% of the total bigeye purse-seine catch, 3.7% of the total skipjack catch and 8.8% of the total yellowfin catch (Table 1).

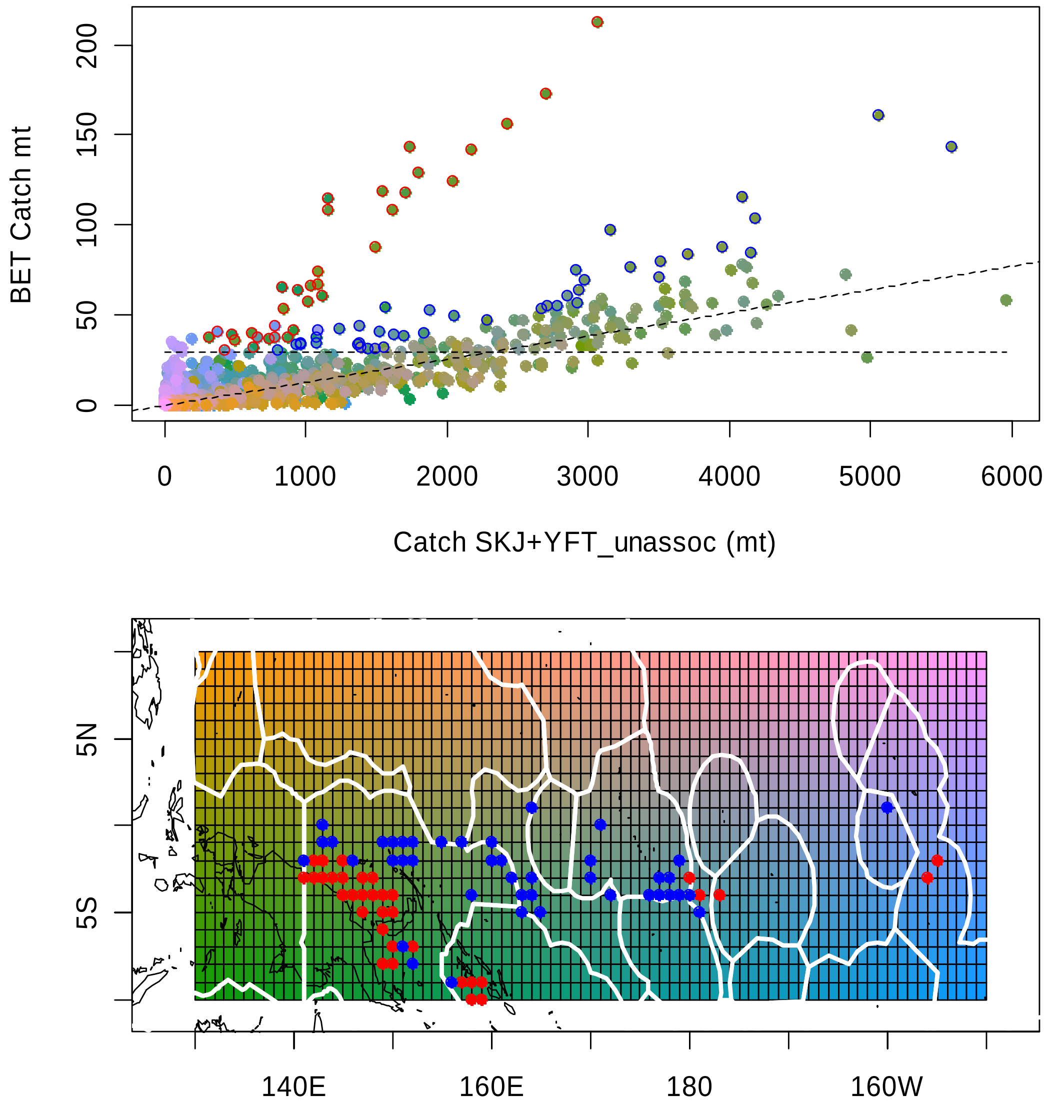

Figure 1. The relationship between average total bigeye purse-seine catch and the combined total purse-seine catch of skipjack (all sets) and yellowfin from unassociated sets (top) for each 1 degree lat/long cell. The colour of the points is coded to the location of the 1 degree cell (bottom). Cells with a high (red) and moderate (blue) level of bigeye catch (relative to the skipjack/yellowfin catch) are also identified.

The areas yielding moderate catches of bigeye, in absolute and proportional terms (blue cells) tend to be distributed through a latitudinal band south of the equator (approximately 0°–3°S) (Figure 1). The associated purse-seine fishery in both the areas yielding moderate and high catches of bigeye accounted for approximately 30% of the total WCPO purse-seine bigeye catch, 10% of the total skipjack catch, and 14.7% of the total yellowfin catch (Table 1).

Table 1. Total average annual catch (thousands of mt) of skipjack, yellowfin, and bigeye tuna by unassociated and associated sets for all 1*1 degree lat/long cells within the equatorial WCPO and for cells identified as having high and moderate catches of bigeye tuna (2000–05 years, inclusive).

Criteria	1*1 cells	SKJ catch		YFT catch		BET catch	
		Unassoc.	Assoc.	Unassoc.	Assoc.	Unassoc.	Assoc.
Total	1,600	382.01	518.22	94.22	75.97	1.68	16.49
High BET	34	4.00	32.62	4.05	15.04	0.08	2.66
Mod. BET	42	31.96	56.93	10.73	10.24	0.18	2.30
Mod-high BET	76	35.96	89.55	14.78	25.28	0.26	4.95

Table 2. Percentage (%) reduction in average annual catch of skipjack, yellowfin, and bigeye tuna by unassociated and associated sets for all 1*1 degree lat/long cells within the equatorial WCPO and for cells identified as having high and moderate catches of bigeye tuna (2000–05 years, inclusive).

Closure	1*1 cells	SKJ catch		YFT catch		BET catch	
		Unassoc.	Assoc.	Unassoc.	Assoc.	Unassoc.	Assoc.
High BET	2.1	1.0	6.3	4.3	19.8	4.6	16.1
Mod. BET	2.6	8.4	11.0	11.4	13.5	10.8	13.9
Mod-high BET	4.8	9.4	17.3	15.7	33.3	15.4	30.1

The analysis also conducted on a quarterly basis (Figure 2 and Figure 3) revealing that the cells within the Bismarck Sea and Solomon Sea consistently yielded higher catches of bigeye both in absolute terms and as a ratio of the composite skipjack (total) and yellowfin (unassociated) catch. In addition, the quarterly analysis also revealed relatively high catches of bigeye tuna in the eastern extremity of the equatorial WCPO during the third and fourth quarters of the year.

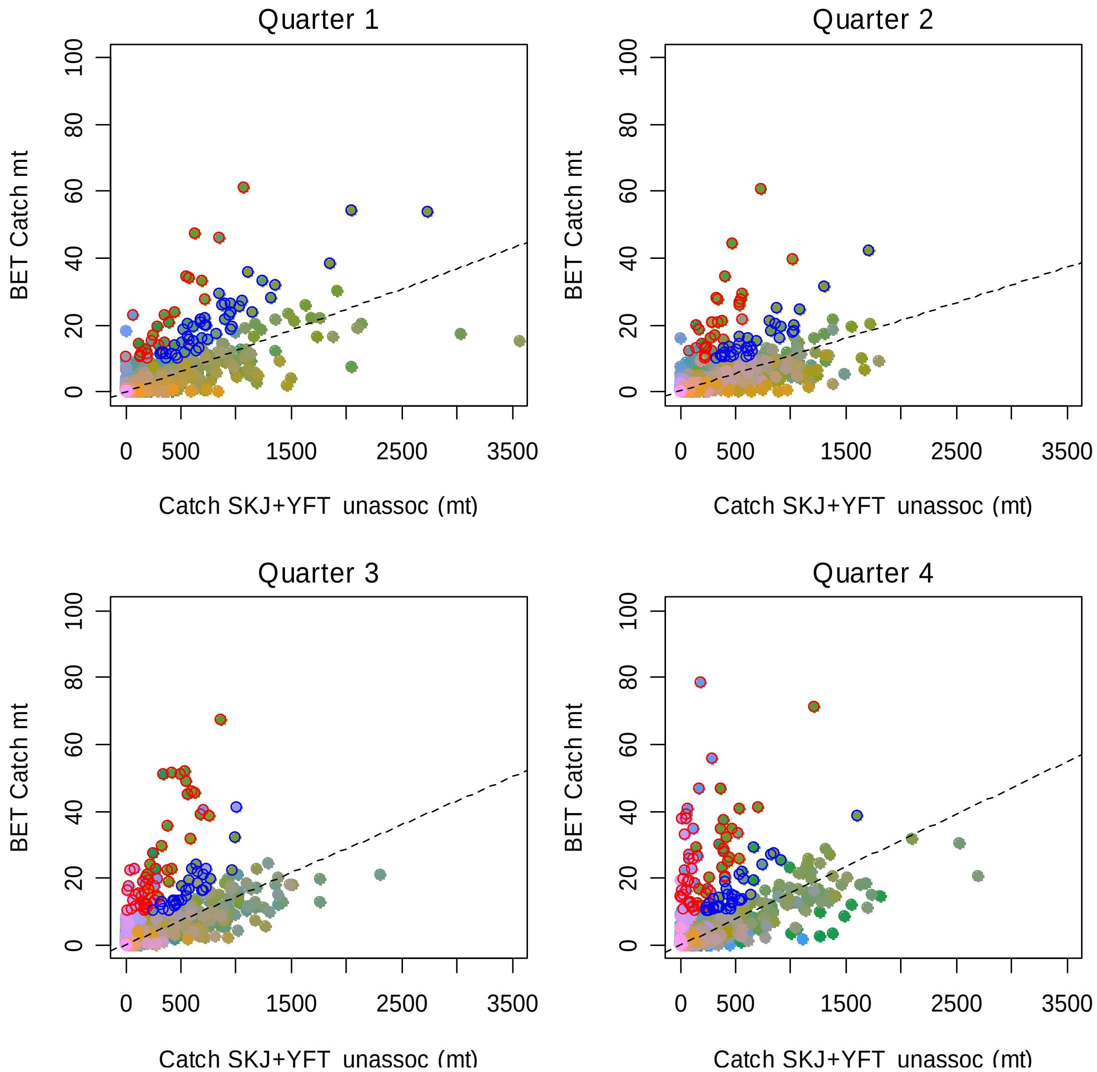

Figure 2. The relationship between average total bigeye purse-seine catch and the combined total purse-seine catch of skipjack (all sets) and yellowfin from unassociated sets (top) for each 1 degree lat/long cell, by quarter. The colour of the points is coded to the location of the 1 degree cell (see Figure 1). Cells with a high (red) and moderate (blue) level of bigeye catch (relative to the skipjack/yellowfin catch) are also identified.

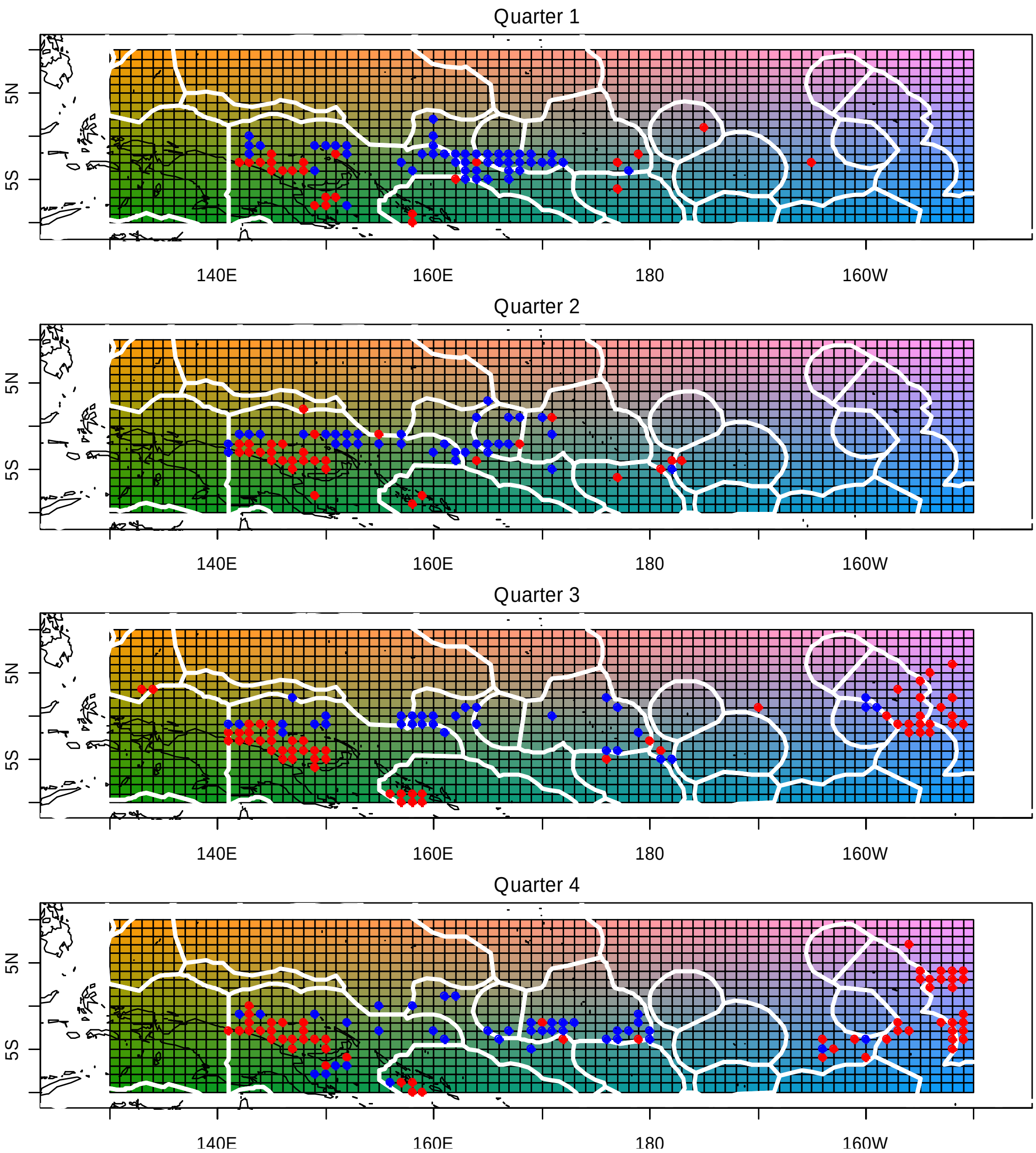

Figure 3. The location of 1 degree lat/long cells with a high (red) and moderate (blue) level of bigeye catch (relative to the skipjack/yellowfin catch), by quarter as identified from Figure 2.

The total associated catch of bigeye by the industrial purse-seine fleet, by quarter, taken in the three areas (Bismarck Sea, Solomon Sea, eastern WCPO) was calculated as a proportion of the total quarterly associated purse-seine catch in the corresponding MFCL region (3 or 4) for the 2001–2004. The period was chosen for comparability with the stock projections under taken in 2006.

Area	Definition		MFCL region	Proportion of MFCL region BET catch, by quarter			
	long	lat		1	2	3	4
Bismarck Sea	141-149E	2-8S	3	0.160	0.211	0.241	0.206
Solomon Sea	157-159E	9-10S	3	0.018	0.029	0.066	0.038
Combined			3	0.178	0.240	0.307	0.244
Eastern WCPO	150W-160W	10S-10N	4	0.014	0.051	0.133	0.260

The potential management outcome, in respect to the fishing mortality based reference points for bigeye tuna, of the closure of these three areas to purse-seine fishing on associated sets was then assessed using the approach described in Langley & Hampton 2006. The base-line level of quarterly effort for the two associated purse-seine fisheries (in MFCL regions 3 and 4) formulated for the projection period was reduced by the proportion of the catch taken in each quarter. For the region 3 fishery, the reductions in effort were applied to all four quarters, while only the third and fourth quarters of effort were reduced in the region 4 fishery. No allowance was made for a transfer of fishing effort from the closed areas or to unassociated sets within the closed area.

The fishing mortality based reference point from the projection simulating the time/area closures was compared to the corresponding reference point from the projection using the base-line of effort. The simulated area closure resulted in a reduction in the F/F_{MSY} from 1.30 to 1.23.

CONCLUSIONS

1. The analysis was conducted using the best available estimates of bigeye catch from the purse-seine fishery. However, definitive catch statistics are not available for bigeye tuna due to the difficulty in identification of juvenile yellowfin and bigeye and the tendency to aggregate the catches of these species in logsheet records. Consequently, this analysis is largely dependent on the accuracy of the model developed to apportion bigeye catches from the composite catch of bigeye and yellowfin (by set type and location).

2. The analysis identifies several areas where a relatively high level of bigeye catch, in absolute terms and as a proportion of the total purse-seine catch, has been taken by the purse-seine fishery in recent years. These areas include the Bismarck Sea and western waters of the Solomon Islands. Both these areas are dominated by domestic (or locally based foreign) purse-seine fisheries that direct fishing activity around anchored FADs. Consequently, there is a local

concentration of fishing effort in these areas, with most effort comprised of associated sets and, therefore, a relatively high proportion of small bigeye tuna in the total purse-seine catch.

3. Based on the distribution of catch from 2000–2005, the hypothetical closure of these two areas to purse-seine associated sets could reduce the total WCPO purse-seine bigeye catch by 16%, while the total skipjack catch is likely to be reduced by about 3.7% and total yellowfin catch reduced by 8.8%. These figures are based on the (unrealistic) assumption that there is no transfer of the associated purse-seine effort from the closed area.

4. There is also a significant catch of bigeye taken by purse-seine vessels operating in the eastern equatorial region of the WCPO, particularly in the second half of the year. During 2000–2005, a total of 12,000 mt of bigeye was caught in this area mainly by the eastern Pacific purse-seine fleet (40%, nationality unknown), Spanish vessels (33%), and US vessels (15%). The level of fishing effort (principally using drifting FADs) and bigeye tuna catch by the eastern Pacific fleet increased considerably in 2003. In the far eastern area of the WCPO, bigeye tuna accounted for 10.4% of the combined skipjack and unassociated yellowfin tuna catch.

5. The likely change in stock status of bigeye tuna in response to the range of closures of the purse-seine fishery was assessed using the 2006 stock assessment model. The specific set of closures modelled were a year-round closure on associated sets in the Bismarck Sea and the small area around the Solomon Islands and the July–December closure of the associated purse-seine fishery in the far eastern WCPO. Collectively, the simulated area closures resulted in a small reduction in the overall fishing mortality on bigeye tuna; F/F_{MSY} was reduced from 1.30 to 1.23. This would result in an annual reduction in the total purse-seine skipjack catch of about 4.2% (approximately 40,000 mt per annum).

6. The relatively small reduction in fishing mortality achieved by the closures outlined above is consistent with previous simulations of management scenarios undertaken for the bigeye stock. The previous studies revealed that a very large (approximately 75%) reduction in the level of associated purse-seine fishing would be required to achieve F_{MSY} in the absence of additional measures applied to the other fisheries, in particular the longline fishery and Indonesian/Philippines fisheries.

7. In the scenario presented above, no consideration is given to the response of the purse-seine fleet to the imposition of any closures, in particular the transfer of effort (principally associated sets) from the closed areas to outside of the closed areas. Consequently, the predicted reduction in the level of fishing mortality should be considered to be an absolute maximum.

8. The scenario presented above, principally the closure of areas of national jurisdiction, would likely have a large impact on the domestic fisheries that have developed in those areas. Hence, the scenarios are presented as a hypothetical case rather than a management proposal for consideration. Nevertheless, the analysis does indicate these local scale fisheries are having a disproportionate

impact on the bigeye stock compared to the other sectors of the purse-seine fishery operating in the WCPO. It is recommended that these areas be the principal focus of future research and management initiatives to minimise the catch of small bigeye and yellowfin tuna by the purse-seine fishery.

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