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SMMARY REPORT FROM YELLOWFIN AND BIGEYE STOCK ASSESSMET WORKSHOP, NOUMEA, APRIL 2006

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1. Introduction

The first meeting of the Scientific Committee (SC) of the Western and Central Pacific Fisheries Committee (WCPFC) met in Noumea in August 2005. The final report of the SC 1 meeting identified a number of outstanding issues in the stock assessment of yellowfin and bigeye tuna in the WCPO. These issues formed the basis of the work programme and research priorities of the Stock Assessment Specialist Working Group for 2005–2006 (see Appendix 1) (http://www.wcpfc.org/sc1/pdf/sc1_final_report.pdf).

To progress these issues, the Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community (SPC) hosted a technical workshop in April 2006. The purpose of the workshop was to investigate the issues specific to the yellowfin and bigeye stock assessments and reach an agreement on the structure of the 2006 assessments for both species, including appropriate sensitivity analyses. Invitations to attend the workshop were sent to key participants in the Stock Assessment Specialist Working Group of SC 1 (Appendix 2).

The specific issues, cross-referenced against the appropriate paragraph(s) from the SC 1 report, are documented as follows:

1) Regional structure
    a) Region boundaries (7.22c, 7.44a)
    b) Separate region encompassing the Indonesia and Philippines fisheries.
    c) Regional scaling factors (7.22c, 7.44a)
2) Longline CPUE indices
    a) The inclusion of catch data for other associated species (esp. ALB) in GLMs (7.43a).
    b) Analyses of operational-level catch and effort data to improve the standardisation of effort (7.43a).
3) Size frequency data
    a) Spatial aggregation of length/weight frequency data.
    b) Review of conversion factors (processed to whole weight) for weight data (7.22b).
    c) Review of length-weight relationships (7.22b).
4) Movement parameterisation (7.44b)
5) Forward projections

Prior to the workshop a range of analyses had been undertaken to explore the specific issues listed above and examine the sensitivity of the 2005 yellowfin and bigeye assessments to these assumptions. These analyses formed the basis of the initial workshop discussions. The results of these analyses and the conclusions of the workshop are documented in this report.

There was limited participation in the workshop. The list of attendees is included in Appendix 3.

2. Regional structure

The 2005 stock assessments for yellowfin and bigeye adopted an equivalent regional stratification based on six regions delineated by the 170° E meridian of longitude and the 20°N and 10°S meridians of latitude (Figure 1) (Hampton et al 2005a, 2005b). These boundaries were reappraised prior to the 2005 assessments. However, there remained concern regarding the appropriateness of the current (2005) boundaries, particularly for yellowfin. For yellowfin, the principal concern was the location of the northern latitudinal boundary. It was considered that the equatorial regions were too large particularly given the distribution of the yellowfin catch which is concentrated between 10°N and 10°S (Figure 1).

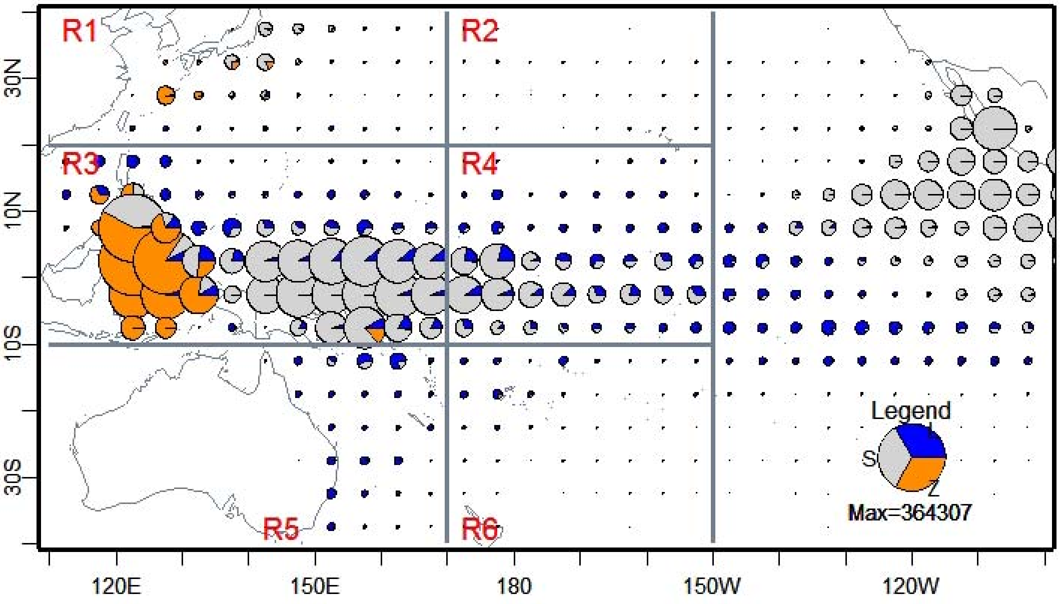

Figure 1. Region boundaries used for the yellowfin and bigeye 2005 WCPO assessments. The pie charts represent the aggregated catch of yellowfin by method and five degrees of latitude and longitude.

The review of the regional structure for yellowfin provided an opportunity to more formally review the regional structure for bigeye. In fact, the regional stratification of the two species is linked by the shared fishery definitions (based on fishing method and location) included in the two models. There is also a very strong argument for maintaining the equivalent regional structure for the two species for the application of the assessment results in the consideration of management measures. For example, the application of the assessment results to examine the impact on the two species of a decrease/increase in fishing effort by a specific method/area fishery.

2.1. Region boundaries

In formulating a recommendation on appropriate regional boundaries, the following criteria were applied:

- Minimise the number of regions and, therefore, model parameters.
- Trends in CPUE from key fisheries in region are comparable within each region.
- Size composition of the catch from key fisheries in region is comparable within each region.
- The availability of sufficient data to derive an abundance index for each region.

- The spatial distribution of key method specific fisheries.
- Consistent regional structure between key fisheries, particularly where there is a strong fishery interaction.

To review current region boundaries with respect to the above criteria, a range of analyses were undertaken, specifically examining the fine-scale trends in both the size frequency data and catch and effort data from the Japanese longline fleet. The results of these analyses were used to qualitatively examine the current regional boundaries.

A further analysis of the catch and effort data was undertaken using a cluster analysis approach to determine the regional boundaries that the delivered the most homogeneous regional structure (i.e. lowest variance) from a range of plausible options.

Previous analyses of yellowfin catch and effort data have generally concluded that it is appropriate to subdivide the fisheries into equatorial and subequatorial regions and further separate these regions longitudinally to delineate the eastern extent of the “warm pool”, thereby, defining six large regions (e.g. Figure 1). The purpose of this analysis is to define the appropriate location of the boundaries that define each of these regions.

In addition, there are management considerations that pertain directly to the Indonesia and, to a lesser extent, the Philippines fisheries. Specifically, these fisheries account for a substantial proportion of the catch of both yellowfin and bigeye, although the level of historical catch and, for Indonesia, recent catch is poorly determined. Therefore, it may be advantageous to define a separate region in the western equatorial area that encompasses these fisheries. This would enable a more thorough assessment of the impact of fishing in that area and reduce the potential for contamination of the assessment results by inaccurate catch data in the equatorial regions further eastward.

2.1.1 Longline CPUE trends

Qualitative analysis

Longline catch and effort data from the Japanese fleet were available from 1952 to 2004 aggregated by month and 5 degrees of latitude and longitude. For each of the 2005 regions, trends in quarterly CPUE of yellowfin and bigeye were derived for each of the 5-degree squares comprising each region. Trends in CPUE, normalised to the mean of the series, were then qualitatively examined to identify the level of consistency of the CPUE trend within the region. Spatial differences in the CPUE trends may suggest the current regional boundaries are not appropriate.

Details of the analysis are provided in a separate paper (Langley 2006a). The key conclusions are as follow:

Yellowfin

- Region 3: Comparable declining trend within equatorial region (10°S to 10°N); weaker decline north of 10°N; sharp decline in far western area (west of 120°E).
- Region 4: Steep decline 1950–1975 in equatorial waters (10°S–10°N); relatively stable CPUE in the more northern areas.

Bigeye

- Region 2: comparable trend throughout the region — initial decline (1950–1970) and then relatively constant.
- Region 3: Variable trends in CPUE within region. South of equator CPUE was relatively stable prior to 1970 then and increase in some areas; north of 5°N, high initial decline then stable (similar to Region 1).

- Region 4: north of 5°N the CPUE trend is comparable to Region 2; south of 5°N CPUE was relatively constant throughout period.

Cluster analysis

A more empirical approach was applied to the analysis of these data using a clustering technique. A seven region structure was examined with a fixed region encompassing the western equatorial area (encompassing Indonesia and Philippines waters, see Section 2.2). The analysis then investigated a range of options for the five other boundaries: northern latitudinal boundary (10°N, 20°N), southern latitudinal boundary (0°, 10°S, 20°S), northern longitudinal boundary (150°E, 160°E, 170°E, 180°, 170°W,), equatorial longitudinal boundary (160°E, 170°E, 180°) and southern longitudinal boundary (160°E, 170°E, 180°) — representing a total of 270 different scenarios (Figure 2).

For each scenario, the deviance from the mean (normalised) catch rate for the region was calculated, as follows:

i. 5-degree square allocated to a region (1–7).
ii. Annual average catch rate (number per 100 hooks) calculated for each 5-degree square and normalised to the mean of the series.
iii. For each region, the annual mean of the normalised CPUE from the 5-degree squares (ii) is determined.
iv. The deviance (sum of squares) of the normalised CPUE from the 5-degree squares (ii) from the regional average (iii) is calculated.
v. A cumulative CPUE index is derived for each region. The index represents the sum of the CPUE from each 5-degree square (total catch/total effort) comprising the region. The index incorporates both the size or the region (number of cells) and the relative level of CPUE (CPUE per cell).
vi. The deviance (iv) from the seven regions is summed, weighted by the CPUE index (v) from each region.

The same approach was applied to both species and the resulting scenarios were ranked according to the weighted deviance from the seven regions combined. The weighting was applied to emphasise the importance of the core regions (highest abundance as indicated by the area weighted CPUE) in the analysis, i.e. it is preferable to have lower variance in the areas that encompass a large proportion of the total biomass compared to regions with a smaller biomass (as indicated by CPUE).

The normalised CPUE trend in each region (iii) converts trends in absolute CPUE to trends in relative CPUE. This essentially replicates the inclusion of the spatial component (lat*long cell) in the current GLM standardisation procedure used to derive the regional CPUE indices (see Langley et al 2005).

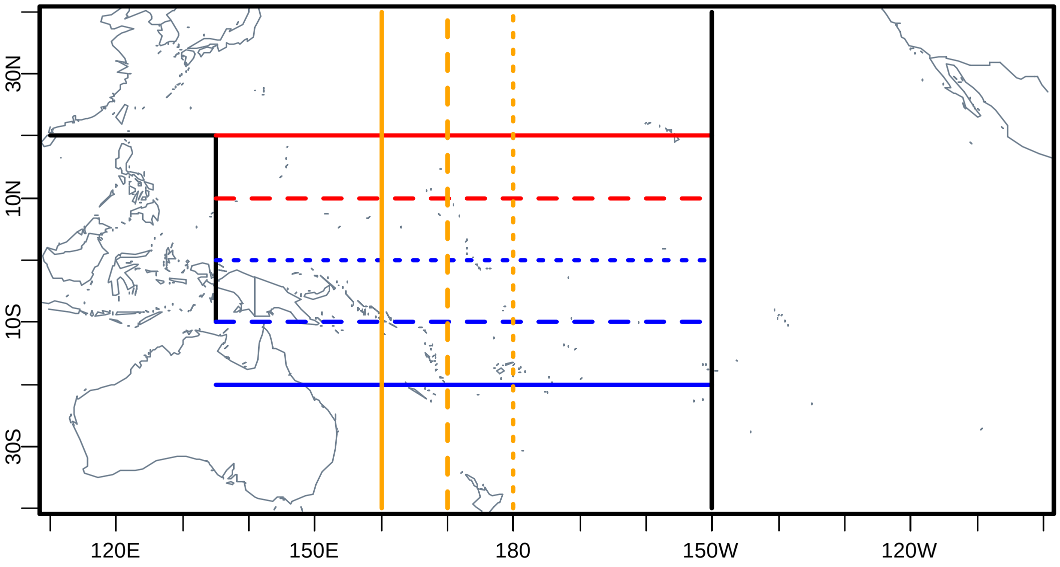

Figure 2. Location of the northern latitudinal boundaries (red), southern latitudinal boundaries (blue) and longitudinal boundaries (orange) investigated in the cluster analysis. The western equatorial area (black) was fixed in all scenarios.

For both species, there are a number of scenarios that were excluded as there are insufficient data to calculate more than a single 5-degree CPUE index within region 6 (south-eastern region). These scenarios are for longitudinal boundaries at 180° and south latitudinal boundaries at 10°S and 20°S (Table 1 and Table 2).

Once these options are rejected, the highest ranking (lowest deviance) scenarios for yellowfin are for a northern latitudinal boundary at 10°N. The most preferred southern latitudinal boundary is at 20°S although scenarios with the boundary at 10°S also yielded a relatively low variance (Table 1). The location of the longitudinal boundaries were more equivocal, although a more western longitudinal boundary (150°E or 160°E) was generally preferred in the northern sector. There was little difference between the longitudinal boundaries at either 170°E or 180° for the equatorial sector.

For bigeye, the highest ranking options all included the northern boundary at 20°N and the southern boundary at the equator. There was little difference in the total deviance with respect to the location of the three longitudinal boundaries (Table 2). Scenarios that were highly ranked for yellowfin (10°N and 20°S) were relatively lowly ranked for bigeye (between ranks 80 and 160 of 270).

A combined index was calculated incorporating the yellowfin and bigeye weighted variance, normalised to the average of each series (Table 3). The lowest composite ranking was for the regions bounded at latitudes 10°N and 10°S. The longitude boundaries were less influential and the analysis indicated the existing boundary at 170°E was appropriate.

Table 1. Results from the cluster analysis of yellowfin longline catch and effort data. The scenarios are ranked by the total weighted deviance. Only the results from the scenarios with the 25 lowest ranks are presented. The last row includes the scenario most similar to the regional structure in the 2005 assessment.

Rank	**Region boundary**					**Weighted deviance by region**							**Total deviance**
	northlat	southlat	long_n	long_eq	long_s	R1	R2	R3	R4	R5	R6	R7	
1	10	-20	160	170	170	18100	12995	14827	18468	3882	3762	2854	74887
2	10	-20	160	170	180	18100	12995	14827	18468	8106	0	2854	75350
3	10	-20	160	180	170	18100	12995	23521	10564	3882	3762	2854	75677
4	10	-20	150	170	170	11694	20218	14827	18468	3882	3762	2854	75705
5	10	-20	160	180	180	18100	12995	23521	10564	8106	0	2854	76139
6	10	-20	150	170	180	11694	20218	14827	18468	8106	0	2854	76168
7	10	-10	160	180	170	18100	12995	10114	9026	14552	8560	2854	76201
8	10	-20	150	180	170	11694	20218	23521	10564	3882	3762	2854	76494
9	10	-20	170	170	170	24970	7950	14827	18468	3882	3762	2854	76713
10	10	-20	150	180	180	11694	20218	23521	10564	8106	0	2854	76957
11	10	-10	150	180	170	11694	20218	10114	9026	14552	8560	2854	77018
12	10	-20	170	170	180	24970	7950	14827	18468	8106	0	2854	77176
13	10	-10	160	170	170	18100	12995	5372	14943	14552	8560	2854	77375
14	10	-20	170	180	170	24970	7950	23521	10564	3882	3762	2854	77502
15	10	-20	160	170	160	18100	12995	14827	18468	835	9476	2854	77554
16	10	-20	170	180	180	24970	7950	23521	10564	8106	0	2854	77965
17	10	-10	170	180	170	24970	7950	10114	9026	14552	8560	2854	78026
18	10	-10	150	170	170	11694	20218	5372	14943	14552	8560	2854	78193
19	10	-20	160	180	160	18100	12995	23521	10564	835	9476	2854	78343
20	10	-20	150	170	160	11694	20218	14827	18468	835	9476	2854	78372
21	10	-20	150	180	160	11694	20218	23521	10564	835	9476	2854	79161
22	10	-10	170	170	170	24970	7950	5372	14943	14552	8560	2854	79200
23	10	-20	170	170	160	24970	7950	14827	18468	835	9476	2854	79380
24	10	-20	160	160	170	18100	12995	7037	30989	3882	3762	2854	79618
25	10	-20	160	160	180	18100	12995	7037	30989	8106	0	2854	80081
81	20	-10	170	170	170	8205	1963	19864	35156	14552	8560	2854	91154

Table 2. Results from the cluster analysis of bigeye longline catch and effort data. The scenarios are ranked by the total weighted deviance. Only the results from the scenarios with the 25 lowest ranks are presented. The last row includes the scenario most similar to the regional structure in the 2005 assessment.

Rank	**Region boundary**					**Weighted deviance by region**							**Total deviance**
	northlat	southlat	long_n	long_eq	long_s	R1	R2	R3	R4	R5	R6	R7	
1	20	0	170	170	170	5221	5001	3685	5336	6187	7695	1048	34173
2	20	0	180	170	170	8295	2409	3685	5336	6187	7695	1048	34656
3	20	0	170	180	170	5221	5001	6415	3107	6187	7695	1048	34674
4	20	0	160	170	170	3264	7470	3685	5336	6187	7695	1048	34684
5	20	0	170	170	180	5221	5001	3685	5336	13197	1587	1048	35076
6	20	0	180	180	170	8295	2409	6415	3107	6187	7695	1048	35157
7	20	0	160	180	170	3264	7470	6415	3107	6187	7695	1048	35186
8	20	0	170	160	170	5221	5001	1882	8229	6187	7695	1048	35263
9	20	0	180	170	180	8295	2409	3685	5336	13197	1587	1048	35558
10	20	0	170	180	180	5221	5001	6415	3107	13197	1587	1048	35577
11	20	0	160	170	180	3264	7470	3685	5336	13197	1587	1048	35587
12	20	0	180	160	170	8295	2409	1882	8229	6187	7695	1048	35746
13	20	0	160	160	170	3264	7470	1882	8229	6187	7695	1048	35774
14	20	0	180	180	180	8295	2409	6415	3107	13197	1587	1048	36060
15	20	0	160	180	180	3264	7470	6415	3107	13197	1587	1048	36088
16	20	0	170	160	180	5221	5001	1882	8229	13197	1587	1048	36166
17	20	0	180	160	180	8295	2409	1882	8229	13197	1587	1048	36648
18	20	0	160	160	180	3264	7470	1882	8229	13197	1587	1048	36677
19	10	-10	170	180	170	11876	12347	4176	2935	2409	1945	1048	36735
20	20	0	150	170	170	1566	11280	3685	5336	6187	7695	1048	36797
21	20	-10	170	170	170	5221	5001	7509	13814	2409	1945	1048	36947
22	20	-10	170	180	170	5221	5001	13558	7908	2409	1945	1048	37090
23	10	-10	170	170	170	11876	12347	2165	5324	2409	1945	1048	37114
24	20	0	150	180	170	1566	11280	6415	3107	6187	7695	1048	37298
25	20	-10	180	170	170	8295	2409	7509	13814	2409	1945	1048	37430
21	20	-10	170	170	170	5221	5001	7509	13814	2409	1945	1048	36947

Table 3. Average ranking for each scenario considered in the yellowfin and bigeye cluster analyses. Only the top 25 are presented.

Rank	Boundary					Index		
	northlat	southlat	long_eq	long_n	long_s	YFT	BET	Combined
1	10	-10	170	180	170	0.7774	0.8529	1.6303
2	10	-10	160	180	170	0.7592	0.8786	1.6378
3	10	-10	170	170	170	0.7891	0.8617	1.6508
4	10	-10	160	170	170	0.7709	0.8874	1.6583
5	10	-20	170	170	170	0.7643	0.9175	1.6818
6	10	-20	160	170	170	0.7461	0.9432	1.6893
7	10	-20	170	170	180	0.7689	0.9237	1.6926
8	10	-20	160	170	180	0.7507	0.9494	1.7001
9	10	-20	170	180	170	0.7722	0.9323	1.7045
10	10	-10	170	180	180	0.8281	0.8771	1.7051
11	10	-10	170	180	160	0.8189	0.8886	1.7074
12	10	-20	160	180	170	0.7540	0.9580	1.7120
13	10	-10	160	180	180	0.8099	0.9028	1.7127
14	10	-10	160	180	160	0.8007	0.9143	1.7150
15	10	-20	170	180	180	0.7768	0.9385	1.7153
16	10	-20	160	180	180	0.7586	0.9643	1.7228
17	10	-10	170	170	180	0.8398	0.8859	1.7256
18	10	-10	170	170	160	0.8306	0.8974	1.7279
19	10	-20	170	170	160	0.7909	0.9415	1.7324
20	10	-10	160	170	180	0.8216	0.9116	1.7331
21	10	-10	180	180	170	0.8414	0.8939	1.7353
22	10	-10	160	170	160	0.8124	0.9231	1.7355
23	10	-10	170	160	170	0.8340	0.9046	1.7386
24	10	-20	160	170	160	0.7727	0.9673	1.7399
25	10	-10	160	160	170	0.8158	0.9304	1.7462

2.1.2 Size frequency data

The appropriateness of the current regional structure used for yellowfin and bigeye was examined by comparing temporal trends in fish size (weight and length) from the sampled catch from the Japanese longline fleet. These data are usually available in a spatial resolution of 10 degrees of latitude and 20 degrees of longitude (block or cell). Each block was defined by the location of the southwestern corner, for example, the block denoted “00N 140 E” encompasses the area from the equator to 10ºN and from 140ºE to 160ºE (Figure 3).

For each block included within a specific MFCL region, the annual median fish size (weight or length) sampled was calculated and trends in fish size were compared between the blocks encompassed by the region. The number of samples from each block was also examined to investigate the spatial distribution of sampling effort. These analyses were conducted for each of the main yellowfin and bigeye longline fisheries: regions 3–5 for yellowfin and regions 2–5 for bigeye. Insufficient size data were available to undertake the analysis for the other regions.

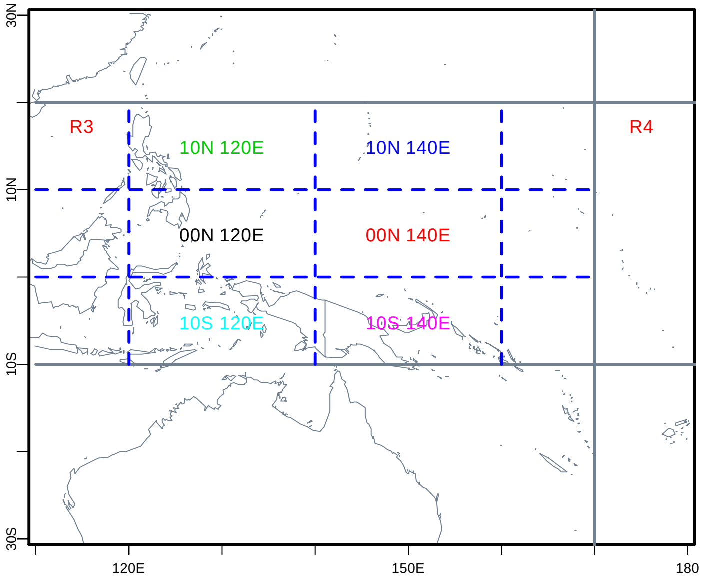

Figure 3. An example of the spatial stratification of longline size frequency data within a specific region (region 3 from 2005 assessments).

The results of the analysis are detailed in a separate report (Langley 2006b). The key conclusions are as follow:

Yellowfin

- Region 3: smaller fish in western area since 1980; smaller fish in PNG waters ("10S, 140E").
- Region 4: increasing fish size eastwards.
- Region 5: fish size increases southward.

Bigeye

- Region 2: fish size generally consistent through the region.
- Region 3: Large decline in fish size in the far north-western areas since mid 1980s; smaller fish in PNG area.
- Region 4: Similar trends in fish size throughout region (comparable to Region 2).
- Region 5: Increased fish size southwards.

General

- Similar trends were evident from both length and weight data.
- There were some strong differences in the spatial distribution of length and weight data. These differences contributed to differences in the trends in the aggregated length and weight data from a specific region.
- There is a need to develop a scheme for aggregating size frequency data within a region, accounting for the distribution of total catch within that region.

2.2. Indonesia and Philippines

The tuna fisheries in Indonesia and Philippines waters account for a significant component of the catch of yellowfin and bigeye from the WCPO. The magnitude of the historical and, particularly for Indonesia, recent catch is very poorly determined. This introduces considerable uncertainty into the current stock assessments for the WCPO and specifically for the regions encompassing these fisheries (region 3; western equatorial). Region 3 also accounts for a large proportion of the total yellowfin catch from the WCPO as it is the main area of operation for the purse-seine fleet. On this basis, it was considered worthwhile to explore the potential to sub-divide region 3 and, thereby, compartmentalise the area encompassing the Indonesia and Philippines fisheries. In doing so, it was considered that the model may provide more accurate estimates of biomass for the area encompassing the main purse-seine fishery.

In addition, the fine-scale analysis of catch and effort data (Section 2.1.1) revealed a stronger decline in the yellowfin catch rate in the western area of Region 3 since the 1980s. Further, the size composition of both yellowfin and bigeye has declined sharply in the western area of Region 3 during the same period (see Section 2.1.2). These observations indicate that exploitation rates in the western area of Region 3 may be considerably higher for both fisheries since the development of the Indonesia and Philippines fisheries — catches from these fisheries increased steadily from the early 1980s. The observed heterogeneity in Region 3 is another strong justification for subdividing the region.

Most of the catch from the Indonesia fishery is taken to the west of 135°E (Figure 4) and the catch eastward of that longitude is principally taken by the purse-seine method. On this basis it was decided to subdivide Region 3 at the 135°E meridian of longitude. The Philippines EEZ extends northwards to approximately 20°N and it was appropriate to maintain the entire EEZ within a single region, likewise the area of the South China Sea. On this basis, the northern boundary was fixed at 20°N.

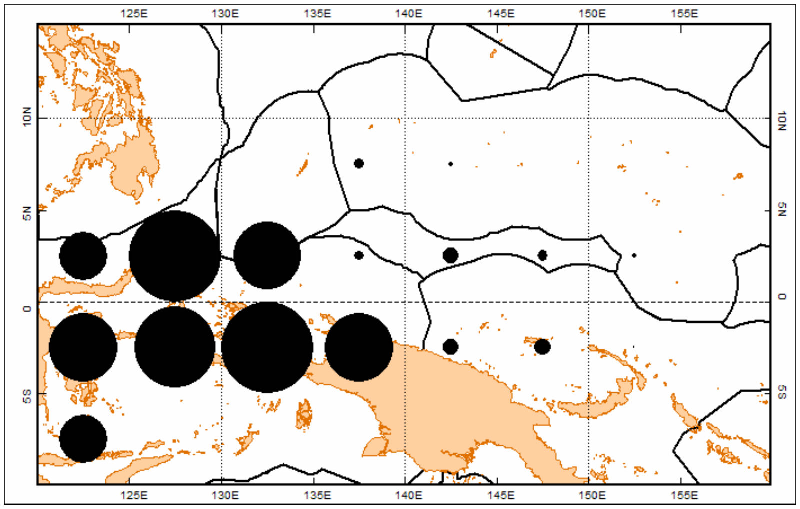

Figure 4. Distribution of catch (all years) from Indonesian vessels, all methods. The catch east of 135°E is almost exclusively taken by purse-seine.

This area definition was applied to a reanalysis of the data included in the 2005 stock assessments for yellowfin and bigeye, i.e., region 3 was separated into two regions at 135°E (see Figure 1). The overall conclusions of the revised assessments were broadly similar to the 2005 base-case assessments for both species; overfishing is occurring ($F_{current}/\tilde{F}_{MSY} > 1$) although the stock is not in an overfished state ($B_{current}/\tilde{B}_{MSY} > 1$). However, the stock status for bigeye was slightly more pessimistic than the base-case, while the current status for yellowfin was more optimistic (see Appendix 4; yellowfin scenario 5, bigeye scenario 6).

For yellowfin, this is explained by the 7-region model estimating higher exploitation rates for yellowfin, particularly juvenile yellowfin, in the western area compared to the eastern area of the former Region 3. The latter area accounts for a much higher proportion of the total biomass and, consequently, the overall level of impact is lower (compared to the base-case).

The situation differs for bigeye where both the western and eastern areas of the former Region 3 have a similar level of biomass. The fishing mortality of juvenile age classes is estimated to be substantially higher for the 7-region model, principally due to the higher fishing mortality on the juvenile age classes in the Indonesia/Philippines area. This results in a lower estimate of MSY and, overall, a slightly more pessimistic current stock status.

In constructing the datasets for the two 7-region analyses, a key consideration was the magnitude and spatial coverage of sufficient catch and effort data from the Japanese longline fleet to derive a reliable CPUE index for the Indonesia/Philippines area. From the mid 1980s, there was a large reduction in the activity of the fleet in the area and an eastward shift in fishing activity out of the South China Sea (Figure 5).

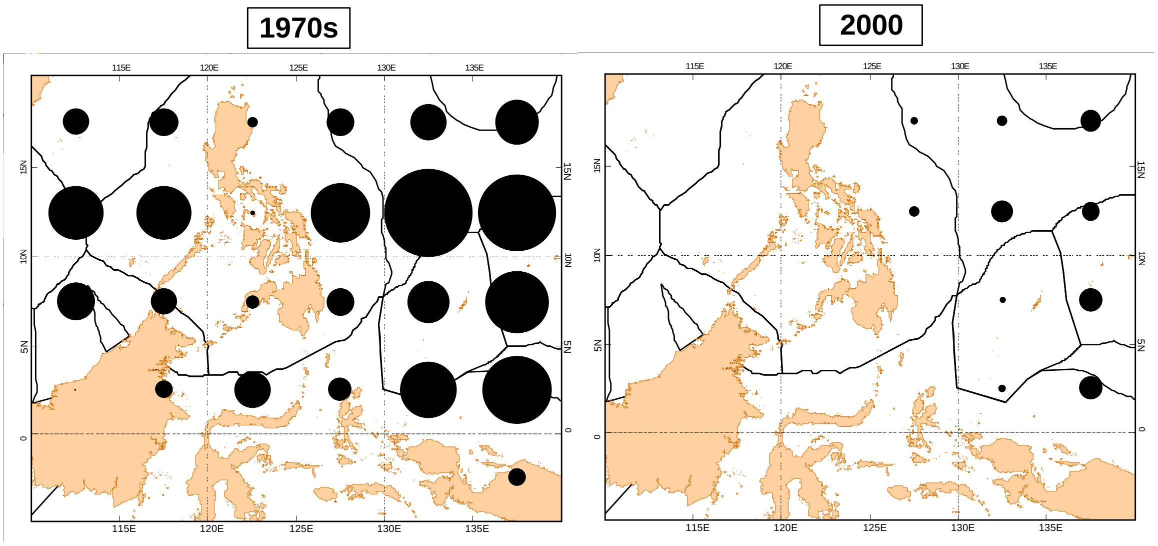

Figure 5. A comparison of the annual distribution of Japanese longline fishing effort in the western equatorial region from representative years during peak fishing activity (mid 1970s) and recent years (2000). The area of the circle is proportional to the level of fishing effort (numbers of hooks set).

These trends may compromise the CPUE index for the region and the longline index from 1984 onwards is incomplete and highly variable, particularly for bigeye (Figure 6). This appears to be less of a problem for yellowfin, although it highlights the need to develop a separate CPUE index for the Indonesia/Philippines area to develop a robust 7-region assessment for both species.

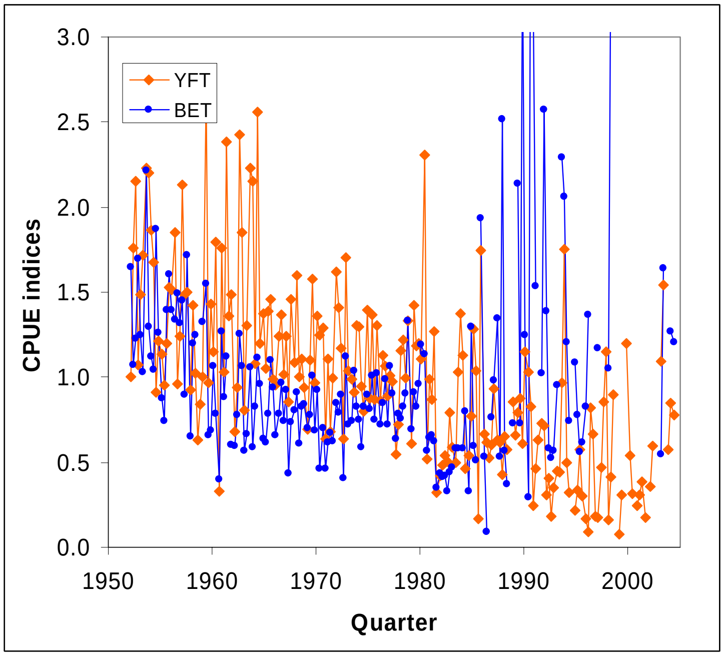

Figure 6. Standardised Japanese longline CPUE index for yellowfin and bigeye for the western equatorial region (west of 135°E and south of 20°N).

The other potential source of catch and effort data from the area west of 135°E is the Philippines large-scale handline fishery. Effort data are available from the fishery since 1997. It is necessary to review the spatial extent of this fishery to determine whether these data provide a reliable index of relative abundance of yellowfin and bigeye in the new western region. Currently, these data are included in the assessments, although catchability is allowed to vary temporally and a lower penalty is applied to the effort deviates.

2.3. Regional scaling factors

There was limited discussion regarding the calculation of the regional factors used to scale the standardised effort series for the Japanese longline fisheries in each region. There were no alternative methods proposed for calculating these scaling factors, although it was noted that the regional scaling factors should be applied to each series normalised to the period for which the scaling factors are derived (i.e. 1960 to 1986 inclusive). In last year's assessments, these scaling factors were applied to each series normalised to the average of the entire series.

2.4. Recommendations

The workshop agreed to the following points regarding regional structure:

- **A new 7-region model would be developed for both yellowfin and bigeye using an equivalent regional structure for both species. The model would include a new region in the western equatorial region (extending to 20°N and 135°E) and encompassing the Indonesia and Philippines fisheries. The remaining regional boundaries would be comparable to the 2005 assessment, except that the northern latitudinal boundary would be moved southward to 10°N (see Figure 7).**
- **The 2005 6-region models would also be updated with the most recent year's data.**
- **In concept, the 7-region model is the preferred base-case assessment. However, it will be dependent on the suitability of catch and effort data from the Philippines handline fishery to be applied an index of region wide stock abundance in the most recent period**

(since 1997). Insufficient data are available from the Japanese longline fishery to derive a reliable index of standardised effort after mid 1980.

- **If the 7-region models are suitable, these will be used for the forward projections.**
- **An equivalent approach will be used to derive the regional scaling factors as used in 2005, although the scaling factor will be applied to the index normalised to the period for which the scaling factor was derived.**

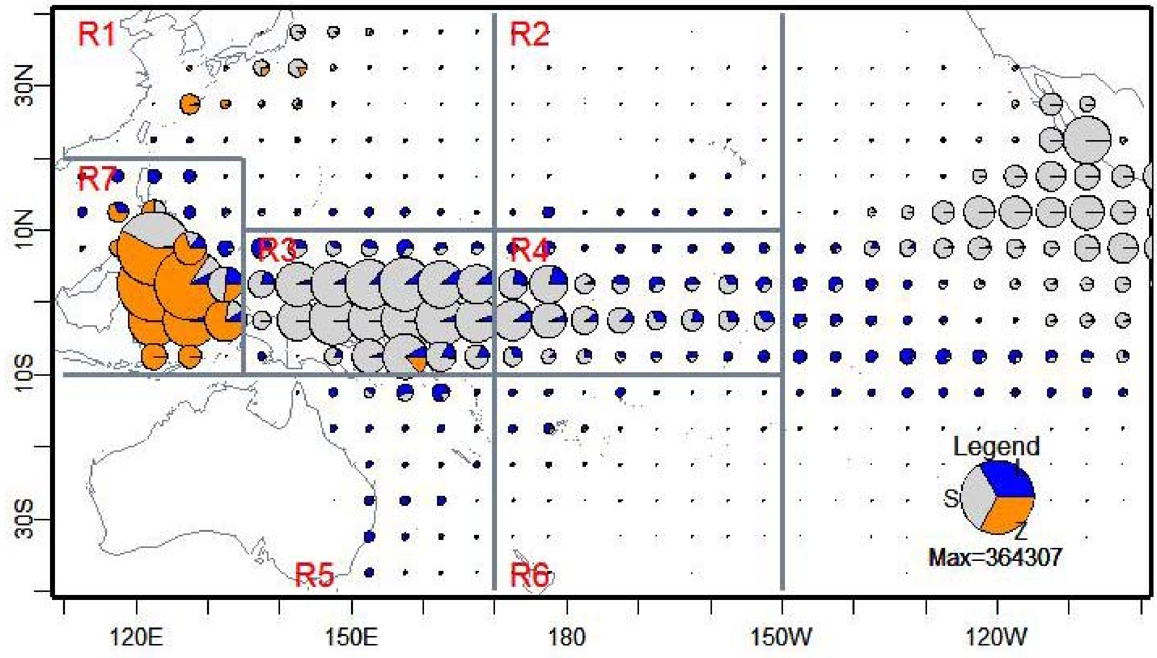

Figure 7. Proposed region boundaries for the yellowfin and bigeye WCPO assessments for 2006. The pie charts represent the aggregated catch of yellowfin by method and five degrees of latitude and longitude.

3. Longline CPUE Indices

The workshop agreed that the GLMs for the JP LL catch and effort data would be run with and without the inclusion of the albacore catch data to examine the sensitivity of the indices to the inclusion of this variable. The statistical habitat based standardisation procedure will not be used this year to derive an alternative effort series for the longline fisheries.

The workshop noted that there was currently no operational level catch and effort data available from the Japanese longline fleet, with the exception of limited logsheet data collected from fisheries operating inside the EEZs SPC member countries. The lack of data precluded the detailed analysis requested by SC 1. However, to progress this issue it was agreed to undertake an analysis of Japanese longline data at 1*1 and 5*5 degree resolution. The analysis would use a GLM approach and would be restricted to a single region of the MFCL model; the western equatorial region (3).

A number of other issues were identified for future work, principally the inclusion of a range of environmental factors in the GLMs (e.g. SST, MLD, current, etc). In addition, there was concern that the exclusion of the JP longline fleet from coastal waters may have resulted in a negative bias in the current CPUE indices. It was considered that these issues should be addressed in a recommendation to SC 2 to undertake further work in refining the CPUE indices.

4. Size frequency data

A key concern from the 2005 yellowfin and bigeye stock assessments was the lack of fit to the length frequency data included in the model. This was particularly evident in the yellowfin assessment and, for both assessments, principally evident for those fisheries where both weight and length frequency data were available (specifically the longline fisheries). This indicates a conflict in the two data sets. There are a number of potential explanations for the apparent differences in size composition from the two data sources:

i. A consistent difference in the size of fish sampled due to spatial heterogeneity in the model regions and a consistent sampling bias for length and weight samples. [While such heterogeneity does exist in some regions, the biases are unlikely to be constant throughout the model period and, therefore, this explanation was discounted. Nevertheless, there are certainly issues to be addressed in how best to stratify the sampling data that need further attention].
ii. An inappropriate conversion factor applied to the processed weight data (gilled-and-gutted) to convert to whole weight.
iii. An inappropriate length-weight relationship applied to the weight frequency data to convert to length.

4.1. Review of conversion factors for weight data

The 2005 stock assessments had assumed a constant conversion factor from gilled-and-gutted weight to whole weight of 1.152 and 1.1018 for yellowfin and bigeye, respectively. The yellowfin value was principally based on an analysis of data collected by observers covering the Japanese longline fleet operating in the Australian waters. These data were reanalysed to calculate a size-specific conversion factor as there was evidence of a systematic trend in the residuals from the linear relationship between processed and unprocessed weights. A simple non linear model was applied to estimate the relationship between processed and whole weight (whole weight = $a[\text{processed weight}]^b$).

Alternative conversion factors were also provided by Naozumi Miyabe (NRIFSF) (see Appendix 6). These were parameterised using a simple linear model with an intercept term. A comparison of the conversion factors by processed weight interval is presented in Figure 8. The NRIFSF conversion factors are implausibly high for small fish (less than 10 kg) due to the inclusion of a constant intercept term in the model. However, the values tend to converge on the conversion factors estimated using the non linear model for large fish. Overall, the non linear model predicts a declining conversion factor with increasing fish size.

For yellowfin, the conversion factor derived from the nonlinear model is higher (lower) than the constant value assumed in previous assessments for fish less (greater) than 20 kg (processed weight) (Figure 8). For bigeye, the conversion factor derived from the non linear model is higher than the constant value over the entire range of processed weights.

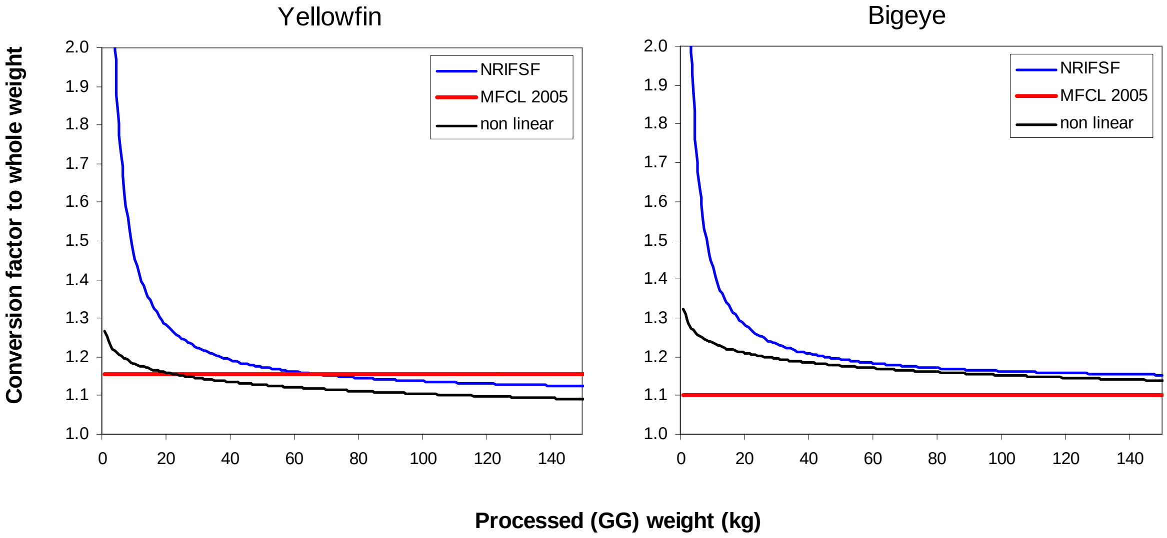

Figure 8. A comparison of the three conversion factors (processed gilled-and-gutted weight to whole weight) available for yellowfin and bigeye.

The lower conversion factor for bigeye tuna used in the 2005 assessment was derived from a small sample (n= 87) of fish from the locally based longline fishery in the Solomon Islands and Federal States of Micronesia. These fish were processed to a gilled-and-gutted state with the tail and operculum not removed. This contrasts with the Japanese gilled-and-gutted fish that have the tail and operculum removed. This is likely to contribute to the higher conversion factor from the Japanese data.

Another issue considered in the application of the conversion factor is the implication of truncation of weight measurements. Most of the processed weights provided to OFP are recorded to the nearest whole kilogramme. This introduces a potential bias in the estimation of the whole weight (and subsequently length) of the fish, particularly for small weight classes. For example, a 9 kg (77.5 cm) yellowfin has a processed weight of 7.8 kg which is recorded as 7 kg. When the conversion factor is applied to the recorded processed weight the whole weight is estimated to be 8.1 kg (74.6 cm) — a negative bias of 0.9 kg (2.9 cm). The bias is minimal for fish greater than 15 kg in (whole) weight. However, it can have a considerable impact on the overall size composition (Figure 9). This source of bias can be corrected with the addition of a random value of 0–1 kg prior to converting the processed weight to whole weight (Figure 9).

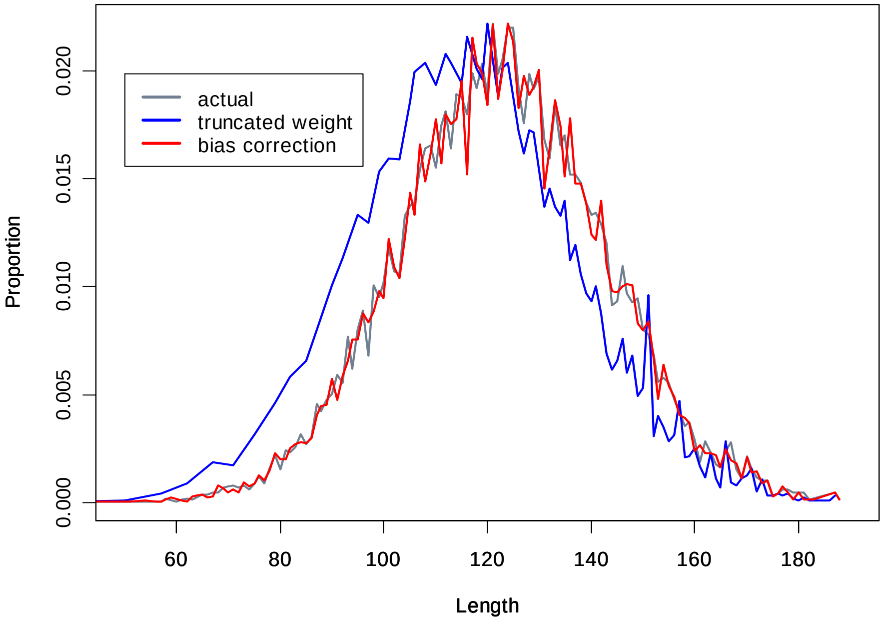

Figure 9. Hypothetical example of the bias introduced to the truncation of processed weight data (to the nearest kg below measured weight) using the conversion factor and length-weight parameters for yellowfin.

4.2. Review of length-weight relationships

The available length-weight relationships for yellowfin and bigeye tuna were also reviewed. The length-weight relationships used in the 2005 assessments were compared with published relationships sourced from FISHBASE (www.fishbase.org) and from NRIFSF (Figure 10).

For yellowfin, the length-weight relationships derived from yellowfin from Hawai'i and the east Atlantic and provided by NRIFSF (Pacific Ocean) were very similar. However, the relationships deviated from the length-weight relationship used in the 2005 assessment. The latter relationship predicted a lower weight for a given length compared to the other three relationships, particularly for fish exceeding 120 cm FL (Figure 10).

For bigeye, the length-weight relationship used in the 2005 assessment was very similar to the relationships for NRIFSF (Pacific Ocean) and east Atlantic (Figure 10). These three relationships deviated markedly from the relationship for fish sampled around Hawai'i (Source: FISHBASE). The latter relationship is incorrect and it is likely to be based on imperial weight measures (weight in pounds rather than kilogrammes).

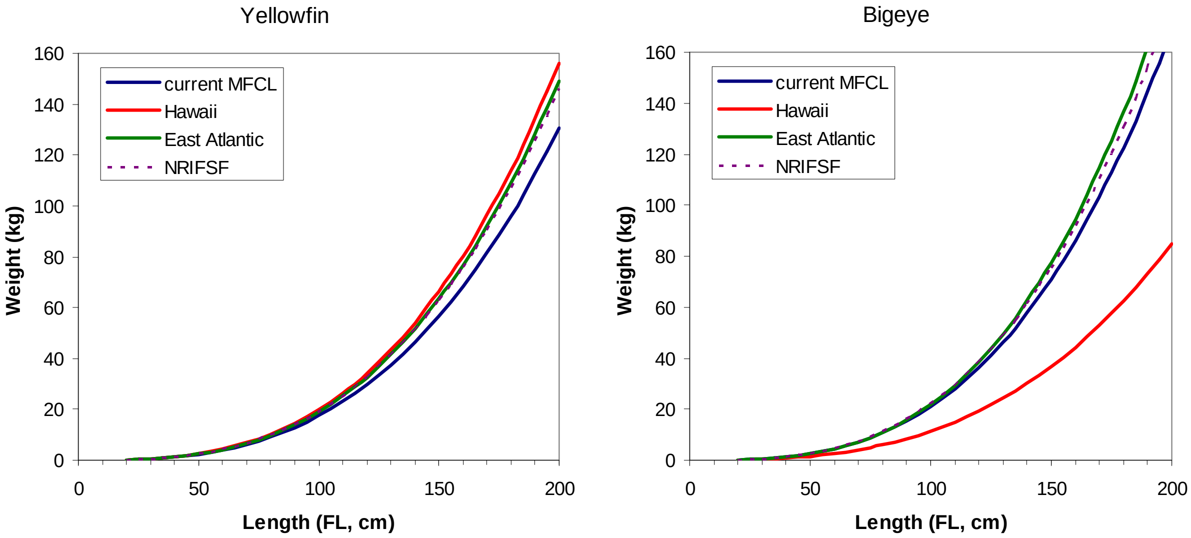

Figure 10. A comparison of various available length-weight relationships for yellowfin and bigeye tuna.

For yellowfin, the higher length-at-weight from the relationship used in the 2005 assessment counters some of the effect of the bias introduced by the truncation of the processed weight data, particularly for larger fish (Figure 11).

The yellowfin model was rerun with the NRIFSF length-weight relationship (yellowfin scenario 4, Appendix 4). This resulted in no substantive change to the key biological reference points compared to the 2005 base-case assessment.

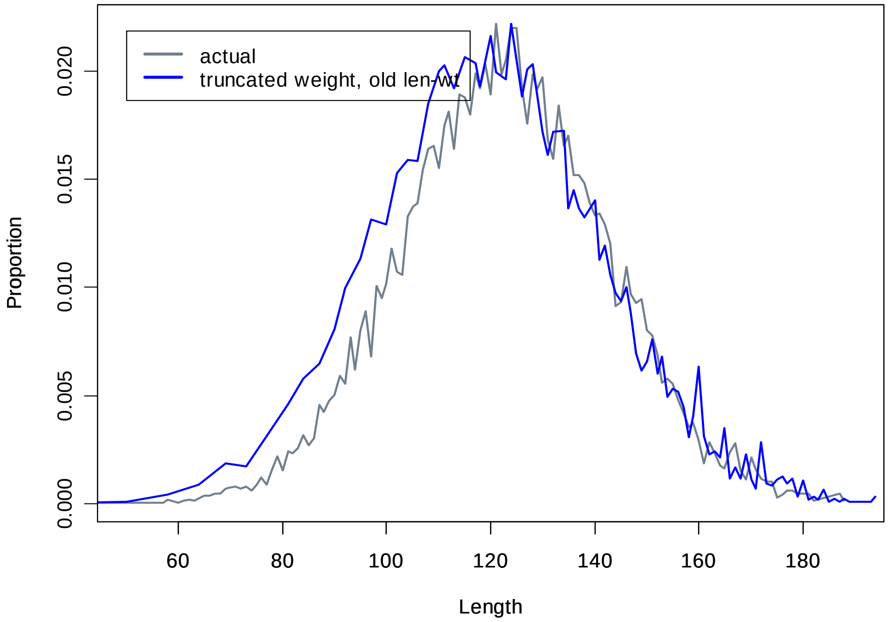

Figure 11. Hypothetical example of the bias introduced to the truncation of processed weight data (to the nearest kg below measured weight) using the 2005 conversion factor and the length-weight parameters for yellowfin.

The 2005 yellowfin and bigeye assessments were rerun using processed weight data corrected for the bias associated with the truncated measurements and the conversion factors determined from the non linear model. In addition, for yellowfin the NRIFSF length-weight relationship was used. For both models, there was a large improvement to the overall fit to the data, principally the size frequency data, as indicated by the reduction in the likelihood values (see Appendix 4). For bigeye, there was a very good fit to both the length and the weight data. However, for yellowfin the fit to the length data from the longline fisheries in the equatorial regions (particularly Region 3) remained poor, while there was a good fit to the weight frequency data from the same fisheries. This issue is discussed in further detail in the following section.

For bigeye, the change in conversion factor and the bias correction resulted in a more pessimistic stock assessment than the 2005 base-case (see Appendix 4, bigeye scenario 4); $B_{current} \big/ \tilde{B}_{MSY}$ = 1.09 and $F_{current} \big/ \tilde{F}_{MSY}$ = 1.67. The reference points from the revised yellowfin assessment were similar to the 2005 base-case (yellowfin scenario 3).

The significant difference in the bigeye assessment (scenario 4) is attributable to a difference in the growth parameters from the model, particularly a higher value for *Linfinity*. The inclusion of the new conversion factor resulted in an increase in the size of fish in the samples, particularly in the earlier period in the model when fish were larger, resulting in the increased *Linfinity* (Figure 12). The current stock status is more pessimistic because of the greater reduction in fish size over time as fewer large fish are observed in weight samples in the more recent years. Consequently, the model estimates higher fishing mortality on the older age classes and, hence, a lower overall level of recruitment.

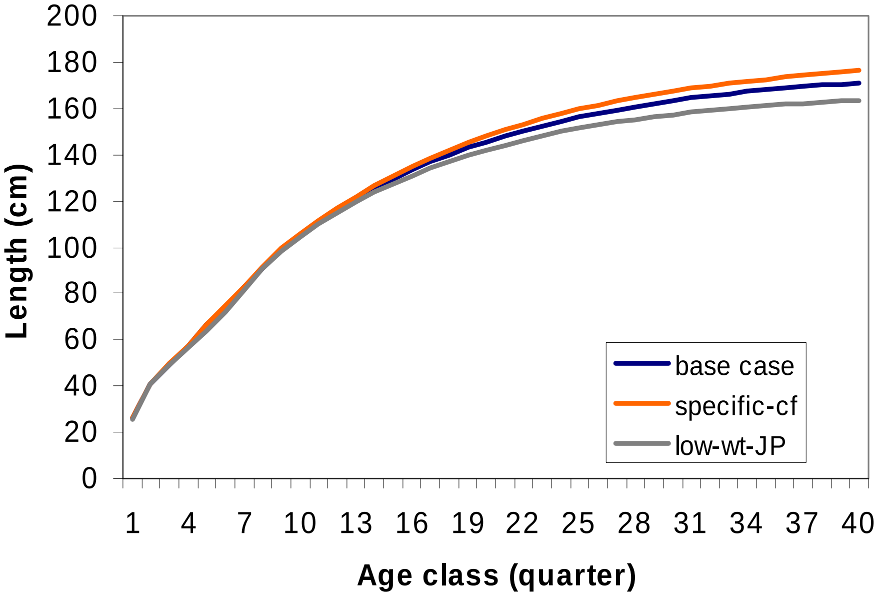

Figure 12. A comparison of the growth function derived for bigeye from three separate model runs: 2005 base-case, revised conversion factors (specific-cf), and with the revised conversion factors but the Japanese weight frequency data down-weighted in the model (low-wt-JP).

Evidently, the assessment is sensitive to the Japanese weight data, particularly from the early period in the model. Downweighting these data (with the revised conversion factor) resulted in a model fit (scenario 5) that had an *Linfinity* lower than for the 2005 base case analysis. The resulting model run was more optimistic than the base-case with respect to the $F_{current} / \tilde{F}_{MSY}$ reference point.

There are limited data available for deriving conversion factors for yellowfin and bigeye, particularly for the locally based longline fleets. However, the available data indicate a difference in conversion factor between the locally based vessels and the Japanese distant-water longline fleet. The locally based vessels process gilled-and-gutted fish retaining both the tail and the operculum. However, the Japanese distant-water fleet processes the fish with tail and operculum cover removed.

This is a likely explanation for the higher conversion factor for bigeye derived for Japanese processed weights. Therefore, it is appropriate to apply fishery-specific conversion factors where consistently different processing techniques are applied.

4.3. Spatial aggregation of length/weight frequency data.

Spatial heterogeniety in the size composition of catch was briefly summarised in Section 2.1.2. A more detailed examination of these data may provide some insight into the persistent discrepancy between the yellowfin length and weight frequency data from the longline fisheries in the equatorial regions (Regions 3 and 4).

For the longline fishery in region 3, a large proportion of the length samples were collected from a 20° longitude, 10° latitude cell that encompasses the northern area of the PNG EEZ ("10S, 140E", see Figure 1). This area was characterised by substantially smaller yellowfin than the other cells that comprise the region (Figure 13). In contrast, the area accounted for a much smaller proportion of the weight frequency data collected from the longline fishery in Region 3 (Figure 14) (Langley 2005b).

These differences may explain the apparent conflict between the two sets of size data from this region. This may be addressed through the adoption of a weighting scheme that combines length and weight samples in proportion to the distribution of catches within a region. A trial weighting scheme was developed for the Region 3 longline data using the following criteria for a regional fishery:

i. Catch data (numbers of fish) from a region are aggregated at the same spatial resolution as the size data (usually 20° longitude, 10° latitude cells).
ii. Check size data are available from all cells that cumulatively account for **70%** of the total quarterly catch from the region. If not, reject the size data from that quarter.
iii. Check there are at least **20** fish sampled from each of the main cells fished and at least a total of **50** fish sampled per quarter. If not, reject the size data from that quarter.
iv. Combine the sample data from each cell weighted by the catch in each cell (number of fish).
v. Scale the overall weighted sample to the total number of fish measured in the quarter.

This weighting scheme was applied to the yellowfin longline data (length and weight) from Region 3. The application of this approach resulted in the exclusion of a considerable number of quarterly length samples from the fishery, principally from the latter half of the series (Figure 15). The weighting scheme increased the overall average size of fish in the aggregate length sample by about 4 cm in the 1965–1980.

For the weight data, there was no substantial difference in the average size of the weighted and unweighted aggregated samples throughout the time period. However, the criteria for determining weight samples did result in a number of the quarterly samples being rejected. These were generally from post 1990 and tended to be comprised of larger fish (Figure 15).

The 1965–1980 years represented the period of greatest discrepancy between the observed and predicted length composition in the yellowfin stock assessment. The application of the proposed weighting schedule may partly account for this lack of fit although the magnitude of the discrepancy within the model is higher than accounted for by the reweighting of the length data.

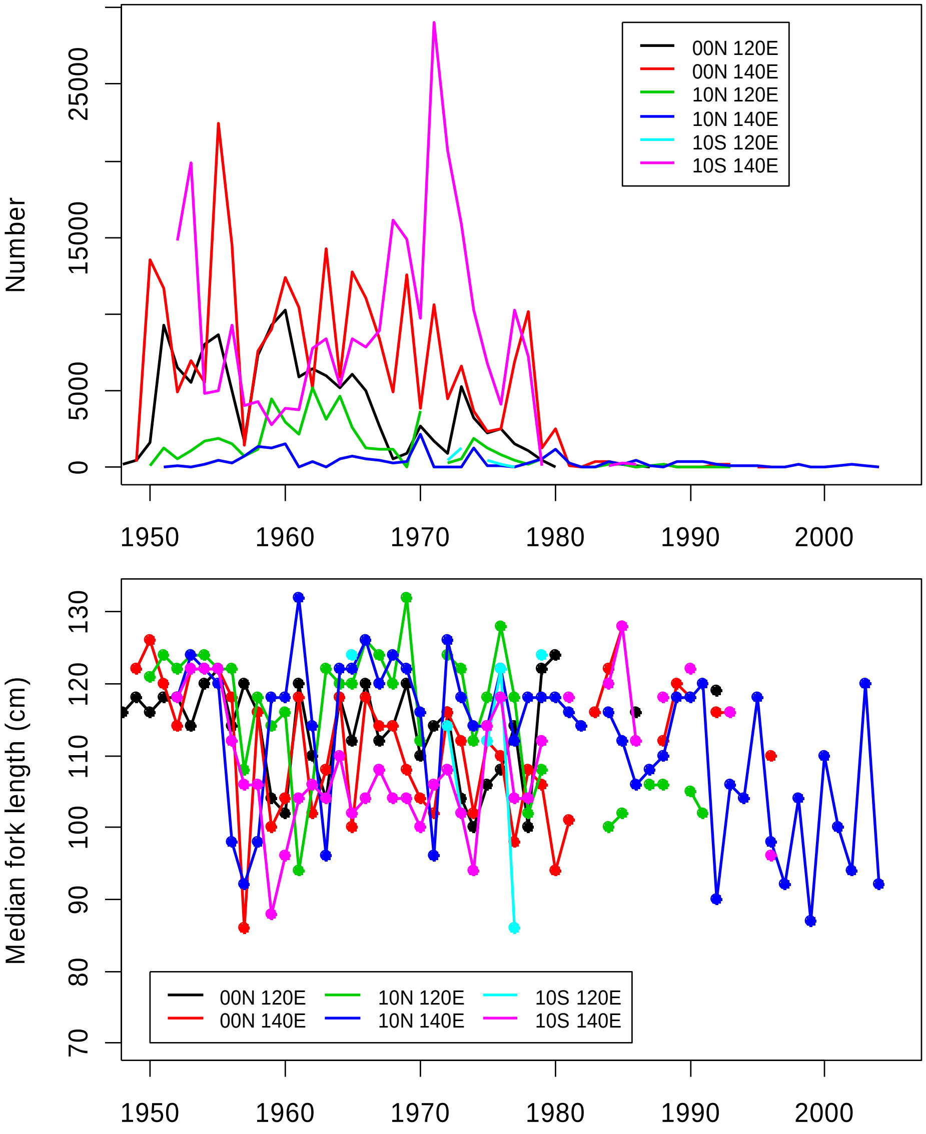

Figure 13. Annual number of yellowfin lengths sampled (top) and median yellowfin length (fork length, cm) (bottom) from the Japanese longline catch for each of the 10 degree latitude/20 degree longitude blocks that comprise region 3. The blocks are defined by the location of the southwestern corner (source: Langley 2005b).

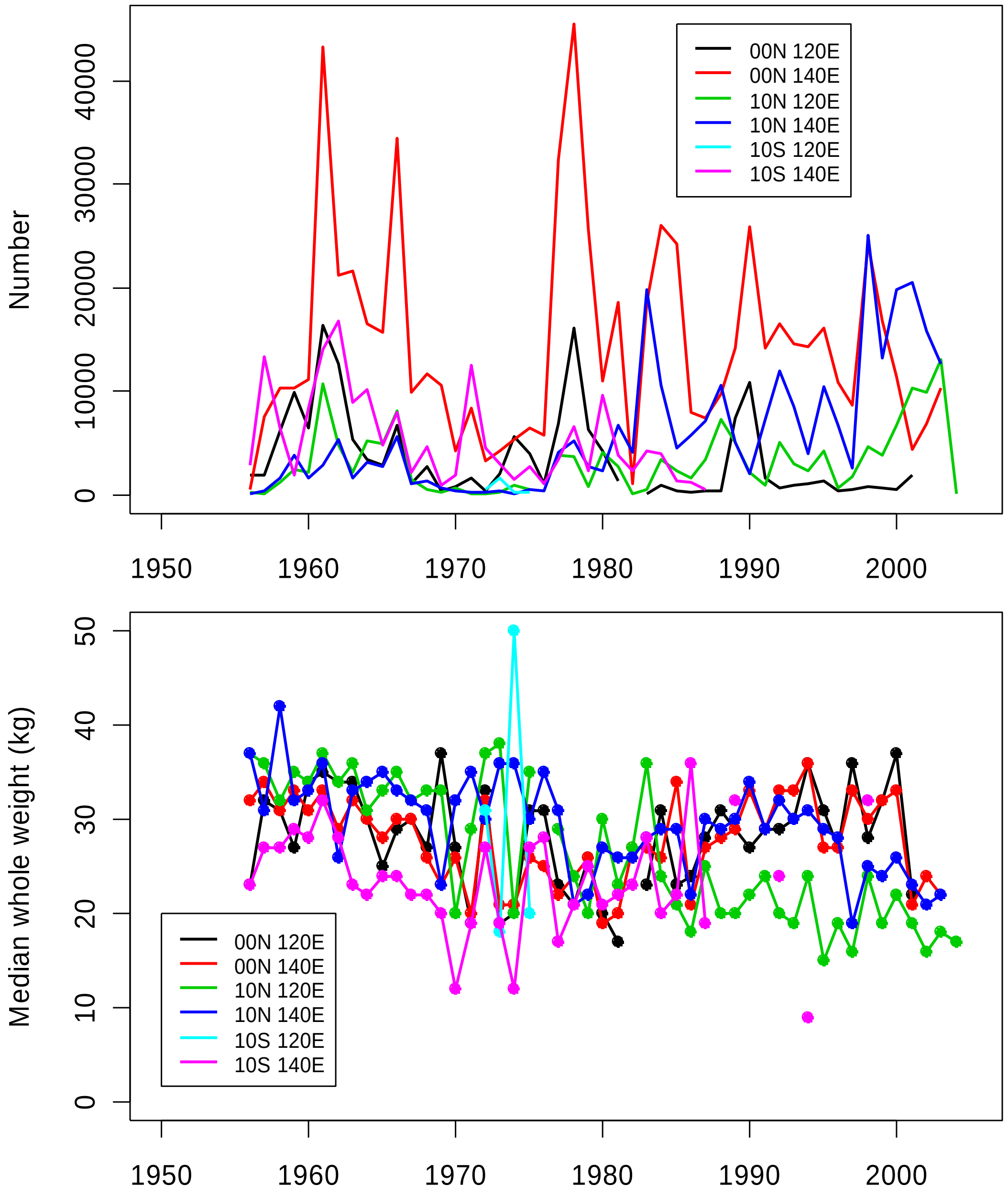

Figure 14. Annual number of yellowfin weights sampled (top) and median yellowfin weight (processed weight, kg) (bottom) from the Japanese longline catch for each of the 10 degree latitude/20 degree longitude blocks that comprise region 3. The blocks are defined by the location of the southwestern corner (source: Langley 2005b).

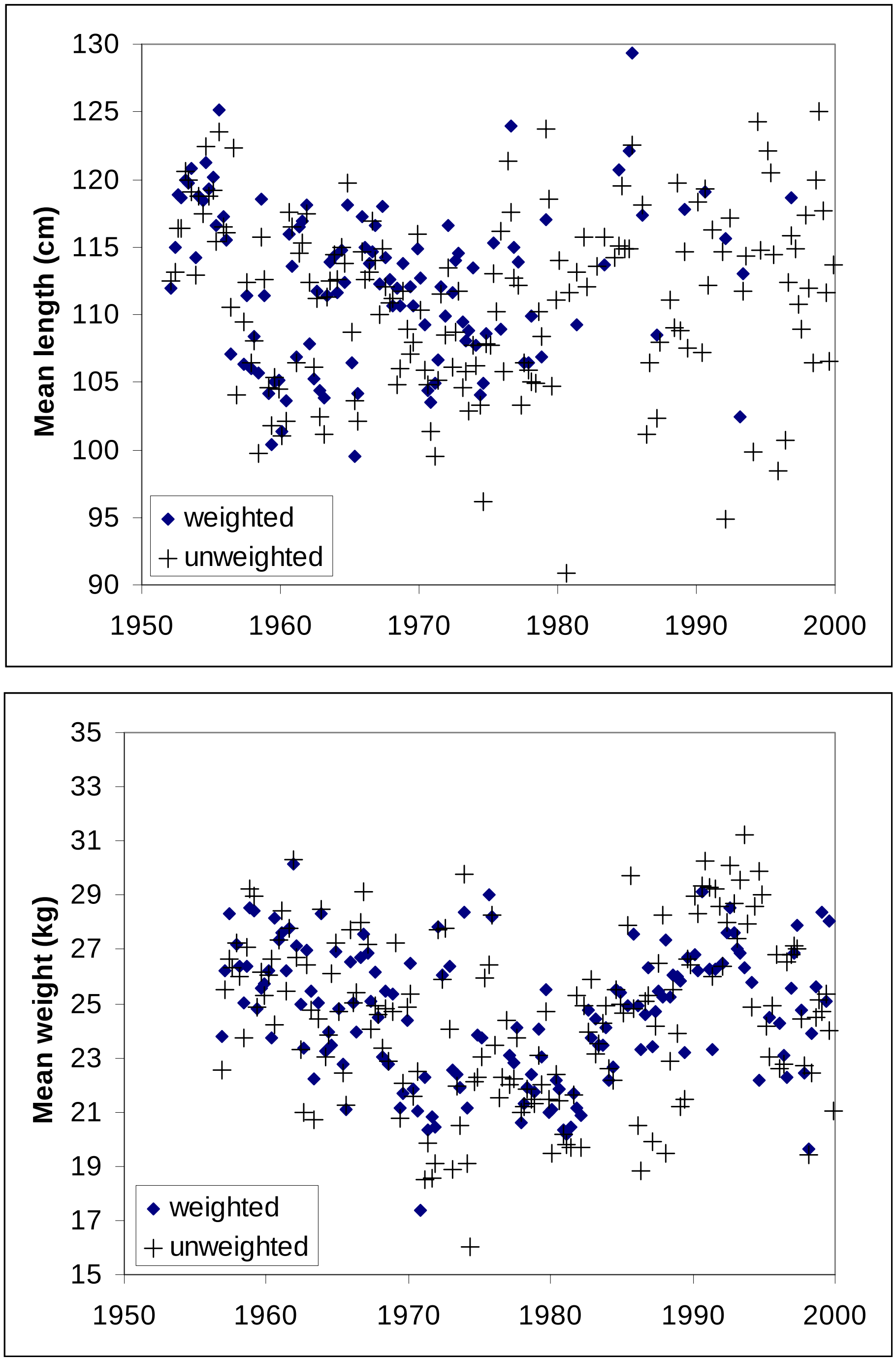

Figure 15. A comparison of the mean size of weighted and unweighted quarterly yellowfin length (top) and weight (bottom) samples from the main longline fishery in Region 3. The weighting was undertaken as described in the text.

4.4. Recommendations

The workshop agreed to the following points of relevance to the inclusion of the size data in the model:

- **The assessments will be undertaken using the yellowfin and bigeye length-weight relationships provided by NRIFSF.**
- **Japanese weight data is included in the OFP database is recorded to the nearest lowest kilogramme from the actual weight. A bias correction is required to account for the weight truncation. Other weight data is most likely to be rounded to the nearest kilogramme (processed weight).**
- **The conversion factors used for the processed weights are potentially highly influential in the assessment, particularly for bigeye. There is information to indicate that the G-G conversion factors for the JP longline fleets differ from other fleets. This is related to whether or not the tail and operculum are removed during processing. On this basis, it is necessary to derive fishery specific conversion factors.**
- **There is a need to document all available data concerning the GG conversion factors for yellowfin and bigeye. This should comprise a separate report to SC2 and identify future data collection needs for the fisheries. The report should recommend the best available conversion factors for distant-water and locally based longline fleets. Other issues include whether or not the JP GG conversion factors are appropriate for pre/post the introduction of ULT freezer vessels (1970s) and ascertaining the appropriate conversion factor for Japanese longline catches unloaded in Guam (it is probably more appropriate to use CF as per locally-based fleet).**
- **There is a need to undertake a sensitivity analysis comparing model runs using different conversion factors applied to the Japanese weight frequency data, particularly the historical data.**
- **For the Japanese longline length and weight data, a scheme for combining the size data will be applied to the calculation of the aggregated size frequencies per region/quarter. This approach will be similar to the approach applied to data from the fishery in Region 3. A summary of the results of the weighting procedure will include the amount of size data excluded by the procedure.**
- **While not really discussed at the workshop, it is clearly important to consider the impact of the relative weighting applied to the size frequency data, particularly for the Japanese longline fisheries. This will be further investigated during the assessment process.**

5. Movement parameterisation

The principal concern identified by SC 1 regarding the movement parameterisation was the very high coefficients estimated for the southward movement of yellowfin between Regions 1 and 3. {There were also issues relating to the movement parameterisation of skipjack, but that is beyond the scope of this workshop}.

To investigate this issue further, two alternative movement scenarios/parameterisations were compared to the base-case assessment:

i. No movement between Regions 1 and 3; movement between all other regions estimated (constant with respect to age).
ii. A fixed quarterly movement scheme (Figure 16). [This was estimated using MFCL by rerunning the 2005 assessment model with very low sample sizes for the size frequency

data and low penalties on the effort deviations, thereby, allowing the tagging data to dominate the model and use tag movements to estimate the movement coefficients].

The fixed movement scheme, parameterised as proportional movements (i.e. the percentage of fish in one region moving to another region), included significant movements of fish longitudinally along the equator with the direction of the predominant movement varying seasonally (Figure 16). There was also a relatively high movement northwards from Region 5 to Region 3 during the third quarter (winter) (Figure 16). The proportional movements need to be considered relative to the actual abundance of fish in each region.

The 2005 yellowfin assessments were rerun with the two alternative movement schedules and the key reference points were compared to the base-case (Appendix 4). Both movement options gave slightly higher MSYs than the base-case, similar biomass based reference points ($B_{current} / \tilde{B}_{MSY}$), and more optimistic exploitation rate based reference points ($F_{current} / \tilde{F}_{MSY}$). The overall fit to the data was significantly worse than the base-case assessment (Appendix 4).

5.1. Recommendations

Given that the yellowfin stock assessment conclusions seemed to be insensitive to the range of alternative parameterisations of movement, the workshop decided that the movement coefficients would continue to be estimated in the fitting procedure (as per the 2005 assessments). A further sensitivity may be undertaken whereby the fixed movement schedule is applied to the 2006 yellowfin (6-region) assessment.

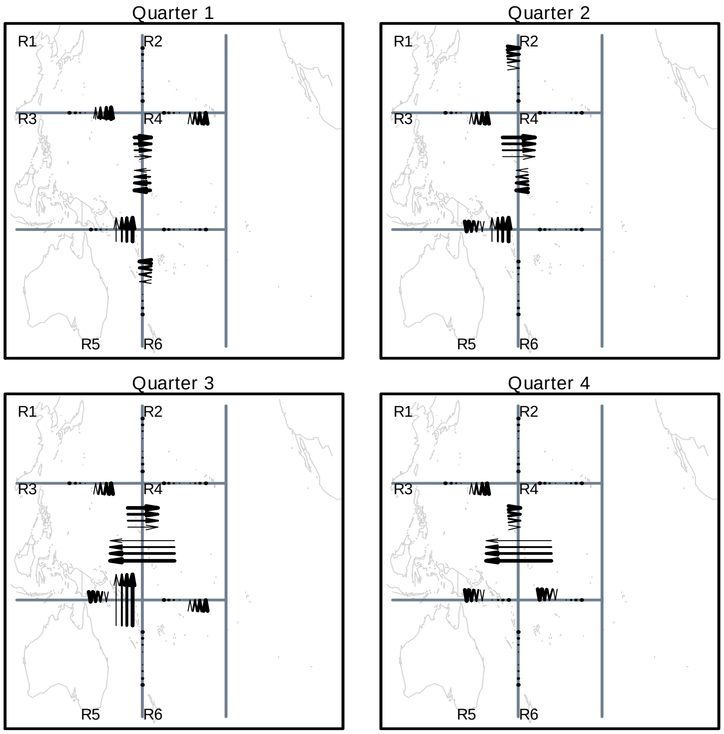

Figure 16. Fixed quarterly movement coefficients at age (1, 7, 15, 25 quarters) for yellowfin. The movement coefficient is proportional to the length of the arrow and increased weight of the arrow represents increasing age. The maximum movement (quarter 3, region 4 to region 3) represents movement of 15.5% of the fish at the start of the quarter.

6. Forward projections

John Hampton presented a summary of the various forward projections that were formulated following discussions between himself and Shelton Harley (see Appendix 5). The workshop agreed that these projections would be conducted using the 7-region models if data issues were suitably addressed. One issue that was identified was the consideration as to how the ID/PH fisheries were included in the forward projections, given the absence of reliable effort data for these fisheries, in particular for the purse-seine method.

7. Retrospective analysis

The 2005 yellowfin base-case assessment was examined to investigate the sensitivity of the analysis to the inclusion of recent data and the precision of the model results in the last few years of the model period. This was undertaken using a retrospective analysis, whereby, data from the last one, two, and three years were excluded from the model. The performance of the model was then examined by comparing the biomass trajectories and recruitment (by region) from each of the model runs with the base-case assessment. Similarly, the trends in estimated average fishing mortality rates for juvenile (age classes 1–8) and adult (age classes 9+) for the entire WCPO were compared.

The trends in biomass (by region) from the three model runs are generally very consistent with the base-case assessment (Figure 17). The only substantive deviation in the biomass trajectory occurs in the last 1–2 years of each of the model runs. Estimates of total biomass in the most recent period of each model run are consistently positively biased compared to base-case assessment. This is attributable to a positive bias evident in the estimates of recruitment in the most recent period (1–2 years) of the assessment (Figure 18).

The bias in the recent recruitment estimates results in corresponding bias in the estimated fishing mortality, particularly for juvenile fish; this bias is usually negative (i.e. under-estimating the mortality rate for juvenile yellowfin) and is highest in the most recent 4 quarters included in the model (Figure 20).

For example, for juvenile yellowfin the estimates of juvenile fishing mortality for the last 4 quarters from the model excluding the 2004 data (i.e. the four quarters of 2003) were 10–20% lower than derived from the base-case model that included the 2004 data (Figure 20). The estimates for juvenile fishing mortality were less biased for the preceding year (quarters 4–8; the 2002 year in this example) and converged with the base-case estimates in quarters 9–12.

A similar pattern in the bias was evident for the model excluding the last three years of data 2002–2004. However, for the model excluding data from 2003–2004 there was a slight positive bias in the estimates of fishing mortality for the last 8 quarters included in the model (Figure 20).

In contrast, the biases in the estimates of fishing mortality for the adult age classes were small and limited to the last few quarters included in the model (Figure 20). The exception was the model that excluded the longest period of data (2002–2004) and in this case all estimates of adult fishing mortality were lower than the base-case. This model estimated higher slightly higher biomass (and higher recruitment) over the entire model period (Figure 17) and it appears the last three years of data were influential in the estimation of the overall average recruitment level.

These results are important of the consideration of which period in the model to use to define "current" fishing mortality. In recent years, "current" was defined as the most recent three year period prior to the last year included in the model. These results confirm that the last year should be excluded for the juvenile component of the population, but it may be sufficiently well determined for the adult component of the stock.

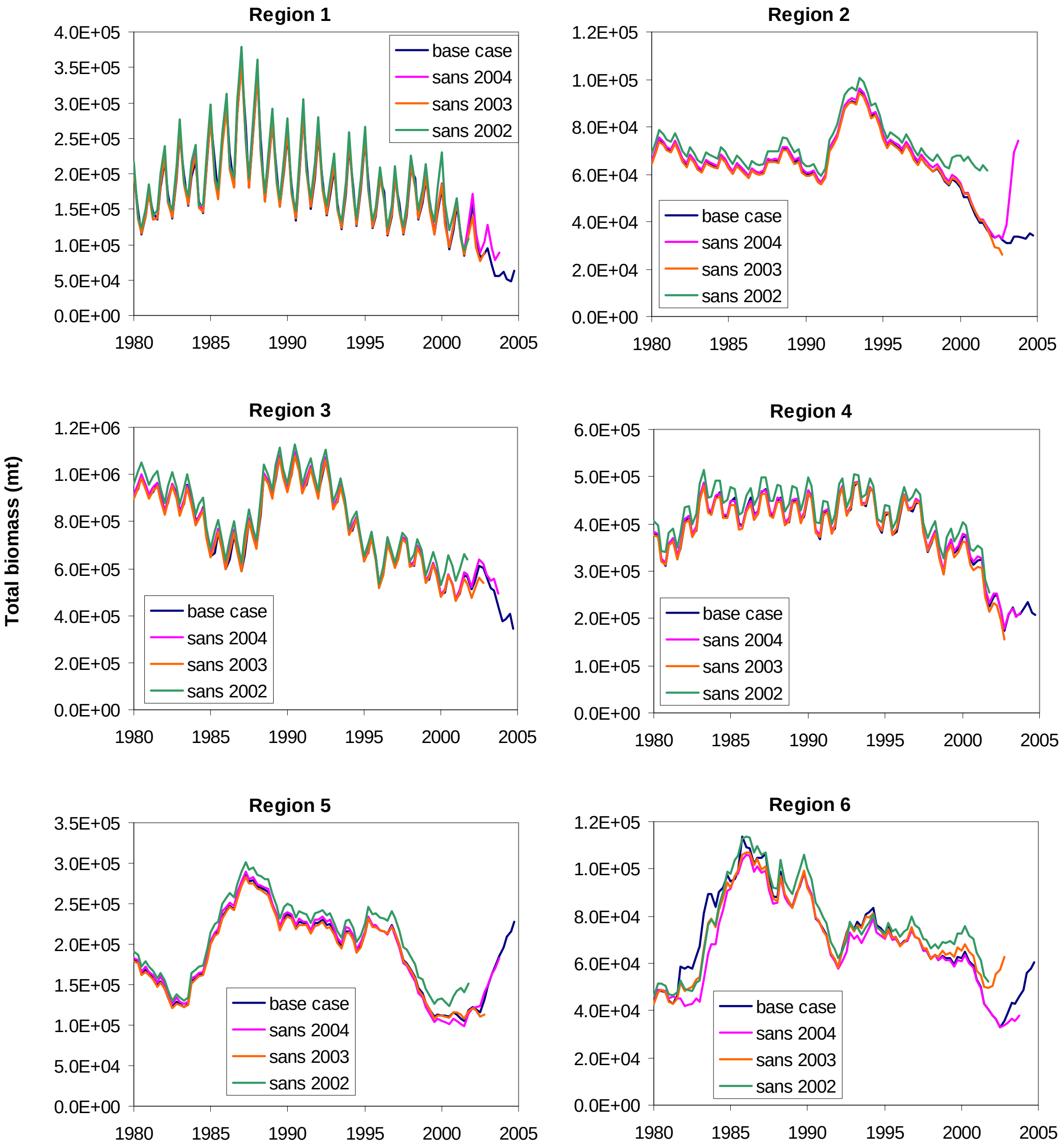

Figure 17. Total biomass of yellowfin by region of the WCPO by quarter from the 2004 base case assessment compared to analyses excluding the last 1, 2, and 3 years data.

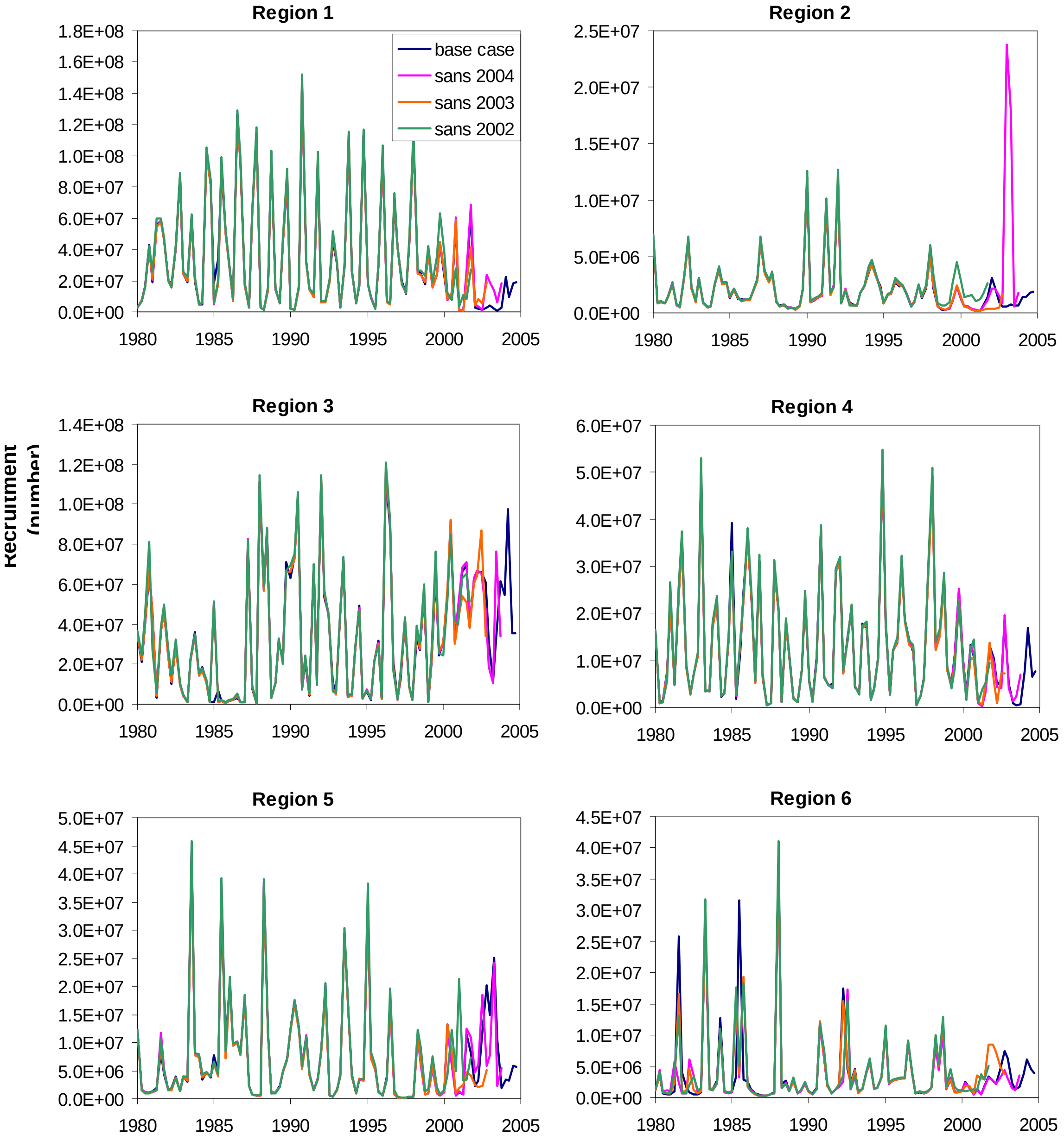

Figure 18. Recruitment of yellowfin by region of the WCPO by quarter from the 2004 base case assessment compared to analyses excluding the last 1, 2, and 3 years data.

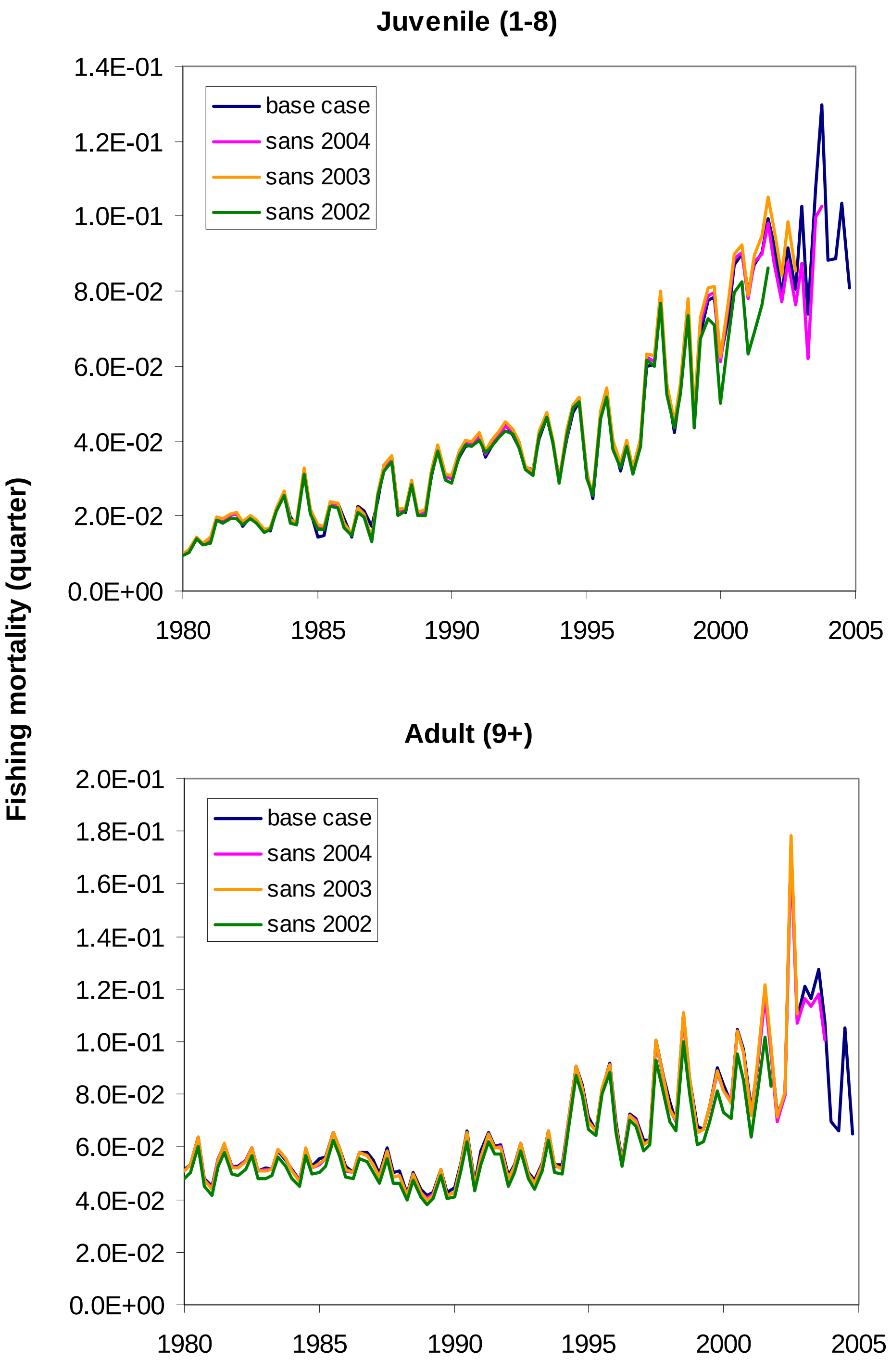

Figure 19. Average fishing mortality for juvenile (age classes 1–8) and adult (age classes 9+) for yellowfin in the WCPO by quarter from the 2004 base case assessment compared to analyses excluding the last 1, 2, and 3 years data.

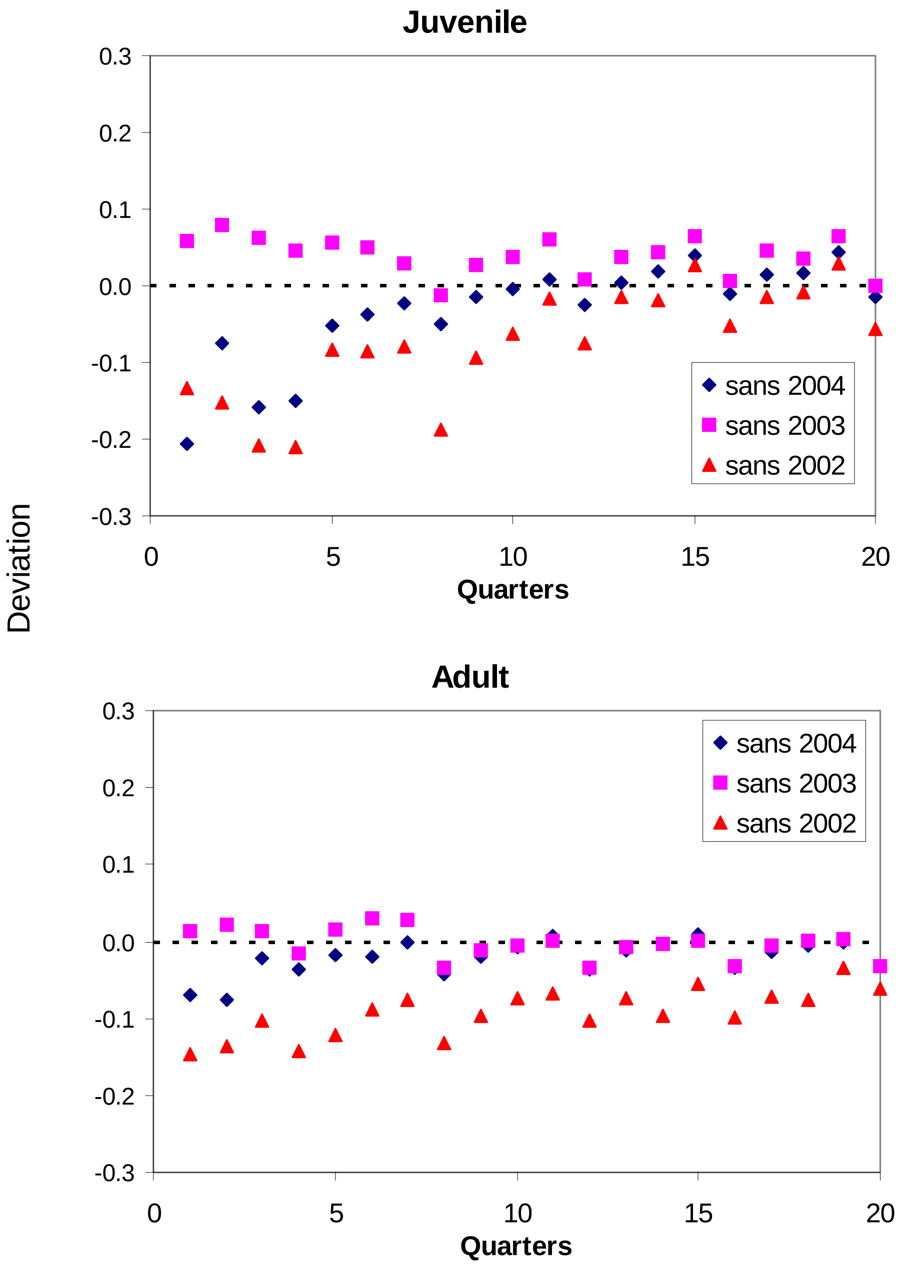

Figure 20. Deviation from the estimated fishing mortality for juvenile (top) and adult (bottom) yellowfin at each time interval for the last 20 quarters included in the analyses excluding the last 1, 2, and 3 years of data. Quarter 1 represents the last (most recent) quarter included in each of the models, for example the last quarter of 2003 in the model run without data from 2004.

8. Other issues

The workshop identified a number of additional sensitivity analyses that were undertaken last year and should be repeated for the current assessment, specifically:

- **The effect of an assumed increase in fishing power for the key longline fleets (1% per year).**
- **A comparison of the model runs with fixed age-specific natural mortality and estimated (constant or variable wrt age) natural mortality.**

9. References

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Hampton, J., P. Kleiber, A. Langley, Y. Takeuchi, M. Ichinokawa, and M. Maunder. 2005b. Stock assessment of bigeye tuna in the western and central Pacific Ocean, with comparisons to a Pacific-wide assessment. WCPFC SC1 SA WP-2.

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Langley, A., Bigelow, K., Maunder, M., Miyabe, N. 2005. Longline CPUE indices for yellowfin and bigeye in the Pacific Ocean using GLM and statistical habitat standardisation methods. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. SC1 SA WP-8.

Appendix 1. Relevant sections of the SC 1 Final Report

SWG WORK PROGRAMMES FOR 2005-2006

STOCK ASSESSMENT SPECIALIST WORKING GROUP (SA-SWG)

7.21 Research with respect to stock assessment is described in the SA-SWG report (Annex IX). This research is focused on the provision of stock status summaries for the Commission.

7.22 The Scientific Committee considered the priorities of the SA-SWG should include:

a) Review and document the technological and operational changes of the longline fisheries, especially those for the Japanese fleet, with the intention of better standardising effort in these fisheries;
b) Review processed weight to live weight conversion factors and length-weight conversion factors in those longline fisheries for which weight data were obtained and used in MFCL analysis;
c) Investigate alternative regional structure for the yellowfin tuna assessment (in light of the high proportion of the catch taken in the western equatorial Pacific); and
d) Large scale tagging experiments for the main target tuna species in the WCPO.

7.23 The Scientific Committee noted that the last item has significant financial implications and would need to be completed in a cooperative manner with other organisations to succeed.

RESEARCH PRIORITIES, RESEARCH PLANNING AND COORDINATION

MODELLING PRIORITIES FOR 2006

7.43 Further development of methods (including improved data inputs) to improve the standardisation of effort and the construction of indices of stock abundance:

a) Analysis of operational level data. (SPC OFP services, Japan);
b) Inclusion of physical factors other than SST and oxygen as proxies for habitat e.g. thermocline structure, deep-scattering layer (Australia); and
c) Expansion of studies of to ascertain hook-depths in longline fleets, especially for the Japanese fleet (possible WCPFC role in acquiring TDRs for deployment in regional/national observer programmes, Australia).

7.44 Further development of stock assessment models (including improved data inputs), and clarification of the structural and statistical uncertainties in these models:

a) Investigate alternative regional structures for the yellowfin tuna assessment. (SPC OFP services); and
b) Investigate alternative movement parameterisation in the MFCL models (SPC OFP services, USA).

7.45 Further evaluation of management options within the WCP-CA:

a) Incorporation of uncertainty in evaluation of management options (Possible SPC OFP services, subject to WCPFC request; USA); and
b) Development of alternative models (ME-SWG).

Appendix 2. Invitation

Dear All

Invitation to YFT and BET Stock Assessment Workshop

As part of the planning for the WCPO assessments this year, we are proposing to hold an informal workshop in Noumea to address some of the key issues in the yellowfin and bigeye stock assessments identified during SC 1 and from other discussions. The items of particular relevance are outlined below. It is envisaged that a focused hands-on workshop could progress these issues further, prior to undertaking the 2006 assessments.

It is proposed to host the workshop at SPC during the week **17-21 April**.

PROPOSED AGENDA ITEMS

1. Regional structure.
a. Is the current regional structure appropriate?
This was examined in 2005 but more detailed analyses have been undertaken since SC1 that indicate spatial heterogeneity in the trends in LL CPUE and size structure within key regions (equatorial waters).

b. Should there be a separate region that encompasses the area of the Indonesia/Philippines fisheries?
This area of the western equatorial region is likely to have higher exploitation rates than the wider equatorial region, particularly for smaller fish. There are also management reasons for attempting to spatially segregate these fisheries in the models. Do we have sufficient data to support the separation of this area into a separate MFCL region?

c. Regional scaling factors.
Last year we established a rationale for deriving regional scaling factors that are applied to determine the relative level of biomass in each region. This had a strong influence on the YFT assessment, in particular. Alternative approaches could be investigated for determining these scaling factors.

2. GLM LL CPUE indices.
At SC1, there was a general consensus to progress with running the YFT and BET models using the GLM CPUE indices. At this stage, the statHBS approach is still considered to be in development and not sufficiently well advanced to provide reliable indices of relative abundance. On that basis, we are not intending to undertake separate assessment runs using statHBS and GLM indices, instead we will focus on the GLM approach. Several improvements in the GLMs based on JP LL data are intended for 2006, specifically the inclusion of catch data for other associated species (esp. ALB) to attempt to address changes in targeting activity.

Another issue of relevance to the CPUE work is the SC recommendation to "undertake analyses of operational-level catch and effort data to improve the standardisation of effort and the construction of indices of stock abundance". This recommendation may require some discussion particularly if we are intending to focus this objective on an analysis of the JP LL data. The ability to undertake this work will be dependent on the availability of high resolution temporal and spatial CPUE data.

3. Size frequency data
a. Previous assessments have simply used the available weight and length data aggregated by time/area(region) strata. An examination of the JP LL size data at the lowest available spatial resolution (usually 10 lat/20 long squares, but sometimes finer) shows spatial variation within

some of the main regions - again reason to reconsider the current regional boundaries. The spatial distribution of the weight and length sampling data within a region may be quite different and simple aggregation of these data may, therefore, not be representative of the total catch from the region. On that basis, it seems appropriate to come up with a schedule to combine length and weight samples in proportion to the distribution of the catch within a region to derive a length/weight sample that is more representative of the catch from the time/region.

b. Temporal changes in selectivity. Following the observation in the previous paragraph, long-term changes in distribution of fishing effort by the LL JP fleet can result in significant differences in the size composition of fish caught within a region. This is in effect a change in selectivity by the fishery, although given the current assumption of fixed selectivity, the models are likely to compensate for this be changes in recruitment. While it isn't intended to change the way selectivity is currently included in the model, there may be time to undertake some preliminary analysis to investigate how temporal changes in selectivity could be parameterised.

c. Conversion factors. Recent efforts to explain the lack of fit with the length data for BET and YFT have indicated that previous assumptions regarding a constant conversion factor wrt size is inappropriate and resulting in conflict between the length and weight data in the models. Nevertheless, there are some issues in converting processed weight data (by 1 kg weight class) to whole weights and this is worthy of some further discussion/consideration.

4. Movement parameterisation.
SC1 also recommended that some further "investigation of alternative movement parameterisations" be undertaken for YFT and BET. This is to address some of the apparent anomalous movements patterns estimated for the models e.g. the large southern movement of juvenile YFT from the northern regions. One approach would be to come up with a movement schedule that fitted other observations from fisheries and research data and then fixing the movement in the model. This is likely to be quite subjective so it would be worth calling on the collective wisdom of a broader group to develop such a movement scheme.

5. Stock projections.
There may be sufficient time to discuss some of the technical issues associated with undertaking stock projections under a range of different management options.

Your participation in this workshop would be greatly appreciated and, I'm sure, would contribute substantially to the continuing improvement of these assessments. It is also hoped that this meeting would be able to streamline some of the SC 2 proceedings, although obviously this meeting has no formal status in that process. Please can you notify me (Adam) regarding your availability and willingness to attend the workshop.

Thank you and best regards.

Adam Langley, John Hampton

Invited participants: Shelton Harley, SungKwon Soh, Andrew Wright, Mark Maunder, Simon Hoyle, Alain Fonteneau, Naozumi Miyabe, Yukio Takeuchi, Pierre Kleiber, Keith Bigelow, John Sibert, Max Stocker, Dan Sua

Appendix 3. Workshop attendees

Yukio Takeuchi, NRIFSF

Hiroaki Okamoto, NRIFSF

SungKwon Soh, Western Central Pacific Fishery Commission

John Hampton, OFP, Secretariat of the Pacific Community.

Adam Langley, OFP, Secretariat of the Pacific Community.

Brett Molony, OFP, Secretariat of the Pacific Community.

Don Bromhead, OFP, Secretariat of the Pacific Community.

Appendix 4a. Summary of results from a range of MFCL model runs based on the 2005 base-case assessments for yellowfin.

	Scenario	**Description**	**MSY (quarter)**	$F_{current} / \tilde{F}_{MSY}$	$B_{current} / \tilde{B}_{MSY}$	**Likelihood**	**Comments (comparison with base-case)**
2005 base case	1	GLM, MFIX	65,600	1.22	1.32	-842,282.83	
Size data	2	Very low weight (sample size n/300), fixed growth parameters	92,980	0.83	1.26	NA	Deviation in growth (higher) for age classes 3-6. Higher (120%) total biomass, comparable biomass trajectory, recruitment slightly higher (110%) and less variable.
	3	Correct weight bias. New CF New len-wt relationship	70,840	1.25	1.21	-918,621.68	New values for CF and ln-wt very similar to those provided by NRIFSF. Higher (120%) total biomass and similar biomass trajectory. Overall recruitment 50% higher (R1-R3).
	4	New len-wt relationship	64,090	1.25	1.34	-843,162	
Region structure	5	7-region model (ID/PH), equatorial region northern boundary 20 N.	73,530	1.00	1.42	NA	Highest impacts in ID/PH region. Slightly higher decline in total biomass, much higher (double) recruitment (west equatorial).
	6	Equatorial 10 N	76,190	1.00	1.27	-875,988.27*	Low steepness (0.57). Higher overall total biomass (from R1,2,4), comparable biomass in

							R3. Lower overall recruitment, differences in movement coefficients.
Movement	7	No movement R1-R3	79,140	1.11	1.20	-840,796.28*	Increased movement from R1 to R2 to compensate. Higher overall total biomass (120-130%), much lower recruitment (60%) and difference in recruitment trend over time, esp. R3.
	8	Fixed movement schedule	74,300	1.00	1.39	-838,757.59*	Very similar level of total biomass and trajectory, very similar overall recruitment.
Tag data	9	Exclude tagging data	69,410	1.25	1.22	NA	Slightly higher (110%) total biomass, very similar biomass trajectory, much lower recruitment (100%) mainly from R1.
	10	Equatorial 10 N, incl. recent HW tag data	72,040	1.11	1.23	-875,677.86*	Higher total biomass overall (mainly R1 & R2), lower recruitment overall (80%). Not substantially different cf HW tags excluded. Low steepness (0.48).
New base-case?	11	7-region model (ID/PH), equatorial region northern boundary 10 N, ID/PH boundary 20N; correct weight bias; new CF; new len-wt; recent HW tag data	75,600	1.00	1.38	NA	Substantially higher recruitment and total biomass. Higher biomass principally in equatorial region. Comparable biomass trajectory.

*not directly comparable with base case

Appendix 4b. Summary of results from a range of MFCL model runs based on the 2005 base-case assessment for bigeye.

	Scenario	**Description**	**MSY (quarter)**	$F_{current}/\tilde{F}_{MSY}$	$B_{current}/\tilde{B}_{MSY}$	**Likelihood**	**Comments (comparison with base-case %)**
2005 base case	1	GLM, MFIX	16,510	1.23	1.25	-792,013.01	
Size data	2	Very low weight (sample size n/300), fixed growth parameters	18,170	1.11	1.30	NA	Total biomass higher (120%) than base-case, comparable biomass trajectory, recruitment higher (120%) and less variable.
	4	Correct weight bias. New fishery specific CF (JP and other).	15,550	1.67	1.09	-909,469.42	Higher L infinity in growth function.
	5	Correct weight bias. New fishery specific CF (JP and other). Down weight JP weight freq data (sample size n/300).	17,280	1.11	1.28	NA	Lower L infinity in growth function.
Region structure	6	7-region model (ID/PH), equatorial region northern boundary 20 N.	14,610	1.42	1.26	NA	
New base-case?	8	7-region model (ID/PH), equatorial region northern boundary 10 N, ID/PH boundary 20N; correct weight bias; new CF; new len-wt; recent HW tag data.	17,700	1.25	1.33	NA	

*not directly comparable with base case

Appendix 5. Proposed model projections.

Task	**Basis**	**Comments**
Bigeye and yellowfin tuna assessments	From WCPFC-2 (Att I – paras 2 and 4) " "***The Scientific Committee, at its second meeting, shall identify levels of fishing effort to ensure that the bigeye and yellowfin stocks will remain at an agreed level above BMSY***"	Yield analysis will be based on average F for the period 2001-2004 (as period frequently discussed in WCPFC-2 report), and both deterministic (long term average) recruitment and recent (last 10 years) averages. Use the yield curve for [Total biomass /Spawning biomass] will give you the F-scalar for various levels at or above Bmsy Examine the impact of including or excluding effort deviates from the yield analysis during the April workshop to guide the final work
South Pacific albacore	From WCPFC-2 (para 33) "*In relation to the Measures on North Pacific albacore and South Pacific albacore, it was agreed that the Commission would review these decisions at the Third Regular Session in 2006.* ***The Commission instructed the Scientific Committee to give priority to developing a stock assessment for South Pacific albacore for consideration in this review****. Pending the results of this review, and any additional advice provided by the Scientific Committee, Members, Cooperating Non-members and participating territories (CCMs) were urged to exercise restraint with respect to increased fishing for this stock in the Convention Area*."	The main focus of the SC work will be examining some of the more complex issues regarding the conclusions about the status of the SP albacore stock. This will be based around a review paper developed by Adam's Langley and include "fishery impact plots" total, spawning, and LL and troll vulnerable biomass, and yield per recruit type analyses (e.g. plots of critical size versus selectivity curves for the main fisheries). If new data become available, last years assessment MIGHT be updated.
Projections relating to resolutions		Only five year projections are necessary and a more detailed examination of uncertainty in the projections will be the focus of work in 2006/07. Projections will be based on recent averages (e.g. 2001-2004 average) for effort distributions, e.g. seasonal, spatial, and set-type (for purse-seine), plus 2004 levels if time allows.

		Undertake projections of the measures as adopted at WCPFC-2 (both LL and PS combined) under two scenarios o LL catches of BET do not increase to take advantage of 2000t limit o LL catches of BET do increase to take advantage of 2000t limit, with a similar proportional increase for YFT
Purse-seine closures	From WCPFC-2 (Att D – para 11) "***In order to achieve the overall reduction in catch and effort required for bigeye and yellowfin tuna, in accordance with advice and recommendations received from the Scientific Committee, the Executive Director shall work with CCMs during 2006 to develop a proposal for consideration at the Third Session of the Commission that is consistent with the IATTC arrangements that allow for a system of temporary purse seine closures***."	The IATTC has two separate closures to accommodate the strong differences in the DOL fishery versus the FAD/UNA fishery. This difference does not occur in WCPO so we only need examine a single closure. Separately reduce PS effort in each quarter by 50% (to simulate a 6-week closure) for each of two effort distributions (see above – recent average versus 2004). If these closures are insufficient to "***achieve the overall reduction in catch and effort required for bigeye and yellowfin tuna***" then longer closures should be simulated. If it is found that the timing of the closure effects the results, then the analysis can be reduced. No modelling will be done for skipjack, but a section of the report will discuss issues such as: o Due to the flatness of a yield curve, a 6 week closure should result in a x% reduction in SKJ catches o Describe catch composition of purse fisheries in subtropical regions (outside of 20 N and 20 S in relation to the utility of closures in these regions

Appendix 6. Length-weight relationships and conversion factors for yellowfin and bigeye from NRIFSF

From: Naozumi Miyabe （宮部 尚純） [miyabe@fra.affrc.go.jp]
Sent: 27 February 2006 15:45
To: Adam Langley
Subject: RE: Stock assessment planning workshop pre SC2, April 2006

Dear Adam,

Sorry, it took some time to find a equation. Please look at the following relationships for the conversions.

BET : WW = 0.19729 * 10^-4 * L^3.0247
WW = 1.133 * GG + 2.980

YFT : WW = 0.2512 * 10^-4 * L^2.9396
WW = 1.100 * GG + 3.698

where WW is whole weight in kg, L is length in cm, and GG is gilled and Gutted in kg. For W-L relation, data were obtained from the Pacific Ocean, but for WW-GG some data from the Atlantic were also used. I hope we can provide updated relationships with additional data in the WCPO.

Best regards.

N. Miyabe (NRIFSF)