SCIENTIFIC COMMITTEE
FOURTEENTH REGULAR SESSION

Busan, Republic of Korea
8-16 August 2018

Report from the SPC pre-assessment workshop, Noumea, April 2018

WCPFC-SC14-2018/ SA IP-01

Graham Pilling and Steve Brouwer[1]

[1] OFP - Pacific Community (SPC), Noumea, New Caledonia

Report from the SPC pre-assessment workshop, Noumea, April 2018

Oceanic Fisheries Programme, Pacific Community (OFP, SPC)

Introduction

To help undertake stock assessments for the WCPFC, the Oceanic Fisheries Programme (OFP) of the SPC has sought input from stock assessment scientists in the region through the SPC pre-assessment workshop process. The tenth pre-assessment workshop was held in Nouméa, New Caledonia, from the 17-20 April 2018.

Twenty scientists from sixteen organizations participated in the workshop, along with SPC staff. A list of participants is provided in Appendix 1.

John Hampton (OFP, SPC) opened the meeting and welcomed the participants. The agenda focused on approaches for the stock assessments of south Pacific albacore and the re-evaluation of WCPO bigeye growth and re-assessment of the stock, developments to the MULTIFAN-CL modelling framework, technical developments in WCPO Management Strategy Evaluation and related activities to progress the WCPFC harvest strategy work plan. Presentations were invited from all participants, with the majority made by SPC staff. The meeting operated under the terms of reference provided in Appendix 2, and was chaired by Steve Brouwer of the OFP Stock Assessment and Modelling section.

This report briefly describes the various presentations made and focuses on important issues discussed by participants, and specific suggestions made. The report does not attribute comments to countries except where the comment related to the agreement to provide data or to undertake particular analyses.

The outcomes of this meeting will be reflected in the papers submitted to WCPFC-SC. Copies of presentations prepared by SPC can be provided on request.

Operational CPUE data analyses

Laura Tremblay-Boyer (OFP, SPC) summarised the latest developments in using geo-statistical approaches for CPUE standardisation, following presentations to SC13 and to a CAPAM[1]-led international workshop on spatio-temporal CPUE modelling in fisheries (La Jolla, Feb 2018). Activities focussed on the inclusion of oceanographic information and improvements in the mesh structure underpinning the geo-statistical modelling. The main challenge highlighted within analyses so far is the confounding of oceanography variables thought to impact catchability (availability of fish) with other variables thought to impact abundance. Proposed subject areas for the development of a scientific paper using these data were also briefly discussed.

Given the extensive nature of the operational data set (11 million records), the workshop discussed strategies to identify appropriate levels of data sub-sampling. Simulation approaches to test sub-sampling are a potential future exercise, but are not planned for the 2018 albacore assessment. A more pragmatic approach will be used in 2018 where the level of sub-sampling will be increased until no substantial changes in resulting indices are found. A key constraint on the time required for analysis was the number of knots used. This has been resolved with a new diagnostic to test the suitability of the mesh structure, developed following the CAPAM workshop. This allows an appropriate number of knots to be identified, and the sub-sampling level to then be maximised within computational constraints. Sub-sampling is currently by knot to retain more samples at the edges of the region, rather than being randomly distributed over the study region. It was noted that for particular regions, sub-sampling by knot could lead to a flag-effect in the sampling given fleet dynamics. The potential to include vessel or flag within the standardisation model was therefore noted for south Pacific albacore.

Operational covariates for inclusion within the standardisation model were discussed. Data for some covariates are limited in space and time (e.g. hooks between floats), which would affect the length of the time series covered by the analysis if those covariates were included in the model.

Approaches to dis-entangling the influence of oceanographic variables on catchability/availability of fish to a gear and on abundance were discussed. The influence of thermocline was noted to vary between stocks and possibly fish size, with juveniles being more influenced by vertical stratification of the thermal habitat. For albacore in the south Pacific, while the thermocline shows sharp changes, the influence of the ENSO cycle south of 10°S is less strong than seen in tropical waters. For bigeye, thermocline depth appeared to influence the distribution of fish smaller than 80cm, has a limited effect on fish between 80 and 110cm, but then appeared to again influence sizes up to around 125cm based on recently published work by Abascal et al. (2018). In turn, diurnal patterns of movement related to the time of setting would also influence availability to a gear, although existing data do not currently allow this to be investigated. Given the different influence of oceanography cycles across the Pacific, the potential to focus analyses in a specific model region (e.g. region 4) to examine the influence of oceanography on CPUE was also raised.

[1] Center for the Advancement of Population Assessment Methodology

The workshop suggested:

- **Inclusion of a categorical effect of 'flag' or vessel within the geo-statistical standardisation approach, to account for potential effects arising from sub-sampling by knot and the uneven distribution of effort by fleet over space and time in the study area.**
- **Examining specific regions (e.g. region 4 of the bigeye assessment model) to investigate the influence of ENSO/oceanographic patterns on CPUE.**
- **Considering both longline and troll CPUE data within the (new) Region 3 of the south Pacific albacore assessment, noting that this might be a focus for future research.**

South Pacific albacore assessment

Laura Tremblay-Boyer presented the proposed approach for and progress towards the (single sex) 2018 south Pacific albacore stock assessment. A key focus was to improve the fit to regional movement and recruitment patterns, and to address the mismatch between troll/longline growth information.

Biological assumptions and growth

Laura Tremblay-Boyer summarised the biological assumptions proposed for the 2018 assessment.

Natural mortality in the 2015 assessment was assumed to be 0.3, following the values used in assessments by other tRFMOs. However, the latest ISC two-sex assessment for north Pacific albacore used an age-specific natural mortality vector 'centred' on values of 0.38/0.48 (males/females). These values were based on the results of a meta-analysis, with age-specific values developed through the Lorenzen approach. The workshop discussed the meta-analysis approach, and ultimately noted that the range of M values used in previous south Pacific albacore assessments appeared to cover that used in ISC's recent assessment, and those assumed by other tRFMOs. It was noted that the current grid values (0.25, 0.3, 0.4) was potentially unbalanced, and the basis for the lower M value should be reviewed.

For the stock recruitment steepness parameter, the 'standard' range of parameter values were proposed (0.65, 0.8, 0.95), noting that SC could discuss appropriate levels of weighting of each of the input values of this and other axes of uncertainty when considering model results.

The spatial distribution of recruitment within the model was discussed. In early south Pacific albacore assessments, the restrictive assumption that recruitment occurred in the southern model region was made, where small fish were 'observed' in catches. This was relaxed in the 2015 assessment, with the starting conditions based on SEAPODYM model outputs that indicated recruitment could occur in more northerly regions, and the assessment model subsequently estimated recruitment distributions across all regions. The assumptions on spatial recruitment patterns would be examined within the 2018 assessment.

The interaction between movement and catchability for albacore was discussed. The paucity of tag data for south Pacific albacore means that MULTIFAN-CL gets most of its information on movement between regions based on patterns in size-frequencies between those regions and fisheries. Alternatives to model this will be explored with one-off sensitivity analyses.

The current information available on the growth of albacore was discussed, in particular the perceived 'mismatch' between growth evaluated from age-at-length estimates primarily from the longline fisheries, versus modal length progression seen in troll fisheries occurring in the southern areas of the assessment region. This might result from a combination of migration (across latitudes), selectivity patterns, and potential spatial variation in growth. In 2015, the length-at-age data were fitted directly within the MULTIFAN-CL model, and this approach was proposed for the current assessment, as it allows the different size selectivities between troll and longline fisheries to be accounted for. A finer temporal (monthly) resolution for the troll fishery was also proposed to improve the information available on the growth of those small fish.

The potential movement of albacore and availability to fishing gears for the region of the western south Pacific off eastern Australia and New Zealand was presented. Some differences in length-at-age were seen in the different regions, with faster growing (larger-at-age) individuals being caught in the longline fishery further north, suggesting that a single region growth curve would be influenced by longline-caught fish. This gear selectivity influenced the perception of the rate of growth (K). A length-based model formulation of selectivity might better capture this effect within the assessment. East/west patterns in growth were also noted, with similar potential patterns in K, but there were no plans to explicitly model this in the 2018 assessment. Sex-specific differences in growth could not be examined within the 2018 combined sex model.

Noting uncertainties in the growth modelling for south Pacific albacore, the proposed approach was to use MULTIFAN-CL to integrate the length-at-age and length frequency data in the estimation of growth, while taking into account fishery size-selectivity. The workshop also suggested relaxing the fit of the growth curve to the data for younger fish, as performed for yellowfin tuna. In turn, an external integrated estimation of growth from the length-at-age and length frequency data could be considered in collaboration with CSIRO, time permitting.

<u>The workshop suggested:</u>

- **That growth be estimated from the length frequency and length-at-age data within MULTIFAN-CL, with the potential to relax the fit of the growth curve to the data for younger ages.**
- **Investigating whether an external integrated growth model, integrating these data, would provide further information, or corroborate the MULTIFAN-CL estimate.**
- **That growth be considered as one of the uncertainty axes within the 2018 assessment, with the potential to examine growth models fitted only to particular data sets, as well as that to the combined length-at-age and length frequency data.**
- **Maintaining the current range of natural mortality values used within that uncertainty axis, but investigating the basis for the current lower value of M (0.25) within this axis of uncertainty, and balancing the axis if appropriate by assuming a lower value of 0.2.**
- **Consider the use of the Lorenzen M-at-age estimation approach for the 2018 assessment.**

Spatial structure and fisheries

Laura Tremblay-Boyer presented the proposed spatial structure of the south Pacific albacore assessment and corresponding fisheries. The initial proposal was to maintain the structure from the 2015 assessment for the southern WCP-CA, with 8 regions, and the corresponding 14 fisheries.

The workshop noted that considerable catch of albacore had been taken in the southern IATTC region (which may include the overlap area) in recent years. As this catch is outside the current model region, there is potential merit in returning to the south Pacific-wide model structure in the longer term. For the current assessment cycle, minimal spatial coverage of the data in the southern IATTC region was acknowledged, as well as operational advantages to a WCPFC-focussed regional structure that met the management demands of reference points and harvest strategy analyses. Inclusion of the catch in the southern IATTC region within the 'albacore trends' paper provided to the WCPFC meetings was suggested.

The spatial structure of the model was discussed in detail. The latitudinal structure was felt to adequately capture the known north/south movements and spawning distribution of the stock. Discussion therefore focussed on the longitudinal regional divisions.

An examination of the spatial patterns in tagging information indicated that the 2015 longitudinal spatial structure bisected the tag release grounds in the southern region, which might influence the estimation of movement within the model. This could be examined through the likelihood profile. It was noted that, given the limited amount of tagging data available, movement values estimated through SEAPODYM could be used if required. Issues with individual fleets being split between areas of the 2015 model, and uncertainty in the longitudinal location of troll fleet catches were also noted.

The removal of the longitudinal bounds was discussed, particularly for regions 1-6 of the 2015 model. This approach would assume that east/west movement was of limited concern, which appeared to be consistent with the tagging data, and might simplify the data structures. It was suggested that regions 7 and 8 of the 2015 model be maintained as separate in the regional structure, to ensure model regions were compatible with those of the bigeye and yellowfin stock assessments, therefore facilitating future bio-economic and MSE analyses.

Results of previous CPUE targeting cluster analyses for total longline fleets against the new proposed regional structure were examined, and showed little change across proposed combined regions. Examination of the average size data between the paired 2015 regions also indicated that average sizes caught were consistent across the larger regions. This preliminary examination suggested that combining regions across longitudes was appropriate.

Within the spatial structure, it was suggested that longline fishing fleets be grouped into 'distant water fishing nation' and 'Pacific Island' fleets. This would also have implications for how fleets were accounted for within the CPUE index.

The workshop suggested:

- **A new regional structure be investigated for the 2018 assessment that merged regions 1 and 4, 2 and 5, and 3 and 6 of the 2015 model structure. Regions 7 and 8 of the 2015 model structure were to be kept separate.**
- **That the 'generic' longline fleets within the 2015 assessment be divided into a DWFN and PICT component, on the basis of e.g. size selectivity/seasonality. The CPUE index for each region would be built from data including both fleets, standardized to account for a fleet covariate (vessel or fleet itself).**
- **That noting the increase in south Pacific albacore catches in the southern IATTC region, information on these be provided within the south Pacific albacore trends paper to SC. In the future, expansion of (new) regions 4 and 5 into the EPO could be considered.**

Size data

Laura Tremblay-Boyer summarised the size data available for the south Pacific albacore assessment. The proposed approach was to follow that recommended by the bigeye assessment review in 2012. The workshop agreed with this approach.

CPUE indices

Laura Tremblay-Boyer presented the available longline CPUE data trends by fishery. The addition of Japanese data to the south Pacific albacore operational data set allows a considerable temporal extension of the series, and may change CPUE trends over time. As in previous years, cluster analyses to identify 'targeting' groups would be performed.

The inclusion of vessel IDs within the model was discussed. Keyisuke Satoh (National Research Institute of Far Seas Fisheries, Japan) presented a summary of their activities assigning vessel IDs to the Japanese fleet using international radio call sign (from 1979 onwards) and registration number. This had been successful for the periods 1979-1993 and 2007-2017. Those for 1994-2006 and for 1971-1978 were under construction, while there was ongoing investigation for the period pre-1970. Partial data sets were likely available by May, but a full data set would likely only be available in June/July. For the 2018 albacore assessment, therefore, an alternative approach would be required.

Discussion focussed on the use of either the 'standard approach' to CPUE standardisation, as used within 2017 assessments, and the potential to use the geo-statistical modelling approach as the primary CPUE indices, with vessel effects but not oceanographic effects included.

The workshop noted that comparisons between the 'standard' indices and those developed through the geo-statistical approach (both suggested to be without the inclusion of oceanographic information) would be needed, to understand the sensitivity of the assessment results. Based upon the outcomes, SPC noted that they would define the CPUE index to be used, or potentially include CPUE as an axis within the structural uncertainty grid.

Full provision of 2016 operational data including updates from that provided by the 30th April 2017 was requested from DWFNs along with their 2017 provisions.

The workshop suggested:

- **Comparisons between the 'standard' indices (primary approach) and those developed through the geo-statistical approach (both suggested to be without the inclusion of oceanographic information) should be performed, to understand the sensitivity of the assessment to the geo-statistical approach. If necessary, CPUE might be included as an axis of uncertainty.**

Model structure and key sensitivities

Laura Tremblay-Boyer summarised the planned stepwise development of the 2018 diagnostic case model approach from the 2015 model, and a consideration of key model runs and areas of uncertainty that might be examined in the 2018 assessment. SPC's plan was to provide the results for the south Pacific albacore assessment across the uncertainty grid, as done for bigeye and yellowfin in 2017, from which SC could then select and weight axes of uncertainty, as done at SC13.

Some axes examined during the 2015 south Pacific albacore assessment may no longer be required, including data weighting (which should now be dealt with through the self-scaling multinomial approach developed within MULTIFAN-CL), and potentially the regional weighting axis, dependent upon the use of geo-statistical approaches for abundance index development, or the sensitivity of model outputs to this assumption examined through one-off sensitivities. Potential uncertainty axes for examination in the 2018 assessment included: Natural mortality; Steepness; Growth; Movement/recruitment. Additional/alternative axes would be identified through one-off sensitivity analyses. It was suggested that the group begin to consider potential weighting of the different elements of these axes of uncertainty.

WCPO Bigeye growth and assessment

John Hampton provided a background to the 2018 bigeye assessment, focussing on the uncertainty axes of growth and regional structure presented to SC13. SC13 recognized that future work was required to improve the 2017 WCPO bigeye stock assessment and to reduce uncertainty. That proposed research concentrated on those two uncertainty axes - growth and regional structure - which were the most influential on stock status. SC13 noted that the growth analysis should continue with the emphasis on providing length-at-age estimates for larger fish between 130 and 180 cm FL. WCPFC14 through the updated harvest strategy work plan, called for SC14 to provide updated advice on bigeye stock status in light of these updated analyses.

Bigeye growth

Jessica Farley (CSIRO, AU) presented a background on bigeye growth analyses as presented to SC13, and the results of growth analyses undertaken since that meeting (Project 81). Under Project 81, 245 new otoliths from the WCPO were read, which included fish larger than 130cm FL and some individuals caught further south than those in the Project 35 samples. Resulting L_∞ (estimated excluding daily ages) was 157cm. This estimate was robust to considerations of otolith readability (158cm). The 'bootstrapping' exercise performed during SC13 indicated that estimates were also robust to the different number of

samples available by age group. Subsequent analysis at the workshop based upon the SC13 data noted CIs of 10cm on L_∞.

Discussing the different sources of length-at-age data from daily ages (IATTC, historical SPC analyses, Fish Ageing Services (FAS, Australia)), the workshop considered why the different ageing providers suggested different age ranges for feasible daily ageing. FAS were confident to read daily increments up to 1 year of age, while IATTC in the EPO felt confident in ageing up to 4 years old. It was suggested that this may result from regional differences in growth rate and legibility, with FAS finding that the 'daily' increments merged and split, particularly in 'older' fish, which would affect the reliability of daily estimates (sections on both axes showing merged/split rings). The workshop recommended some comparison between otolith reading labs for daily increment counts to standardise the approaches (WCPO and EPO), noting that 'sister' otoliths were only available in some cases. This would best involve blind-reading of otoliths marked with e.g. strontium chloride, to ensure ages could be validated.

The workshop suggested using the daily increment readings to examine the 'birth date' assumed for the decimal ages used within the von Bertalanffy growth estimation (currently 1st July, consistent with the assumed spawning period).

Keyisuke Satoh presented comparisons between WCPO and EPO growth models and data. Within the EPO, a combination of the daily otolith readings and tagging data were integrated to estimate growth, in a similar way to the WCPO model described in SC13-SA-IP-06. The presentation suggested that the reliability of WCPO growth models be examined with alternative data combinations: annual otolith length-at-age data only up to age 2-3, and tagging data; using daily increments for ages 1-2, annual counts for ages 2-9 and high confidence tagging data; and recommended a direct comparison of daily/annual increment counts by FAS and IATTC (see also suggestion above).

The workshop discussed these issues at length, noting uncertainty in decimal annual ages, the potential mismatch between ages estimated through annual or daily increment counts (although whether this was an underestimation of age from daily increments, or overestimation from annual increments was not clear), and influences of spatial patterns (and hence sampling locations) on growth.

The workshop discussed alternative sources of growth data, which included the tagging-based analyses presented to SC13. It was noted that tagging data showed a relatively large amount of variability, although the data set had been subset for measurement reliability, time at liberty and the removal of individuals that showed a decrease in measured length at recapture. Noting the existing daily increment/tag growth model (e.g. Figure 6 of SC13-SA-IP-06) and the integrated models developed in the IATTC region, the workshop suggested that the tagging data for the WCPO be subjected to the same data cleaning approach as used by IATTC to examine the impacts on model estimates.

A graphical comparison was made between the daily length-at-age estimates from IATTC, SPC, and FAS. SPC and FAS age estimates were consistent up to around 300 days, the period over which FAS indicated they had confidence in their estimates, and implied slightly higher length-at-age than those from IATTC at those ages. For older ages, SPC and IATTC estimates agreed reasonably well, while those from FAS implied larger lengths-at-age.

The workshop also evaluated the growth increments for the WCPO estimated through integrated daily otolith and tagging data, compared to those from annual otolith data. This was plotted during the workshop using the annual otolith age readings, the annual-tag integrated models, and the daily estimate-tag integrated model. Those with annual data were relatively consistent. The plots suggested that the daily increments counted by FAS underestimated age, as seen for other tuna species. The plots also showed considerable variability in tag recovery growth increments.

It was noted that FAS ages were only counts of opaque zones. For direct comparison with daily ages, a decimal age would need to be calculated that accounts for otolith edge type, birth date, capture date, etc. As these data are not available (as a comprehensive 'annual' ageing study has not been undertaken in the EPO), comparison between the two data sets was therefore difficult. Further study and comparative work was therefore required.

Additional bigeye otoliths were potentially available from the Coral Sea region. These samples were collected in the early 2000s, and would need to be re-read using current techniques to ensure ages were consistent. The workshop noted that the regional differences in growth, as seen in the GAM modelling results from current samples, could influence resulting growth estimates.

Noting the request from SC13, in order to define the growth values to be used in the 2018 bigeye assessment update the workshop focused on what was feasible to achieve between the time of the PAW and SC14. Discussions focused on the results from Project 81, data available from daily otolith increment counts, and the tagging data.

Keisuke Satoh proposed areas of research to further understand the influence of the aging method on bigeye growth estimates. Noting the variability in observed growth of tag recoveries, filtering of the tag data would be necessary, but no clear methodologies for this were defined. The presentation proposed comparing integrated growth models based upon truncated age data, either daily or annual, below a breakpoint age or length and using only tags above this point, against a growth model using only otolith data. Noting the consistency between the growth models from Project 32 and Project 81, the workshop considered whether the proposed models using the additional data would be different from the work presented in WCPFC-SC13-2017/SA-IP-06. The workshop concluded that additional investigation should be considered separately to the proposed work for SC14 in 2018.

Jessica Farley presented published work examining the validation of daily ageing, which showed underestimation of age through daily readings by up to 30%. It was noted that only 5 fish were aged for this validation work, and that those fish were generally larger than ~80cm, but that further otoliths were available. Previous work had shown that daily increment counts from transverse and longitudinal sections in bigeye in the WCPO were similar across ages, suggesting that the daily age estimates from Project 35 and 81 for fish aged > 1 (from longitudinal sections) also underestimate age. It was recommended that if daily ages be used within growth estimations, ages only up to 1 year old be included (approx. 75cm). However, given the validation trials described, it was not certain that the increments being read were actually laid down on a daily basis. In turn, larger individuals within the SPC daily otolith dataset were obtained from French Polynesia, and might therefore be influenced by spatial growth patterns. The

workshop noted that bigeye annual otolith counts had been validated with strontium chloride marks, and a report was available on this.

Discussions returned to which data sets should be included within analyses, and which approaches should be used for the stock assessment. SPC proposed a way forward to meet the request of SC13 in time for SC14. This was based upon the work of Project 81, including daily otolith counts up to ~300 days and annual counts. SPC noted there were some concerns to the inclusion of tagging data within any growth assessment without thorough data checking to ensure a 'high confidence' data set. A range of alternative growth models might be explored for the companion paper on bigeye growth, but for updating the 2018 assessment update, given constraints, a single growth model was preferred.

A suggestion was made to use the integrated length/otolith data as direct MULTIFAN-CL inputs to allow the model to estimate growth. It was noted this was a one-off sensitivity model within the 2017 assessment, but the greater numerical complication of the approach did raise potential modelling issues.

The query of integrating the otolith and tagging data was further discussed, and it was noted that, using the 2017 'best' tagging data the growth estimates were similar. Given existing uncertainty in the quality of the tag data set used in that approach, further effort to improve the reliability of the tagging data set for future analyses was warranted.

<u>The workshop suggested:</u>

- **The use of an updated growth model based upon daily growth increments for individuals up to 1 year old, removal of corresponding annual age estimates within the data set (from 'sister' otoliths), and annual counts for older fish with a readability score of 3 or greater, for the 36 'new growth' models within the 2017 structural uncertainty grid for bigeye.**
- **If time allowed, considering a MULTIFAN-CL model where length and length-at-age data from otoliths were internally 'integrated' within the model.**
- **Developing a 'reliable' tagging data set for bigeye that could be used in future integrated growth estimates, for reporting to PAW in 2019. This might be in collaboration with IATTC to use the same data cleaning methodology they apply.**
- **Noting that compared to the IATTC EPO growth curve otoliths aged by FAS are greater in age for a given size, the discrepancies between WCPO and EPO readers should be investigated. A workshop should be arranged to compare techniques and age estimates between otolith reading labs, to standardise the approaches for daily increment counts. If possible IATTC and FAS should read sister otoliths for daily counts, based upon SrCl marked otoliths. This would require funding.**
- **That daily increment readings could be used to examine the 'birth date' assumed for the decimal ages used within the von Bertalanffy growth estimation.**

Francisco Abascal Crespo (IEO, Spain) described a preliminary simulation study on the potential impact of bigeye behaviour in relation to oceanographic patterns on growth estimates. Oceanographic influences

were assumed from different regions of the WCPO, based upon the regions from which otolith samples were taken. Results, assuming a specific hooks between floats value, suggested differences in von Bertalanffy estimates could be influenced by the oceanographic influences on fish available to the gear.

The workshop noted that the growth curve used was that estimated within the assessment, with growth flexibility in the younger ages, which did not necessarily follow the von Bertalanffy growth curve as a result. The workshop also noted that fisheries in Australia operated at night, when fish were higher in the water column and hence available to the gear. A comparison of the results from day or night setting assumptions for all sets may therefore help bracket the uncertainty on growth estimates.

The workshop noted that the depth distribution was assumed to be by size, rather than age. This would influence the modelled possibility of catching smaller-at-age fish. Moving towards size-based selectivity within the MULTIFAN-CL assessment would be useful in this regard.

The workshop agreed that examining depth distribution and size selectivity influences on growth estimates was an interesting approach to pursue.

2017 WCPO bigeye updated assessment

Matthew Vincent (OFP, SPC) presented the proposed approach for incorporating the updated growth estimates within the 2017 bigeye assessment framework. The proposed approach was to re-estimate stock status for the 36 grid model runs where 'new growth' was assumed, using the updated growth parameters. Results across the grid would be summarised in a comparable way to those new growth/old growth combinations presented in the 2017 bigeye stock assessment report, and under the growth weighting values selected by SC13.

On the plans for updating growth, the workshop noted that when calculating the probability of risk of being below the LRP, rather than noting the individual runs that fell below the LRP, alternative approaches using the hessian/likelihood profiles could be a better way of calculating this. It was noted that the computational load would limit the potential to do this in time for SC14.

A request was made for more extensive diagnostics to be made available from all uncertainty grid model runs. SPC responded that the .rep files could be provided for the 2017 bigeye assessment uncertainty grid prior to SC14, so that members could examine the outputs to define appropriate potential (and practically feasible) diagnostics for grid runs for future years.

<u>The workshop suggested:</u>

- **That the 72 '.rep' files from the 2017 bigeye assessment uncertainty grid be made available to allow members to consider desired diagnostic outputs.**

Matthew Vincent presented the proposed approach to address the SC13 request to evaluate the influence of model spatial structure on bigeye assessment outputs. The logic behind the spatial structures used within MULTIFAN-CL assessments was summarised, and preliminary spatial data analyses for bigeye

consistent with this logic presented. Discussions on the data series provided noted that region 4 in particular with a boundary maintained at 20°N would be a mix of high purse seine fishing areas and areas of no purse seine fishing, and hence the smaller region with a boundary at 10°N was suggested to be more homogeneous.

The workshop noted that there was a pattern of purse seine CPUE below the 10°S boundary, and discussed whether a southerly shift in that boundary to 15°S should be considered. On investigation, it was shown that the level of purse seine catch south of 10°S was minimal.

The workshop suggested:

- **That the logic behind regional structure decisions within SPC stock assessments be presented to SC14, and that SPC consider looking at the consequences of 15° and 20°N northern boundary for regions 3 and 4 of the bigeye assessment. This would be as one-off sensitivities from the diagnostic case run (10°N).**

Evaluation of CMM 2017-01 with updated bigeye assessment

Graham Pilling (OFP, SPC) summarised the approach used to provide advice to underpin the development of CMM 2017-01 for bigeye tuna, and presented the proposed approach to provide SC14 with updated information to evaluate the potential performance of that CMM in light of the updated bigeye assessment. The workshop noted the proposed approach.

Yellowfin age and growth project

Jessica Farley presented the preliminary work performed during 2018 on the yellowfin age and growth project. The presentation was to elicit advice from the pre-assessment workshop prior to the larger scale study. The trial work examined 40 otoliths and 40 spines for annual ageing, and 10 otoliths for daily ageing, using the longitudinal axis. Challenges with the daily ageing, where daily increments were seen to split and merge across the otolith, were noted.

Thirty seven of the 40 otoliths were successfully aged using annuli. Resorption and vascularisation of spines appeared to occur at young ages, limiting their use for ageing of fish older than 1yr. Otolith validation options were presented.

Chinese Taipei noted they have yellowfin otoliths that may be available from the WCPO which could be included within the analysis. These would be gratefully received by the project.

As bigeye and albacore tended to be larger-at-age in the east of the region, following the examination of the wider data set the workshop was interested to know whether a similar pattern was found in yellowfin.

The workshop suggested:

- **As for bigeye, consider a workshop to improve the consistency of daily age estimation across labs.**

Developments in the MULTIFAN-CL software

Nick Davies of Te Takina Ltd presented developments in the latest release of the MULTIFAN-CL software (version 2.0.4.0), focusing on those areas of particular relevance for the upcoming stock assessments, and the work plan for MULTIFAN-CL development over the coming year.

The likelihood profiling of assessment models was discussed, noting that it took up to 24 hours to develop the likelihood profile in many MULTIFAN-CL assessments. In terms of data conflict, the general approach has been to ensure that the CPUE data are reasonably consistent with the overall likelihood. However, conflict in the data is not unusual, and may be driven by mis-specification in the model, or a feature of the data (particular time periods, particular regions).

The differences in the bigeye assessment outputs under the old and new MULTIFAN-CL executable were discussed. Comparison of the objective function value indicated that the new minimiser reached a better objective function value in 59 out of 72 model runs. This issue was to be investigated further.

For pseudo-data generation, the workshop clarified that the facility to include observation error in the size data has been added within the MULTIFAN-CL functionality, although additional uncertainty via process error may be necessary through sampling selectivity deviates.

The workshop noted the activities in MULTIFAN-CL development and the work plan for the software in 2018.

Following the preliminary attempts to develop a two-sex model for southwest Pacific swordfish in 2017, Yukio Takeuchi (OFP, SPC) described the proposed development activities for the two-sex modelling approach within MULTIFAN-CL in 2018.

The workshop asked whether the current formulation, with shared effort devs, could be used as a multi-species model. It was noted that, as long as a plausible biological rationalisation for sharing those parameters could be developed, then this would appropriately allow multi-stock/multi-species analysis.

It was noted that the developments towards 'two-sex' MULTIFAN-CL capability would be the subject of an information paper to SC14.

Harvest strategy developments

Graham Pilling provided background on the activities of relevance to SC14 within the WCPFC harvest strategy work plan for 2018. Each of these activities was the subject of specific presentations to the PAW.

'Science/manager dialogue' meeting in the WCPFC

Rob Scott (OFP, SPC) presented the background of a suggested 'terms of reference' for the WCPFC 'science/manager dialogue' meeting. The approach was to develop a 'straw person' that would allow SC14 to provide technical input into the scientific elements to be covered by that body.

The workshop noted that inclusion of observers/wider stakeholder groups had proved useful in other RFMOs. The body should be set up to allow dialogue and recommendations both to the Commission and back to SC to drive further work. Flexibility in meeting timing has been useful in other RFMOs. For the WCPFC, this might be constrained by the existing meetings that could 'piggy-back' the management-science dialogue meetings (SC, TCC, Commission).

The workshop heard that IATTC had a similar group that functioned in two consecutive sessions, one informal and one with a formal decision making role. This was held over at least two days, and the duration and format of the meeting would need to be considered for the WCPFC situation.

The workshop suggested that the body should have the capacity to develop HCR options, and to reduce the suite of examined HCRs to a manageable number of 'preferred' options for consideration by the Commission.

The workshop suggested:

- **That the outline TOR note the benefit of including the wider stakeholder group within this body.**
- **That the outline TOR note that flexibility in the timing of the meeting would be useful.**
- **That combining an informal and formal approach to the meeting should be considered.**

Technical developments in WCPO Management Strategy Evaluation

Rob Scott and Finlay Scott (OFP, SPC) presented the technical activities planned in 2018 to underpin the WCPFC Harvest Strategy work plan.

Technical framework development

Finlay Scott described progress and plans developing the technical framework for MSE, focussing on skipjack tuna. The framework is being developed combining MULTIFAN-CL and the R statistical language to develop the operating model and management procedure components. Results from an initial 'proof of concept' MSE were presented to illustrate the process.

Performance indicators for the skipjack fishery were summarised, and it was noted that the TRP for SKJ may combine many of the objectives already, while others may be monitored through the monitoring strategy in the 'real world', since some of the objectives would depend on decisions made by governments.

The workshop welcomed the demonstration of the current framework, and noted that including some more extreme HCRs to show contrast in results may be useful. Performance indicators incorporating catch rate levels and variability have been key in other tRFMOs.

Operating model developments for skipjack

Rob Scott presented initial work conditioning operating models for skipjack tuna MSE, using the 2016 skipjack tuna assessment uncertainty model grid as a basis. This included an examination of the pseudo-data generation from those operating models. Ideas on the OMs for the reference and robustness model sets were briefly covered.

Workshop discussions noted that when evaluating different estimation models, the value of the tagging data to the assessment and advice might also be examined to show the value of this information.

Analysis of potential target reference points for yellowfin tuna

Yukio Takeuchi presented proposed analyses to evaluate 'minimum' target reference points for yellowfin tuna, defined by alternative levels of risk of falling below the limit reference point. These analyses were comparable to those presented in MOW3 WP-02. It was noted that, if this exercise was to be repeated for bigeye (consistent with the harvest strategy work plan for 2018), it would need to be performed after SC14, once that meeting had defined the structural uncertainty grid components (and weightings) from the updated assessment. SC14 could, however, comment upon the technical approach.

Activities to underpin south Pacific albacore target reference points

Graham Pilling summarised the request of SC14 from WCPFC14 to provide analyses and advice to underpin the 'pathway' to developing a target reference point for the south Pacific albacore stock. Noting that stock status advice would be defined based on the new assessment presented to SC14, proposed activities focussed upon progressing harvest strategy elements, in particular a harvest control rule based upon catch rate information. The approach was to provide a paper to SC14 discussing these issues and presenting any analyses performed identifying candidate CPUE indices.

Other activities

WCPO bycatch estimates

Tom Peatman (OFP, SPC) presented the latest analyses estimating bycatch within WCPO fisheries, summarising the available data, methodology, estimates and comparisons with existing catch data. The fate of individuals (and condition for SSI) would be summarised within the final report.

The workshop noted that areas of the longline fishery appeared to have limited information on hooks between floats. This would influence the ability to perform standardisation analyses, for example. This issue would be covered by the data gaps paper to SC.

The workshop noted the effect of time of setting (day/night) on longline catch rates. A post-hoc approach to defining the predominance of time of setting within a region/fleet might be appropriate, in a similar way to that within analyses of turtle bycatch, given that time of setting information is not available for all fleets. Although current analyses were not performed at a fleet level, the variability between fleets would be important to consider where feasible.

The workshop noted the comparisons between estimated and reported catch. It was pointed out that there is variability in the reported catch data, as well as catch estimated from the model. It was suggested that estimates derived from regions where observer coverage was good might identify whether observer coverage, or other factors, affects the quality of catch estimates.

The potential to base estimates on landed target catch rather than effort was raised. With appropriate stratification by fishery/region, this could be done but bycatch/target catch ratios would need to be estimated from observer data, and the current model-based approach was felt to have benefits.

A comparison of the CVs on catch estimates between purse seine and longline fisheries was suggested, to highlight whether the greater observer coverage on purse seine fleets led to a notable improvement in precision.

The workshop suggested:

- **Comparing estimated and reported catches restricted to an area with good observer coverage (rather than WCPFC-CA wide comparisons).**
- **Presenting CVs on the longline catch estimates by species/year, and comparing to those from the purse seine fishery where observer coverage is greater.**

Northern stock definition

Yukio Takeuchi presented some areas of work to assist SC14 in its consideration of whether striped marlin and blue shark in the northern hemisphere of the Pacific could be defined as 'northern stocks' to address the request from WCPFC14 (see para 378 of WCPFC14 summary report). WCPFC requested SPC and ISC provide to SC14 papers that present available information on the status of these stocks and the catch levels in their associated fisheries. The WCPFC Secretariat will coordinate the approach with ISC and SPC.

The ISC vice chair was happy to provide any aggregate information necessary for this work, noting that access to operational data would require national clearance. The evaluation approach was discussed, noting that while the definition was unspecific, a northern stock was one that occurs 'mostly' north of 20°N; candidate proportions against which to evaluate this had been discussed at previous SC meetings. It was noted that blue shark had already been reviewed and SC had commented on the issue at SC10 (Majuro), using available tagging data (e.g. Sippel et al., ISC/11/SHARKWG-2/04). Biomass estimates north and south of 20°N from assessment models were suggested as being potentially informative. In turn, the proportion of aggregated 5x5° catch data north and south of this latitude might also be informative, although discards would not be included in such estimates (particularly for blue shark).

The workshop suggested:

- **The WCPFC Secretariat liaise with SPC and ISC to coordinate the response to the WCPFC14 request.**

Final remarks

Steve Brouwer thanked participants for a fruitful workshop and indicated that a draft workshop report would be circulated for comment among meeting participants prior to finalisation and submission to SC14.

APPENDIX 1: List of Participants

Name	Affiliation
John Annala	Ministry for Primary Industries, NZ
Rob Campbell	CSIRO, AU
Jessica Farley	CSIRO, AU
Sangaa Clark	PNAO
Wetjins Dimlich	FFA Secretariat
Tim Adams	FFA Secretariat
Keith Bigelow	NOAA, US
Eric Chang	National Sun Yat-sen University, TW
Hung-I Liu	Overseas Fisheries Development Council, TW
Keisuke Satoh	National Research Institute of Far Seas Fisheries, JP
Hidetada Kiyofuji	National Research Institute of Far Seas Fisheries, JP
Yoshinori Aoki	National Research Institute of Far Seas Fisheries, JP
Francisco Abascal Crespo	IEO, Spain
Sung Il Lee	National Institute of Fisheries Science, KR
Manuel Ducrocq	Maritime Affairs, NC
Ueta Faasili Jnr	Ministry of Agriculture and Fisheries, WS
Elaine Garvilles	Bureau of Fisheries and Aquatic Resources, PH
SungKwon Soh	WCPFC Secretariat
Pham Viet Anh	Directorate of Fisheries, Vietnam
Victor Restrepo	ISSF
John Hampton	SPC
Laura Tremblay-Boyer	SPC
Matthew Vincent	SPC
Yukio Takeuchi	SPC
Rob Scott	SPC
Finlay Scott	SPC
Graham Pilling	SPC
Steve Brouwer	SPC
Peter Williams	SPC
Tom Peatman	SPC
Nick Davies	SPC Consultant

APPENDIX 2: Terms of Reference

The Oceanic Fisheries Programme (OFP) of SPC is contracted by WCPFC to undertake stock assessments. The results of these assessments will be presented at the WCPFC Scientific Committee. In preparation for these assessments, OFP is hosting a pre-assessment workshop to discuss key issues related to the assessments. The terms of reference for this workshop are provided below.

Terms of Reference

- Review the most recent completed assessments, in particular, any concerns, suggestions and/or recommendations raised by the Scientific Committee, the Commission, research providers, individual CCMs, or any independent reviews;
- Review preliminary work undertaken by the service provider relating to the stock assessments, including any proposed:
  - revisions to biological parameters
  - revisions to historical data
  - changes to structural assumptions in the model
  - methodological issues, e.g. characterization of uncertainty
  - standardized CPUE analysis
  - incorporation of tagging data or other auxiliary data
- Provides guidance to the OFP on:
  - the suitability of any proposed changes and any suggested additional work
  - a minimum set model runs to be undertaken, in particular the range of key sensitivity analyses
  - desired model diagnostics to be presented
  - alternative modeling approaches that could be considered

The outcomes of the meeting will be documented in two ways, a report of the meeting and in the assessment working papers themselves. The report of the meeting will be distributed to workshop participants for comment within 10 working days of the meeting and revised and provided to WCPFC Scientific Committee members 30 days after the meeting. It will also be submitted to the next Scientific Committee as a Working Paper. Many of the matters discussed to the workshop will be the subject of meeting papers to the Scientific Committee.

Due to the timing of the meeting, any model runs presented will be based on previous assessment data sets, and therefore no preliminary stock assessment runs will be undertaken. Further, the workshop will occur prior to the submission of data and completion of supporting analyses (e.g. CPUE analyses). Therefore, any major changes to historical data submitted by CMM's, or new data could result in a need to consider alternative model runs or structures not considered previously. In such instances, supporting documentation will be provided to the SC via working papers to allow the SC to determine the merits of any proposed changes.

The consultation will be open to participation by all CCMs and to other experts, by invitation. CCMs will be expected to fund their participation although SIDS and participating territories may seek support from the Commission's Special Requirements Fund or other sources, as appropriate.