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Report from the SPC pre-assessment E-workshop, Noumea, April 2020

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Pacific Community (SPC), Noumea, New Caledonia

E-Meeting

Report from the SPC pre-assessment workshop, Nouméa, April 2020

Oceanic Fisheries Programme, Pacific Community (OFP, SPC)

Introduction

To help guide stock assessments for the Western and Central Pacific Fisheries Commission (WCPFC), the Oceanic Fisheries Programme (OFP) of the Pacific Community (SPC) has sought input from regional stock assessment scientists and representatives from regional fisheries organisations through the SPC pre-assessment workshop (PAW) process. The twelfth pre-assessment workshop was held in Nouméa, New Caledonia, from the 22-23rd April 2020. Due to the impacts of the COVID-19 pandemic, the meeting was held electronically, and the content reduced to focus on the two key stock assessments for 2020: yellowfin *Thunnus albacares* and bigeye tuna *Thunnus obesus*. Twenty eight external participants from 13 organizations participated in the workshop, along with 16 SPC scientists and an SPC consultant. The agenda and list of participants are provided in Appendices 1 and 2.

Graham Pilling (OFP, SPC) opened the meeting and welcomed the participants. The agenda focused on approaches for the stock assessments of western and central Pacific Ocean (WCPO) yellowfin and bigeye tuna, related data inputs, data treatment and modelling approaches, and developments to the MULTIFAN-CL modelling framework used for tuna assessments in the WCPO. Presentations were invited from all participants. The majority of presentations were made by SPC staff, with presentations on age and growth studies for yellowfin and bigeye tuna provided by CSIRO scientists and radiocarbon age validation for bigeye tuna from a Japanese scientist. The meeting operated under the terms of reference provided in Appendix 3 and was chaired by Paul Hamer of the OFP Stock Assessment and Modelling section.

This report briefly describes the various workshop presentations 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 relevant stock assessment scientists will address the recommendations provided in this report to the extent possible. It must be noted that the extent to which suggestions can be incorporated into the modelling prior to sixteenth regular session of the WCPFC Scientific Committee (SC16) will in particular be constrained by the ability of the model to converge under the assumptions required and the availability of certain new MULTIFAN-CL features being developed and tested.

The outcomes of this meeting will be reflected in the papers submitted to WCPFC-SC16. Copies of presentations prepared by for the workshop can be provided on request.

Growth modelling

Jessica Farley (CSIRO, Australia) presented the preliminary findings of WCPFC Project 82 for yellowfin tuna growth estimation from otoliths. This new research provides important biological information for the 2020 yellowfin stock assessment. The presentation described the preliminary results from age readings of 1563 otoliths, including 43 daily age estimates of small juvenile yellowfin tuna. The presentation also covered recent additional ageing workshops in Florida and work in the Atlantic Ocean for yellowfin tuna. Plans for additional work to finalise the outcomes of Project 82 were detailed. Jessica noted that for the previous bigeye assessment the PAW suggested to use only high confidence otolith readings within the estimates of growth. This suggestion arose from differences in the estimates of growth that resulted from using the full data set versus just the high confidence readings. While similar differences were not observed in the yellowfin preliminary data, the question was raised whether to include all estimates within the estimate for the yellowfin stock, or just the high readability samples. Jess also asked whether PAW participants would like to review a summary of the final results prior to SC16.

The workshop asked whether the otolith age-at-length data would be included directly within the MULTIFAN-CL model for the yellowfin assessment or to externally estimate growth parameters to be used as inputs to the model. SPC responded that the current plan was to test both approaches, but this depends on whether the MULTIFAN development to include conditional age-at-length is completed in time for implementation. The workshop also asked whether season was included within the growth modelling. Jessica noted that area, size and month were used as strata for the selection of the samples, with the aim to achieve samples across each of these strata. However, the growth model pooled all the data, with the objective of estimating regional growth parameters. The lack of small fish in some model areas and larger fish in others was noted, which was a function of the samples available within the tissue bank that was ultimately related to either the selectivity of the gear or local availability. This potential sampling bias makes robust spatial comparisons of the growth parameters problematic.

The workshop asked whether the influence of possible outliers within the length-at-age data would be examined further. Jessica noted that where otolith weights were available (noting many otoliths are damaged), this would provide additional information that could be used to identify and remove length outliers from the data set. It was also noted that some otolith interpretations may represent less ‘certain’ readings, that may be removed from the final dataset subject to results of the independent re-reads. The workshop noted differences in sex may be influenced by the lack of samples across sexes for ages older than 6 years, and that robust comparisons between sexes would require more data across the full age distribution.

The new growth curve was discussed in relation to differences from the previous growth curve. SPC noted that the main difference was that the K estimate in the new preliminary otolith-based growth model was about half of that estimated in the growth model used for the 2017 assessment. The requirement to estimate decimal age consistent with the quarterly time steps in the MULTIFAN-CL assessment was discussed and the workshop supported the use of otolith weight to inform the estimation of decimal ages. The use of growth models based on all data and the high readability otoliths

only was suggested to be included as a sensitivity in the diagnostic model development. Use of a reading score of 3 or greater, consistent with the approach for bigeye tuna, was suggested.

The workshop suggested:

- **That a summary of the final estimated otolith-based growth curve be provided by CSIRO prior to the SC16.**
- **That two growth estimates be developed using all available otolith data and an estimate restricted to just the high readability otolith data. The criteria to designate an otolith sample as 'high readability' should be consistent with the approach used for the last bigeye tuna assessment.**

High confidence tag data set

Mathew Vincent (OFP, SPC) presented the approach applied to developing a high confidence tag/recapture data set to be used for estimating growth parameters. The filtering process to develop the data set was presented and the resulting data set described. The challenges encountered, even following the filtering approach, were described. In particular measurement error in release and recapture lengths were problematic. It was concluded that a high confidence tag/recapture dataset for growth estimation of yellowfin and bigeye tuna is not currently possible due to the issue of measurement error. However, there is value in using the tag-based growth data in the integrated growth modelling; acknowledging that even otolith based growth estimates will suffer from a certain amount of length measurement error. Growth modelling is expected to be an axis of uncertainty within the assessment model grid.

The workshop noted that the measurement error limited the utility of the tagging data alone for growth analysis and discussed how measurements could be improved in the future. SPC noted that measurement error on release is common due to the live nature of the fish, but suggested that if recapture lengths or location are unknown, these fields should be left blank rather than attempts made to fill that information in with highly inaccurate or made up data. The potential for transcription errors on release was also noted, and some form of electronic monitoring of the release lengths might help with this. For recapture, approaches used to improve data accuracy including increased rewards for recaptures where the fish is available to be sighted by a tag recovery officer. However, such approaches appear to have limited value with respect to the numbers of returns achieved due to practicalities of such a system (e.g., in the eastern Pacific Ocean (EPO). The potential to use quantiles of the growth increment distributions to exclude data that are likely to be highly unreliable is being considered within the integrated growth modelling (below).

SPC noted that some data with high quality measurements could be obtained for electronic tagged or strontium-chloride (SrCl) marked fish, where the whole fish is returned to the tag recovery officer who can then take an accurate measurement. The approach used in EPO, where a tag recovery officer had sight of the fish could be explored. It was suggested that estimates of the numbers of accurate tag/recapture records required to estimate growth parameters with sufficient certainty would be useful.

The issue of post-mortem shrinkage identified in the EPO, where bigeye tuna individuals shrunk by around 2% due to freezing was noted, but similar studies have not been done for yellowfin. It was also noted that the status of recovered fish is not known for all tagging programmes and hence this will be difficult to implement. For consistency, this effect would also need to be considered within the broader length composition data, but given that historical port measurements could be frozen/fresh/mixed compared to fresh observer measurements on board, it would be impossible to adjust historical data for any such biases. There was also discussion of the possible biases in measurement error depending on how the fish are measured (e.g., callipers, boards, tapes, cradles etc.) and that measurement method is generally unknown/not recorded. Including information on measurement method would be useful in that biases can be estimated through controlled studies and data adjusted.

The workshop suggested:

- **Improve education around the importance of accurate reporting of tag recapture data. At a minimum, ensure that data are reported accurately, including omitting data elements (e.g., fish length) if unknown.**
- **Explore potential sources of bias in tuna length measurement. Suggestions include recording the type of measurement approach (e.g., instrument types, total length, fork length) and fish state (e.g., previously frozen) on the tag release and recapture reports. Use controlled studies to understand these biases.**
- **Determine the number of high-quality tag recapture reports that would be necessary to reliably inform a growth model, and the feasibility of obtaining these observations through improved protocols.**
- **Investigate potential of including an e-monitoring approach to measure/confirm fish lengths at release and recapture (at least where the recaptured fish can be sited by tag recovery officer).**

Integrated growth modelling

Paige Everson (CSIRO, Australia) presented preliminary results from integrated growth modelling using tag/recapture (from the work discussed above) and otolith data for yellowfin and bigeye tuna.

Different model configurations were explored, but overall there was little difference between the model results that used otoliths only and those that used both otolith and tag data. For bigeye, the spatial bias associated with most of the larger tag/recaptured fish being from around northern Australia/Coral Sea was suggested as an explanation for why the tagging and otolith growth data showed some divergence at older ages. The influence of spatio-temporal differences in samples should be investigated further. While a tag-only growth estimate was attempted, the outcome was not realistic, given the sizes over which fish were available. The distribution of estimated release ages was modelled using a lognormal distribution and displayed slight bimodality. SPC noted that this might be due to the different fishing gears used within the tagging programmes. The potential to examine the sensitivity of growth estimates to different rules for excluding growth increment outliers was also suggested. A proposed solution was to classify fish into groups based on release length and time at liberty, and within each group, only include fish within the 10th and 90th quantiles of the growth increment distributions. Also, other studies

have shown that tagging fish can temporarily affect fish growth; thus, fish at liberty for less than 30 days were excluded. Again, given the different growth models, the PAW participants further recommended that growth be included as an axis of uncertainty within the assessments.

The workshop noted there is the potential to add length composition data as a source of information for the integrated growth modelling. The question was whether evidence of modal progression is seen within the data available, and whether those data are from a sub-section of the fishery. This would be discussed further offline.

The workshop suggested:

- **Further examine the sensitivity of growth estimates to the different criteria used for excluding 'outlier' data points.**
- **Further investigate the influence of the larger tagged bigeye recovered in the Coral Sea on the tag-based growth estimates.**
- **Investigate the potential implications of spatial/temporal mismatches in sample regions between tag/recapture and otolith samples.**
- **Include the integrated growth estimate within the uncertainty grid for yellowfin and bigeye.**

^{14}C otolith age validation for bigeye tuna

Kai Okamoto (National Research Institute of Far Seas Fisheries (NRIFSF), Japan) presented preliminary findings of ^{14}C isotope age validation for bigeye tuna otoliths from the tropical WCPO (144-164°E). The ^{14}C trends in 0+ bigeye otoliths fitted well to those of corals from Kure Atoll, demonstrating the potential of the approach. It was recognized that there was a need to expand the decay model with information from 2001 to 2010, where samples are currently lacking and further improve the delta-^{14}C model to examine validation of ages for older fish.

The workshop noted that the Kure Atoll was distant from where the 0-age otoliths were sampled and asked whether delta-^{14}C curves from other closer Pacific locations could be compared. Okamoto-san noted that given oceanographic current patterns and mixing, the comparability between Kure Atoll and the location of bigeye samples was appropriate.

SPC noted that they could examine the specimen bank to see whether 0-age bigeye were available but noted that individuals were likely close to 1 year old. Young-of-year bigeye obtained though Project 60 and other sources, such as the Philippines, could potentially be obtained.

The workshop suggested:

- **SPC explore the tissue bank records to see whether 0-age bigeye otoliths were available to supplement this study.**

Tagging data

Matthew Vincent summarised the approach to developing the tag/recapture data set for the bigeye and yellowfin assessments, in relation to use for estimating movement and mortality parameters. In particular, issues relating to how to account for tagger effects and patterns in reporting rates over time

were discussed. It was suggested that more tag seeding is needed to improve estimation in reporting rates, as this had dropped off in recent years. It was thought that the lower tag seeding effort may have affected the recent reporting rate estimates since 2015. An approach to better estimate the mixing period based on the actual time at liberty, rather than gross quarter, was summarised following suggestions for one of the external scientists.

The workshop noted that tagger effects are currently analysed on a species by species basis. However, tagger effect may be shared across species. There is therefore the potential to allow some of these effects to be shared, and others to be species specific, which will help with sample size issues for bigeye tuna tagger effect estimations. The tagging event (which is correlated with gear type) 'accounted' for a lot of the variability in the data, but this could also be shared across species.

The reason(s) behind the declines seen in tag seeding events since 2015 were discussed. SPC noted that they had raised this issue at the last SC15 Pacific Tuna Tagging Programme (PTTP) committee meeting and had requested for observer coordinators and observers to attempt to deploy more tag seeding kits. Work is therefore underway to address this, but the current COVID-19 restrictions will delay progress as many observers are being returned to home ports.

Keisuke Satoh (NRIFSF, Japan) noted that limited further tag returns (around 10 for bigeye and yellowfin) had occurred since 2017 for Japan, and time at liberty was very short. Implying these recent data were insufficient to add information to the assessments. Further discussions with SPC would happen offline.

<u>The workshop suggested:</u>

- **Re-evaluate the approach to estimate tagger effects by pooling data across species and considering alternative models in relation to tag event effects. In addition, it was suggested that the sampling gear (i.e., handline versus pole and line) may be an important source of variability to explore with respect to tagger effects.**
- **Improve upon the approach for quarter allocations of tag/recaptures**
- **Concerns regarding model estimated tag reporting rates hitting the upper bounds; no advice provided by participants on how to deal with this**
- **Continue to push to expand tag seeding activities to improve estimation of tag reporting rates.**

CPUE analyses

Nicholas Ducharme-Barth (OFP, SPC) summarised the geostatistical modelling approach using the VAST R package applied to analyse operational longline catch per unit effort (CPUE) data to develop the standardised abundance indices. Results of various analysis were presented to support a proposed model for both bigeye and yellowfin tuna involving:

- Sub-sampling of 5 samples per strata (year-quarter x 5° cell x Flag Group)
- Number of spatial knots = 150
- Oceanographic covariates = None
- Catchability covariates: Flag group x HBF (10 hook bins, w/prediction)

- Error structure: Lognormal

The workshop noted that the consistency among the results from the alternative spatial knot structures trialled indicated that 150 knots was appropriate, but to consider a larger density of knots around Region 9 where the model region is quite small. The workshop discussed the modelling of the hooks between floats (HBF), noting there was potential to model this as a continuous function rather than a binned HBF factor. As HBF information was not available from early in the time period, it was felt that estimating HBF within bins is more feasible than as a continuous variable. The workshop noted that examining alternative smaller bin sizes that can be used as a spline may be appropriate. The potential to subsample only those records where HBF information were available was discussed, but it was noted that this would require assumptions for the historical period and would need to be representative of the entire data set. SPC indicated they would look at applying a bin of 5 to model the HBF. There were also suggestions from CT that some of the high (i.e. >30) HBF records were probably erroneous, and that this data should be re-examined and decide whether to remove the high HBF data.

It was noted that starting the assessment in 1952 did limit the potential use of a wider set of gear characteristics that have been captured within the log sheets for the last decade or so. Including these recently available gear factors had the potential to improve the estimates, rather than just using HBF as a fishing method effect proxy.

SPC were not convinced about modelling oceanographic data as abundance covariates. They indicate they would like to include dissolved oxygen, as that was thought it to be important; however, a sufficient data product for the full time series is lacking. Suggestion to SC16 to obtain a suitable product for use in the analysis.

The consistent positive catch residuals from the preliminary bigeye CPUE model was discussed, and SPC agreed to look into this. It was noted that bias correction was not applied as the predicted impact was negligible, based upon the simulation analysis presented in 2019. This might be applied for the final index, given the computational implications of that calculation.

<u>The workshop suggested:</u>

- **General support for the proposed geospatial approach to CPUE standardisation.**
- **Spatial knots of 150 was supported, but consider increasing density or number of knots around region 9 (Coral Sea) within the mesh.**
- **Some uncertainties about hooks between floats (HBF) from Chinese-Taipei (CT): SPC has had a look at the distribution of HBF by flag-fleet across all combinations and will remove all records with HBF greater than 50.**
- **Examine the potential for classification of unknown HBF at 5 HBF bins. Time permitting, it was suggested to try modelling HBF at 5 hook bins using a continuous spline.**
- **Explore potential for use of additional gear factors/covariates available with recent operational data and options for splicing recent and historical data (not for this assessment though).**
- **Investigate the source of the positive catch residuals for the bigeye model.**

Purse Yellowfin tuna CPUE analyses

Tiffany Vidal Cunningham (OFP, SPC) presented an analysis of yellowfin tuna CPUE (catch per set) for purse seine sets on drifting fish aggregation devices (FADs) as an investigation into the potential for this approach to provide an index of juvenile yellowfin tuna abundance. The geostatistical approach using the VAST R package was used. The premise for this work is the observation that purse catches of yellowfin tuna on drifting FADs are mostly comprised of juveniles (modal length of 50 cm). Operational drifting FAD purse seine CPUE data from the observer program (2010-2018) were presented and compared with logbook data available over a longer time period (2000-2018). The results appeared consistent for the overlapping time period suggesting that the longer-term logbook data could be used to produce the index. The index was highly variable at the quarterly and annual time scales and showed a long-term declining trend, with recent peaks (post-2010) predicted to be lower than those earlier in the time series. Trends in the standardized CPUE using the geostats approach deviated substantially from 0+ recruitment estimated by the most recent integrated MULTIFAN assessment. Understanding these differences will require further consideration. Some concerns were expressed over changes in effective effort over time which may not be adequately captured, and the need to develop more informative catchability covariates as the preliminary model was relatively insensitive to those explored. Feedback was sought on data filtering, improved effort metrics, and the choice of oceanographic covariates as variables affecting catchability and local density. It was also noted that with the VAST geostats approach there is a distinction between catchability and density covariates. The catchability covariates are standardized out, while the density covariates are not, and will influence the estimation of abundance.

The workshop noted that given the yellowfin length composition for the drifting FAD purse seine fishery ranged from approximately 20 -130 cm, the resulting index did not accurately reflect catch rates of age 0+ , but was more akin to a 'young' fish index. With respect to the stock assessment model fitting, the selectivity of the purse seine drifting FAD fleet would be applied to this index, thus addressing the concern that larger fish were included in the drifting FAD catch rates. Alternatively, it was suggested that it could be possible to adjust/prorate the index to account for the length composition of the catches so that it more accurately reflects abundance of fish < 1 year old. This may be explored by the SPC.

Noting that the index would be a new development for the assessment, the workshop asked whether this index would be included within the final yellowfin assessment, and that at least the impact of the inclusion/exclusion of the index on the model outputs should be demonstrated within the assessment. SPC noted that this would be defined during model development, and the impact of this index on model estimates would specifically be evaluated by one off sensitivity tests.

The workshop noted that thermocline depth was included as a catchability covariate, and SST included as a density covariate, but correlation between these variables is likely as they are both influenced by ENSO variability. SPC will further explore correlation among environmental covariates applied in the model.

<u>The workshop suggested:</u>

- **Include this new index as a one off-sensitivity analysis in the YFT stock assessment report but not include in the final assessment due to the preliminary stage of this work.**

- **Further explore correlations between the ENSO related density and catchability covariates.**
- **Length composition data to be used in conjunction with the CPUE index to better inform dynamics of the juvenile component of interest (age-0 to age-1 fish).**

Fishery overviews

Matthew Vincent and Nicholas Ducharme-Barth summarised the data available for the fleets in each proposed region of the yellowfin and bigeye stock assessments under the 10° and 20° spatial structures. An 'index fishery' approach, as used in the 2018 South Pacific albacore assessment is being pursued, which adds 9 'longline' index fisheries to the assessment that would have a shared selectivity across all regions.

Particular issues with data gaps were raised for yellowfin and bigeye, including shifts in length composition for recent data that appear related to selectivity changes due to changes in the dominant sources of data. Declining patterns in the equatorial associated purse seine fishery bigeye catch were also noted. No weight composition data were available for the Japanese longline fleet post-2010. JPN confirmed weight data are scarce, but length data are be available. JPN and US indicated that additional data are available that could help fill the gaps and they will work with SPC to provide these data.

The approach of down-weighting the size data within the index fishery was noted, and the interaction between that and the size data weighting within the model uncertainty grid was questioned. It was clarified that the down-weighting of the size data with the index fishery was to ensure the overall longline fishery size influence was not affected.

The workshop suggested:

- **JPN and the US will work with SPC to provide data to fill the identified gaps.**

Size composition data treatment

A presentation summarised the work of Tom Peatman (SPC consultant) on treatment of the size composition data. The need to ensure appropriate weighting between the index and actual (i.e. extraction) fisheries was noted, with the suggestion to split the composition data equally between the two fisheries. The size composition of the index fishery could then be weighted by the standardised CPUE, preferably consistent with the way data were subsampled to develop the standardised index. It was also noted that many of the sample grids at 10 x 20° cross regional boundaries, and that data could be split 50:50, or weighted by the relative catches in each region. The need to preserve the total number of sizes sampled was noted. The spatial interpolation from the purse seine composition was to be removed, to be consistent with the approach to longline.

The workshop clarified the use of 'index' fishery versus the 'extractive' fishery within the stock assessment model. In the 2020 models, this would equate to 9 additional 'index' fisheries that would receive the composite standardised CPUE index, but have negligible catch attributed.

The workshop suggested:

- **Support for applying the index and regular (extraction) fishery approach.**
- **Suggestion to split the data for index fisheries equally (50:50) between the index fishery and the regular fishery was generally supported. The size composition of the index fishery could then be weighted by the CPUE.**
- **For the sample grids at 10 x 20° that cross regional boundaries, the data will be weighted by the relative catches in each region.**
- **The spatial interpolation from the purse seine composition is to be removed, to be consistent with the approach to longline.**

Developments in MULTIFAN-CL and potential applications of new approaches to the 2020 yellowfin and bigeye tuna assessments

Nick Davies (SPC consultant) described the recent fixes, enhancements and new developments in MULTIFAN-CL since the 2019 PAW, including some that may be applied within the 2020 stock assessments, and development of features to enhance the Management Strategy Evaluation (MSE) framework. A new release version 2.0.7.0 of MULTIFAN-CL is now available along with a new macOS executable.

The new MULTIFAN-CL features that were discussed, including those not presented at last PAW but implemented in the previous version, included:

- Self-scaling multinomial (SSMULT) to estimate the effective sample size for length or weight composition samples
- Tagging data Censored-Gamma likelihood for large overdispersion
- Maturity-at-length
- Richards growth estimation
- Capability for no tagging data, single region, no movement
- Unique maximum ages

Other enhancements/corrections included:

- Stochasticity in terminal numbers at age
- Tagging negative binomial upper bound on overdispersion parameter
- Multi-species tagging calculations - optimised for region-species adaptation
- Correction to multi-species single region model
- Correction to multi-sex model – shared effort deviates parameter placement
- Correction to growth curve variance calculation
- Correction to scalars for age_pars(3, 4) in parameter placement

The workplan for 2020/21 was then outlined, which includes:

- Catch-conditioning approach for estimating fishing mortality

- Alternative likelihood for tagging data that informs movement only and not mortality
- Length-structured model for growth
- Conditional age-length likelihood – annualize over quarters
- Optimize the estimation model used for the MSE estimation model
- Reinstate length-based selectivities
- Simulation projection functionality
- Penalty function implementations to ensure recruitment and effort deviates approach mean of 0
- Include recapture size from tagging data to inform growth estimation
- Tagging multi-sex feature

The MULTIFAN-CL update presentation was followed by a presentation from John Hampton (SPC) on the results of testing some of the new MULTFAN-CL features in preparation for the upcoming assessments. In particular, potential options for the SSMULT data weighting approach were presented. Related to this, the need to provide fishery length or weight composition data as the actual numbers of fish measured, and not rescaled data, was highlighted. It was also noted that for the MSE work the estimated effective sample size (ESS) is used to generate the size composition data. If the ESS is estimated from raised composition data, it will likely underestimate true variability, further emphasising the importance of receiving composition data as the actual numbers of weights or lengths measured.

The workshop noted that the use of a 5^{th} order SSMULT_RE_ARAR rho parameter being optimal under simulations, but that the assessment scientist would need to examine the most appropriate level for a particular situation.

The workshop briefly discussed the model fit results from the gamma likelihood implementation in the tagging recapture at length estimation model of negative binomial, which had impacts on resulting population estimates. Down-weighting the tagging data in the example presented did appear to have an effect, which may have resulted from conflict with other data inputs into the model.

The workshop confirmed that the growth transition matrix in the length-based approach would be region-specific, to allow region-specific growth to be estimated.

Noting the potential to add an environmental correlate on movement, the question was asked whether the current movements structure in MULTIFAN-CL would allow time-variant movement within the existing code? Nick Davies clarified that this is currently not the case, although implementing such a time subscript would be possible as the current parameterisation could allow it.

<u>The workshop suggested:</u>

- **Nick and SPC assessment scientists need to further discuss priorities for MULTIFAN-CL development work in 2020. It was suggested to prioritise the conditional age at length development under the proviso that this would be a quick piece of work, then return to the catch conditioned model function. For the catch conditioning, the focus should be on getting**

the single-species case working at this stage and not worrying about multi-species generalizations.

- **SSMULT (self-scaling multinomial) for estimating effective sample size for length and weight frequency data has been tested and may be used in the bigeye and yellowfin assessments. Potential to remove weighting options for length or weight frequency data in the uncertainty grid is a bonus to this approach, but there are concerns with run times requiring some further trials. If SSMULT is used, then the composition likelihood axis could be replaced by a CPUE CV axis.**
- **Essential that length and weight frequency data is as actual numbers of fish measured (this needs some follow-up checks to confirm for some data sets).**
- **Including effort data only for index fisheries was tested on bigeye and is recommended to pursue in these assessments, further testing to do on yellowfin.**
- **Catch conditioning approach still to be completed and tested – cannot guarantee it will be used in the upcoming assessments.**
- **Censored gamma tagging likelihood – needs to be tested on yellowfin and bigeye before deciding to apply to the upcoming assessments.**
- **Recapture-conditioned tag likelihood – not likely to be available to use for these assessments.**

Stepwise diagnostic model development

Matthew Vincent and Nicholas Ducharme Barth presented the proposed approach for the stepwise progression from the 2017 assessment model for yellowfin and updated 2018 model for bigeye, to the 2020 diagnostic case models. Aspects of the stepwise development process sought to reduce the number of parameters to attempt to reduce the time to convergence and facilitate certain diagnostics. It was noted that the ability to implement some steps will depend on the progress with MULTIFAN-CL developments discussed above, in particular the conditional age-at-length and catch conditioning. Preliminary results from implementing some of the suggested steps were presented. The following is a summary of the proposed stepwise changes for both assessments:

- Increasing length and size bins from 2 to 4 cm and 1 to 2 kg, respectively
- Apply the catch conditioned approach if available, this will reduce computation overhead and improve diagnostics. This should be prioritized.
- Moving to index fishery approach.
- Changes to the size composition partitioning between index and regular (extraction) fisheries.
- Ensure lengths match raw numbers, not scaled numbers of lengths.
- Improve integrated growth estimates.
- Conditional age-at-length if available.
- Add in maturity-at-length feature.

Additional changes related to tagging data:

- Ensure tagged fish have sufficient mixing periods.
- Explore sensitivities to tagger effects and other release scaling factors – want to revisit the 7% shedding rate.

- Tag pooling time for bigeye may be too long.
- Test sensitivities to movement priors – which may help model convergence.
- Trial using SSMULT to inform size comp weighting.

The workshop noted that for yellowfin tuna, based upon the preliminary otolith age-at-length estimates, an increase from the current 28 quarterly age classes within the model may be required. This would be considered within the stepwise approach. The preliminary estimates of yellowfin growth did not appear to match the modal progression seen in available size structure data, and the workshop noted that those size data could help identify birthdates, and may be used as input into the integrated growth model for yellowfin.

A potential step in model development was to move from quarterly estimated movement over time to constant quarterly movement. The workshop noted that constant movement by quarter was not biologically reasonable. SPC noted that, given the low number of tag releases/returns for some regions, the data may not be available to inform those quarterly movement parameters. Statistics would be examined to see if the reduced number of movement parameters was justified by the extent of degradation in fit.

The workshop asked about the conflict in standardised index in Region 8 and the tagging data hitting the bounds. SPC noted that approaches to reduce the number of estimates hitting the bounds would be investigated, which would include Region 8.

The workshop suggested:

- **Support for changing the length and weight frequency bins to 4 cm and 2 kg, respectively.**
- **For yellowfin tuna, based upon the preliminary age-at-length estimates, an increase from the 28 quarterly age classes within the model is required.**
- **Explore the use of the size data to help identify birthdates by region, as input into the age algorithm developed for calculating yellowfin decimal age. To be followed up by SPC and CSIRO.**
- **Explore the move from quarterly estimated movement over time to constant quarterly movement.**
- **SPC to consider approaches to reduce the number of tag reporting estimates hitting the upper bounds, including Region 8.**

Potential model grids

Matthew Vincent and Nicholas Ducharme-Barth outlined the key model runs and areas of uncertainty that could be examined in the 2020 assessments. SPC's plan was to provide the results for the bigeye and yellowfin assessments across the uncertainty grid, as done in recent years for other stocks, from which SC could then select and weight axes of uncertainty as desired. The range of proposed one-off sensitivities were listed that would inform the uncertainty grid, and the initial proposed uncertainty grid, were discussed.

The tentative grids covered: stock-recruit relationship (SRR) steepness (3 levels), tag mixing (2 periods), size composition weighting (3 levels, unless the self-scaling multinomial function within MULTIFAN-CL was felt sufficiently robust for this assessment), regional structure (10°N and 20°N), tag overdispersion (2 levels, although this may be estimable), and growth (otolith only, otolith and tag, conditional age at length; the last would depend on MULTIFAN-CL developments being available). However, this resulted in 216 models, which is considered too large to be practical. The potential to 'merge' the tag uncertainties of mixing period and overdispersion value, or to estimate the value of tau in each case, could be pursued. The question of retaining only the 10°N regional structure was also raised.

The workshop noted that for the previous yellowfin assessment advice, only the size composition of 20 and 50 were used. Results from size composition weightings of 10 and 20 produced similar results and hence the 10 was dropped from the final grid. A similar approach was recommended for yellowfin this year.

The workshop discussed the potential to retain the 10°N regional structure only for both assessments. The workshop noted that there should be an *a priori* decision on the regional structure, based upon the ability to capture the patterns of the fishery, and other factors. It was also noted that the spatial structure did not notably affect the results of the yellowfin assessment in the last assessment. For bigeye, the impact of the regional structure assumption was more significant and variable. SPC noted that the 10°N structure did appear to be more stable for bigeye. The workshop noted that there has been a transition from the 20°N structure to the 10°N structure in the previous assessment, and the 10°N structure was generally considered to be 'best' in terms of capturing the spatial structure of the fishery in particular.

The workshop noted that for growth, the bigeye estimate based upon length composition data only was excluded in the previous assessment as it was considered to be unrealistic in the face of age-at-length data. For yellowfin, the equivalent growth model did not appear to have that weakness. The workshop considered that the length composition-only growth estimate should be retained in the grid. SPC noted that the conditional age-at-length, if it can be implemented, would combine size frequency and otolith data, and by using more information should represent a stronger candidate for the grid axis than the length-only estimate.

The ability of the 'Negative Binomial' approach to estimate the overdispersion parameter was questioned. SPC noted that it did appear to estimate overdispersion parameter reasonably well for skipjack, but the performance for bigeye and yellowfin was to be determined. The workshop also noted that the use of the self-scaling multinomial weighting would potentially influence the uncertainty grid structure.

The suggested uncertainty grid is as follows:

Axis	Value 1	Value 2	Value 3
Steepness	0.8	0.65	0.95

Mixing period	1	2	
Overdispersion*	1	2	
Size Composition	20	10	50
Regional Structure	10 N		
Growth	Otolith Only	Otolith and Tag	Conditional length-at-age **

*Note we will investigate estimating the overdispersion parameter within the model which may allow it to be removed from the axis of uncertainty.

** Assuming this feature is available and tested in the MULTIFAN-CL updates.

The workshop suggested:

- **Support to use the 10°N spatial structure only within the grid for both bigeye and yellowfin assessments**
- **The tentative model uncertainty grid indicated above for both assessments.**

Grid weighting methods/approaches

SC15 raised the issue of developing an approach to weighting individual models within model uncertainty grids. John Hampton described some potential approaches to developing more objective weighting levels, given that while values on uncertainty axes are all considered valid, particular combinations of grid models and associated parameters may be considered less biologically plausible.

The workshop noted that generalized cross validation (GCV) estimates had been suggested, while retrospective hindcasting was also a potential approach. The latter had significant computational overheads but could be investigated further. Conducting simulation testing to evaluate approaches would be important to provide input on robust weighting approaches.

Objective approaches to grid weighting were certainly preferred and the workshop encouraged further work in this area. However, the workshop noted that given the workload and likelihood that SC this year would be compressed, the ability of the SC to give the necessary time to this issue would be reduced. The workshop recommended SPC concentrate on the objective grid weighting issue over the intervening time between SC16 and SC17.

The workshop suggested:

- **Objective approaches to grid weighting are certainly preferred, however, the workshop recommended that SPC concentrate on the current assessments for now and increase the focus on the objective grid weighting approaches over the intervening time between SC16 and SC17.**

Presentation of model diagnostics

Graham Pilling (OFP, SPC) highlighted the request from SC15 to present diagnostics across the assessment model grid, as well as for the harvest strategy operating models. He requested members provide any feedback on the types of diagnostics that members wanted to have presented to SC this year. The workshop noted that there will be challenges with those grid combinations that may be less biologically plausible and that is important to be clear on how any diagnostics are to be used in the assessment outcomes/recommendations.

Final remarks

Paul Hamer thanked participants for a fruitful e-workshop and indicated that a draft workshop report including recommendations would be circulated for comment among meeting participants prior to finalisation and submission to SC16. He requested that participants provide feedback on the workshop by completing a survey to be distributed.

APPENDIX 1: Agenda

Wednesday 22nd April (Tuesday 21st US)	**Preparatory Workshop for 2020 Yellowfin and Bigeye tuna assessments** E-meeting (Microsoft Teams), 22 and 23/4/2020 (21 and 22/4/2020 US time) Version 17/4/2020	
09:00 – 09:30	• Introductions • Reminder of ToR and objectives for the preparatory workshop • Agreement on agenda • e-meeting format/procedures • Any other introductory comments	GP/PH
09:30 – 10:30 *Session 1*	• Yellowfin Growth – otoliths (Live: presentation **P1**) • Tag/recapture data for integrated growth modelling (Recorded: presentation **P2**)	JF/MV
10:30 – 11.00	BREAK	
11.00-12.00 *Session 2*	• Integrated growth modelling (Live: presentation **P3**) • Bigeye otolith ^{14}C (Live: presentation **P4**) • Tag formatting, other tag related discussion (Recorded: presentation **P5**)	PE/KO/MV
12.00-13.00	BREAK	
13:00 – 14:30 *Session 3*	• CPUE analyses – YFT and BET (Noted slides: presentation **P6**) • Juvenile Yellowfin purse seine CPUE analysis (Recorded: presentation **P7**)	NDB TV

14.30-15.00 *Session 4*	• Fisheries overviews (Yellowfin: recorded presentation **P8**) (Bigeye: noted slides presentation **P9**)	NDB/MV
15.00-15.30	Discussion and wrap up day 1	GP/PH
Thursday 23rd (Wednesday 22nd US)		
09:00 – 9.20	Get online for day 2 and recap day 1	GP/PH
9.20-10.45 *Session 5*	Developments in MULTIFAN-CL (Live presentation **P10**)	ND
10:45 – 11.00	BREAK	
11.00-12.30 *Session 6*	• Potential application of new approaches (Noted Slides: presentation **P12**) • Length composition (Recorded: **P11** – Tom Peatman) • Stepwise reference model development	NDB/MV/JH/TP
12.30-13.30	BREAK	
13:30 – 14:30 *Session 7*	• Potential model grids • Grid weighting methods/approaches (Presentation: **P13**)	MV/NDB/JH/all
14.30-15.00	Final discussion and Wrap up	GP/PH
Follow-up	• Workshop recommendations/key points circulated: **Thursday 24/4** • Recommendations agreed: **Tuesday 28/4** • Meeting draft paper circulated for comments: **Friday 1/5** • Comments received: **Friday 14/5** • Meeting paper finalised for SC16 submission: **Monday 1/6**	PH

GP Graham Pilling, PH Paul Hamer, NDB Nicholas Ducharme Barth, MV Matthew Vincent, JH John Hampton, JF Jessica Farley, PE Paige Eveson, ND Nick Davies, KO Kei Okamoto, TV Tiffany Vidal Cunningham, TP Tom Peatman

APPENDIX 2: List of participants

Name	Affiliation
John Annala	Ministry for Primary Industries, NZ
Laura Tremblay Boyer	Dragonfly Data Science, NZ
Leyla Knittweis	Ministry for Primary Industries, NZ
Nick Davies	SPC consultant
Rob Campbell	CSIRO, AU
Jessica Farley	CSIRO, AU
Paige Eveson	CSIRO, AU
Sangaa Clark	PNAO
Wetjins Dimlich	FFA Secretariat
Julie Lloyd	FFA Secretariat
Reuben Sulu	FFA Secretariat
Keith Bigelow	NOAA (Pacific Islands Fisheries Science Centre), US
Jon Brodziak	NOAA (Pacific Islands Fisheries Science Centre), US
Mark Fitchett	Western Pacific Regional Fishery Management Council (US)
Eric Chang	National Sun Yat-sen University, TW
Yi-Jay 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
Kei Okamoto	National Research Institute of Far Seas Fisheries, JP
Hiroshi Minami	National Research Institute of Far Seas Fisheries, JP
SungKwon Soh	WCPFC Secretariat
Elain Garvilles	WCPFC Secretariat
Tim Jones	WCPFC Secretariat
Mi Kyung Lee	National Institute of Fisheries Science, KR
Jung-Hyun Lim	National Institute of Fisheries Science, KR
Claudio Castillo Jordon	University of Washington
Juliette Konkamking	IRD, France
John Hampton	SPC
Graham Pilling	SPC

Sam McKechnie	SPC
Matthew Vincent	SPC
Nicholas Ducharme-Barth	SPC
Rob Scott	SPC
Finlay Scott	SPC
Nan Yao	SPC
Peter Williams	SPC
Marino Wichman	SPC
Tiffany Vidal Cunningham	SPC
Paul Hamer	SPC
Tim Park	SPC
Joe Scutt Phillips	SPC
Simon Nicol	SPC
Jed McDonald	SPC

Other input received via email: Francisco "Curro" Abascal: Instituto Español de Oceanografia, Spain.

APPENDIX 3: 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 modelling 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.