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Report from the SPC pre-assessment workshop (PAW), March 2021

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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 thirteenth pre-assessment workshop was held from the 30th March – 1st April 2021. Due to the COVID-19 pandemic, the meeting was held electronically, and focus mostly on the three key stock assessments for 2021: South Pacific albacore *Thunnus alalunga,* southwest Pacific swordfish*, Xiphias gladius,* and southwest Pacific blue shark, *Prionace glauca*. Across the three days over 50 participants joined the workshop. The agenda is provided in Appendix 1 and list of attendees that participated for some or all of the workshop in Appendix 2.

Day 1 focused on data inputs and modelling approaches for the assessment of swordfish in the southwest Pacific, led by Nicholas Ducharme-Barth (SPC). Day 2 focussed on data inputs and modelling approaches for the assessment of albacore in the South Pacific, encompassing both the WCPFC and IATTC Convention areas, led by Claudio Castillo Jordan (SPC) in collaboration with Haikun Xu (IATTC). Day 3 started with an overview of recent developments and consolidation work on the MULTIFAN-CL (MFCL) stock assessment software, presented by Nick Davies, before moving into data inputs and modelling approaches for the assessment of blue shark in the southwest Pacific, being conducted by Saggitus LTD and Dragonfly Data Science (Stephen Brouwer, Philipp Neubauer and Kath Large). Day 3 finished with a presentation from Eric Chang of National Sun Yat-sen University on collaboration work with SPC to improve length – weight conversion equations for bigeye tuna, and a brief update of the follow-up work and the process for peer review of the 2020 yellowfin tuna assessment in the WCPO.

The meeting was chaired by Paul Hamer (SPC, Oceanic Fisheries Programme). The core presentations were made by SPC staff, with additional presentations on age and growth studies for albacore tuna provided by Jessica Farley (CSIRO), and CPUE analysis for swordfish in Australia and New Zealand provided by Rob Campbell (CSIRO) and Owen Anderson (NIWA), respectively. The meeting operated under the terms of reference provided in Appendix 3.

This report briefly describes the various workshop presentations and related comments and discussions with a focus on the important issues and suggestions made. The report does not attribute comments to countries or individuals except where the comment related to the agreement to provide data or to undertake particular analyses. The relevant stock assessment scientists will address any 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 the Scientific Committee (SC17) will be constrained by the ability of the models to converge under the assumptions required, and the data available. The application of new MULTIFAN-CL (MFCL) features recently being developed and tested for new MFCL version 2.0.8.0 may also be used for the albacore and swordfish assessments. It should also be noted that the PAW is conducted in the very early stages of the development of the assessments, and issues will often come up that are not raised or discussed in the PAW. The stock assessment team may consult with particular individuals and countries as required to provide clarity on specific issues, particularly those related to data inputs. Ultimately the final decisions on model development, data inclusion, and structural uncertainty are made by the SPC assessment team, or in the case of South Pacific albacore in 2021, the SPC/IATTC assessment team, and documented in the assessment report that is reviewed by the Science Committee (SC) of the WCPFC. The comments and discussion related to the various presentations are noted in the document, with the comments etc. from the PAW participants in ***bold italics text*** followed by the responses in plain text.

The outcomes of this meeting will be reflected in the papers submitted to WCPFC-SC17. Copies of presentations prepared for the workshop can be provided on request to Paul Hamer (paulh@spc.int).

DAY 1 – Southwest Pacific swordfish

Stock assessment overview presentation

Spatial/fishery structures and fishery data

The assessment of southwest Pacific swordfish will be conducted with the most recent MFCL version 2.0.8.0. The overview presentation from the lead assessment scientist, Nicholas Ducharme-Barth – SPC, began with a review of the previous assessment conducted in 2017 (Takeuchi et al. 2017). The spatial and fishery structures used and the uncertainty grid of 72 models were summarised as well as the results for the key management quantities. The result of the 2017 assessment showed that the stock had declined steeply since 2000, and, for numerous models in the uncertainty grid, overfishing was suggested to be occurring.

A number of recommendations were made from the 2017 assessment, some of these related to, or depended on, improvements in data collections, including more sex specific data, and more detailed operational data on longline setting practices etc.. Improvements to data collection have, however, not occurred to any great extent since the last assessment, although, some key recommendations will be followed up for the 2021 assessment including:

- further exploration of a multi-sex approach
- improving CPUE standardisations
- considering the area of high catches near/outside the north east corner of WCPO assessment region

The 2021 assessment proposes to apply the same spatial structure as the 2017 assessment as there are no new information or recommendations to support changing this. The structure will therefore have two regions, and three fishery areas within each region (Fig. 1). The same fishery structure as the previous assessment will be applied with the exception that the Spanish fleet (ES) will be separated out from fishery 5 to become a separate fishery due to their catches being mostly reported in metric tonnes (i.e., lacking the catch in numbers data that other longline fleets report) (Table 1). Furthermore, as the vessels assigned to Vanuatu (VU) are actually distant water vessels fishing under charter (i.e., mostly from Chinese Taipei), for the 2021 assessment, they will be removed from fisheries 5, 12 and 13 and included with the more similar distant water fleets, i.e., fisheries 1, 2 and 6-8 (Table 1).

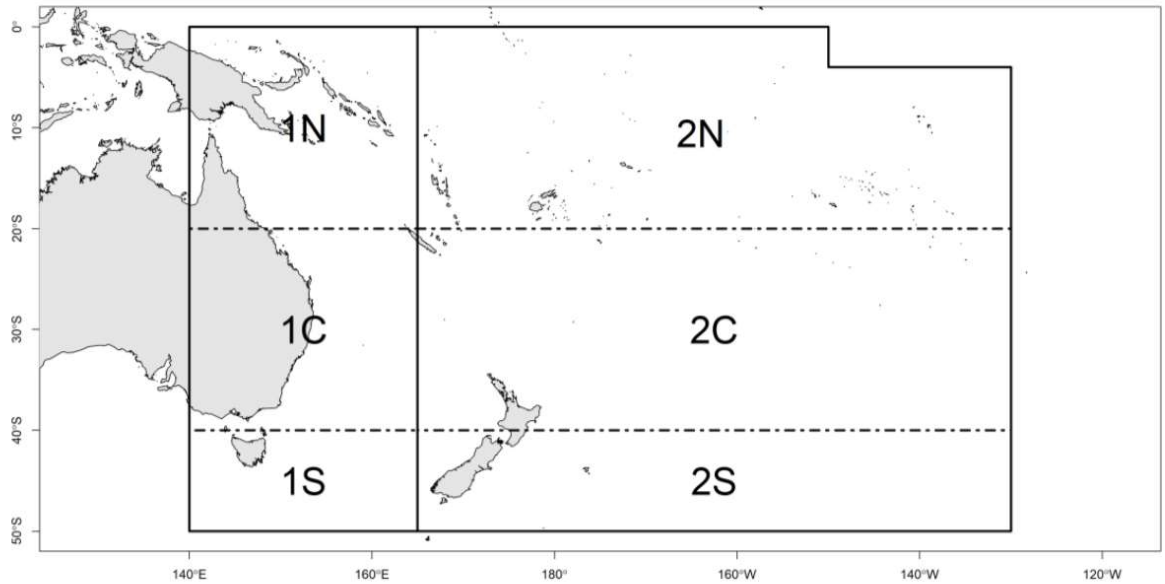

Figure 1. Map showing the regional and fishery area structure for the 2021 southwest Pacific swordfish assessment.

Table 1. Fishery structure proposed for the 2021 southwest Pacific swordfish assessment.

Fishery	Flags	Areas	Year start	Year end
1	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS,	1N		
2	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS,	1C		
3	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS,	1S		
4	AU,	1N,1C,1S		
5	AS, BZ, CK, ***ES***, FM, FJ, PF, ID, KI, MH, NC, NZ, NU, PG, PH, WS, SB, TO, TV, USAS, USMC, USHW, US, ***VU***,	1N,1C,1S		
6	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS,	2N		
7	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS,	2C	1952	2000
8	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS,	2C	2001	2019
9	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS,	2S		
10	NZ,	2S,2C		
11	***ES***, PT	2N,2C,2S		
12	AS, AU, BZ, CK, FM, FJ, PF, ID, KI, MH, NC, NU, PG, PH, WS, SB, TO, TV, USAS, USMC, USHW, US, ***VU***,	2N		
13	AS, AU, BZ, CK, FM, FJ, PF, ID, KI, MH, NC, NU, PG, PH, WS, SB, TO, TV, USAS, USMC, USHW, US, ***VU***,	2C		

An overview of the available catch and composition data from each of the defined fisheries was then provided. Discussion was then invited on:

- The proposed fisheries and spatial structures,
- Weight composition bin size (currently 10 kg), option to reduce to 5 or even 2 kg, noting length bins cannot go below 10 cm due to rounding,
- Apparent conflict between weight & length frequency data for some fisheries,
- Re-balancing multi-flag fishery size frequency data to be representative of the flag-specific spatio-temporal catch (i.e., size frequency reweighting),

- Treatment of the size-frequency likelihood → SSMULT-RE,
- Key sensitivities as related to data inputs,
- Inclusion of high catches to the north east of subregion 2N.

Comments and discussion:

- ***Comment on reducing weight bin intervals and rounding issues.*** There is no clear indication of rounding in the aggregated weight composition data but will need to look more closely at the fleet level to be sure, will then consider reducing weight frequency bins.
- ***How will conflicts in size composition data between the AU and NZ fishery impact the result of the assessment?*** We will try to reduce this issue by choosing the most representative compositional data (either weight or length) from these fisheries.
- ***Suggestion to consider time varying selectivity for some fisheries that have varying contributions for different flags (with potentially variable sample sizes and different selectivity) overtime (noting the need for good sample sizes*)**. *Also, which fisheries catch the largest fish, and are there issues with lots of variability over time in which flags and sizes are contributing to that fishery.*** Subject to available time, time varying selectivity may be explored for fisheries with sufficient size frequency data to indicate and estimate selectivity changes.
- ***Suggestion to be careful when reducing weight bins as the weight intervals lower than their equivalent length bin intervals for the population may cause issue for the model***. This is apparently not a concern for MFCL.
- ***Given the variable sample sizes and different flag contributions overtime, is it possible to consider the most reliable and representative flags data overtime for informing selectivity?*** Time-permitting it is possibly worth looking into for some fisheries although there is a lack of long-term temporal consistency in the contributions of size composition data for specific flags that might be considered for this (e.g. Japan). Also query about available sex-based composition data, however, very little sex specific data is available across the model region.
- ***Question on reweighting of compositional data.*** Plan is to apply the approach as previously applied to yellowfin, bigeye and albacore to re-weight the size composition data to make it more representative of the catches for the extraction fisheries and the abundance for the CPUE indices.
- ***The issue of size composition data for specific flags changing from length to weight measurements overtime.*** This was raised as an issue for Spain, and it is planned to just use the weight composition data for this flag and make it a separate fishery. Acknowledged there can be issues with lack of composition data if individual flags are treated as separate fisheries.
- **Some discussion on the starting time given the lack of size composition prior to early 1990s.** Preference is to start the model as early as possible where there is catch data (i.e., 1952) – we may consider exploring a starting year from when size composition is available as a sensitivity, time permitting.
- **Suggestion to further explore the regression tree approach to stratify fisheries *(i.e., as applied in EPO and for the albacore assessment)***. Agreed this approach could be useful but would not have the time to explore for the current assessment.

- ***Some discussion on the basis of the length or weight composition data.*** Confirmed they are from port and/or observer sampling of length and weight for the same fish. However, worth looking more closely at the conversions and processes for this sampling to increase confidence in data. The length-weight relationship is assumed stationary and consistent across the model regions, which is also unlikely.
- **Discussion on the high catch area that partially overlaps the north east boundary of the WCPO model regions.** We will include these catches as a sensitivity and may also explore altering the size of the catch area included.

New model ensemble approach

Presentation titled: ***Focusing on the front end: A framework for constructing model ensembles for use in integrated stock assessment***, was presented by Nicholas Ducharme-Barth. This presentation outlined a new approach for constructing model ensembles to describe uncertainty in management quantities. It is proposed to apply this new approach to the 2021 swordfish assessment as an improvement on the traditional orthogonal uncertainty grid as a test case. The new approach involves developing a multivariate prior for the key biological uncertainties and then drawing from this prior to develop the ensemble of models for capturing the uncertainty in the derived management quantities. The approach propagates parameter uncertainty and correlation through the stock assessment while providing an implicit model weighting based on data and previous analyses. A proof-of-concept study was presented using the previous swordfish model comparing the results from the new approach with the traditional orthogonal grid. The new approach showed better performance in all the comparisons; including robustness of estimates (i.e., $SB/SB_{F=0}$, SB/SB_{MSY}) to the Hessian being positive definite or not, numbers of models required to run, and spread of uncertainty (i.e., unrealistic parameter combinations have very low probability of being included compared to the orthogonal approach, the approach has implicit weighting of parameter combinations).

An approach for presenting results that better represents the combination of structural uncertainty from the ensemble models, and the statistical uncertainty from the individual models was presented. The approach represents the statistical uncertainty of the individual models based on parametric bootstrapping. The approach combines all the bootstrap samples for the individual models into the ensemble so that full ensemble of models includes both statistical and structural uncertainty on the management quantities. Example showed how the inclusion of structural and statistical uncertainty expanded the range of uncertainty but importantly presents a more holistic measure of uncertainty.

In summary the study showed:

- The new approach was more efficient, i.e., management advice provided from 30 model or 300 model ensembles was statistically similar,
- More stable optimization, and marginally better convergence rate,
- Marginally better total likelihoods,
- Reduction in parameter/structural uncertainty by using parameter correlation and life-history information to remove implausible combinations.

Comments and discussion:

- ***Question on whether to consider using the model performance diagnostics for the ensemble approach to support inclusion/exclusion/weighting of models.*** Response was that the model ensemble approach fits well with the use of diagnostic-based approaches to weighting models (i.e., as being developed by IATTC). The combined statistical and structural uncertainty will also provide a better picture of the overall uncertainty.
- ***Query on how to determine the CV for the joint priors, specifically for growth parameters.*** It can be determined from the external data set, and the CVs can be fixed in the model. Building the appropriate priors still requires representative data. Some follow-up discussion around penalized likelihoods, similar to imposing priors on poorly estimated parameters with flat likelihoods within the model, i.e., the likelihood is penalized as parameter estimates move away from some prior "best guestimate". Perhaps, for at least key biological parameters that cannot be well estimated in the model – the proposed ensemble approach might be preferable as it better captures the uncertainty in available information.
- ***While further work is required, the PAW provided good support for the new Bayesian ensemble approach, considering it a positive step forward***. ***It was pointed out that despite ensemble models, we still need to be mindful that such an approach is not going to deal with the uncertainty issues related to poor data going into the model, particularly historical data that it is hard to ascertain the quality/representativeness of.***
- ***It was mentioned that with this approach it could mean that some of the biological parameters that could be estimated more appropriately within the model (e.g. growth) may be dealt with outside the model.*** Pros and cons to estimation internal and external to the model. In relation to growth parameters, it was argued that the limitations of the age – length data set and other compositional data in the model, it is a safer approach to estimate the growth parameters and associated uncertainty outside the model and include as part of the multivariate parameter distribution. This approach will be used in the assessment. The issues/implications of external versus internal estimation on management outputs could be explored through further simulation studies.
- ***It was noted that the similarity among the converged and non-converged model results for the new ensemble approach may suggest the non-converged models may either need more iterations or be due to nuisance parameters. Further exploration of the non-converged models could be worthwhile.*** This could be possible thanks to a new feature of MFCL that can identify parameters that are preventing the Hessian inversion (-ve eigenvalues). Seems that for very complex models with lots of parameters it may often be a few nuisance parameters.
- ***Suggestion to consider using likelihoods (i.e., overall fit) for the models to contribute to weighting them in the ensemble for presenting the management advice.*** This could be possible and would be considered as part of the next phase of work on this new ensemble approach.
- ***Should the new ensemble approach should be presented alongside the traditional orthogonal grid for this assessment?*** Further consideration on this may be required, but the preference is not to do this as it might muddy the waters. Propose to only present the new ensemble

approach in this assessment but may consider, time-permitting, running a traditional orthogonal grid for comparison.

- ***When using this method for the projections, how would this compare to the orthogonal grid approach?*** Expect that this would function in same way as a conventional grid projection, every model from the ensemble would be used in the projections.

Biological assumptions

Presentation of the biological assumptions was provided by Nicholas Ducharme-Barth, who also provided an overview of the biological parameters used in the previous assessment. These were discussed in relation to developing the joint prior for the model ensemble. Acknowledgement of the recent swordfish review work conducted for SPC by Brad Moore of NIWA (Moore et al. 2020) that supported further analysis of biological parameters and development of a two-sex model. Information on growth parameters from recent otolith ageing (i.e., Farley et al. 2016, WCPFC-SC12-2016/SA WP-11), spawning potential ogive, and length/weight relationship was discussed. Data on sex ratio at length and length/weight relationships was obtained from observer data held by SPC. Models used to generate the joint prior were implemented in STAN. Presentation of re-analysed growth data showed an error in the previous assessment model due to an incorrect conversion to lower jaw fork length, this has been rectified. In relation to the spawning potential (i.e., sex-ratio x female maturity) ogive, MFCL can now use maturity at length which is preferred over maturity at age. Strong prior on 50:50 sex ratio at smaller sizes, but minor effect. Some difference in the length-weight relationship were observed in the updated analysis, and females appeared heavier than males of the same length for the larger sizes.

For natural mortality, review of the previous approach showed some unusual natural mortality models were applied with some having higher M for larger/old fish compared to small juveniles. This seemed inappropriate and as there was no information to justify the earlier M approach, an alternative is proposed to model M at age using the adult M (estimated from the approach of Then *et al.* 2015) and applying the method used in Stock Synthesis to create a Lorenzen M-at-age for males and females. It was acknowledged that other approaches are possible, and advice was sought from the PAW.

For steepness – a uniform prior (0.65-0.95) was applied in the trial study, but alternative approaches were explored including Thorson et al., (2017) (FishLife) and Mangel et al., (2010). The Mangel et al. approach required information on survival of the egg and larval stages, which is not available for swordfish but has a major influence on the steepness distribution produced. This approach was deemed inappropriate, but choice of approach is still to be decided, the default being a uniform prior.

Comments and discussion:

The discussion mostly focused on steepness.

The large spread of the steepness distribution produced by the Thorson FishLife method was pointed out, in particular the really low values included in the predicted distribution. Probably due to the large range of species information used and included in the RAM legacy database. It was noted that given the uncertainty in the steepness value that it is important to include a suitable range of values.

A follow-up comment suggested to be wary of these meta-analysis approaches, and there was no evidence for low steepness values for tuna like species such as swordfish.

For paramaterising M at age, consider the Maunder IATTC method. This was tried but provided results that didn't seem realistic, males had very much higher M at the same ages as females for younger fish. Mark Maunder to follow up with Nicholas on this issue.

Additional comments. ***Included to use appropriate growth models for younger fish of species with dimorphic growth. And that there is enough evidence from other billfish to suggest high steepness values are more likely, so use this information to get the ballpark right***.

The sensitivity of management quantities to various growth parameters was mentioned, specifically t_o that seems influential in the ensemble models e.g.., t_o = - 2 years, is not realistic but an artifact of selectivity in the sampling process. It is worth considering alternative constrained growth models to fix the t_o at something more reasonable. It would be possible to place priors on t_o, currently use a broad prior, but perhaps better to use a much lower and narrower prior.

Questions on MFCL capacity to use different growth models for different parts of the growth curve, i.e., linear for up to L1 then say VB after that. MFCL is not as flexible as SS is for growth modelling, but good to try this externally.

Question about incorporating variance around the growth curve. Variance around growth curve can be estimated externally and fixed or internally, internal estimates are higher.

Suggestion to include a steepness of 1, as then can compare to the IATTC swordfish assessment that uses 1. This can be included, or at least a value very close to 1. (But note the follow-up comment on steepness of 1 being implausible and therefore should not be used).

Suggestion to use a more flexible growth curve, i.e., Richards. Agree, worth looking into and trying the Richards, time-permitting.

Multi-sex considerations

A multi-sex model was a recommendation from the last assessment due to the dimorphic growth of males and females (females larger in size and weight at age). The previous assessment ran a two-sex model as a sensitivity. Some recommendations were derived, including: define selectivity as a function of length, define zero-selectivity as a function of length not age, apply alternative forms of selectivity beyond cubic spline and logistic for multi-sex models. Progress on recommendations from the previous assessment has been limited and there has been no real progress on improving sex-specific data collections.

A summary of available sex-specific data was provided, indicating that sex specific data is limited compared to sex aggregated data, so even if running a sex specific model, the aggregated data will still be used to drive most of the dynamics. Spatial patterns in sex ratios were displayed, emphasizing the occurrence of large females in the south west area of the WCPO (especially around NZ) and males in the north east area. Male and female LF data is only really available from the 2000's. Large females also do appear in the north east corner of the assessment region in different quarters to when they occur in the southwest region. More research is required to understand the relationship between the swordfish in the north east region of the southwest Pacific and across the different convention areas.

Preliminary model runs of multi-sex models against the single-sex model showed that inclusion of sex specific data did not result in significant changes in spawning potential (biomass) trends, however when applying female weight conversions, the spawning potential was, as expected, notably higher (females being larger than males) but with similar trends and variation as the single sex model. The multi-sex model however, did not achieve a positive definite Hessian.

The planned approach is to develop the assessment as a single-sex model, with the intention of basing management advice off a single sex model ensemble. Pending continued refinements to MFCL's multi-sex capabilities, a multi-sex version of the single sex model will be developed as a sensitivity to ensure that management reference points are not overly biased due to biological simplification.

Comments and discussion:

- ***Question on natural mortality at age by gender if a multi-sex approach, what are the base assumptions.*** The test models with sex specific biology used a Lorenzen mortality at age, with higher mortality for males.
- ***Question about sex ratios at age rather than length.*** Important to follow-up on the sex ratio at age, to be confident in the assumption of higher natural mortality at age for males. Some indication of higher proportions of larger/older females in the age samples, however, more data needed to increase confidence in sex ratio at age for older ages.
- ***Under the proposal to run a single sex model, to account for the variation in growth between males and females it would be important to increase the CV on growth.*** Agreed, for a single sex model it would be important to account for this extra variation in growth.
- ***Comment that it does not make sense to run a single sex model when you know you have different growth, even if you have other parameters shared.*** A multi-sex model will be attempted pending fixing some issues with the multi-sex features of MFCL. It is important to note that currently the multi-sex model does not return a positive definite Hessian solution.

CPUE

Nicholas Ducharme-Barth provided an overview of the five CPUE time series (two in region 1 – DWFN (Japanese) and AUS – provided by CSIRO, and three in region 2 DWFN x 2 split pre and post 2001 and the Spanish fleet) and the core vessel filtering approach used in the previous assessment. Concerns were raised over the previous assessment in relation to the time of CPUE splitting for DWFN (i.e., Chinese Taipei) in region 2, and loss of data due to the core filtering approach, the use of single fleets (i.e., Japan and Chinese Taipei) to represent the entire DWFN fleets, fitting to multiple indices in a region, and need for overlap between the split indices.

It was discussed that opportunities for improvement are available using the index fishery approach, including the AUS index, and the spatio-temporal VAST approach for other fleets to get past the need for core filtering. Also, if splitting the Chinese Taipei index, it seems more appropriate to split in the 1990s rather than 2000. Considering the issue of fitting to multiple indices within a region, conflict could be mediated via iterative re-weighting of CPUE or including fits to individual CPUE indices as axes in the uncertainty grid (i.e., similar to previous striped marlin assessment). If using split indices, it might be possible to force overlap by going to index fishery approach, and provide a high CV for the overlap period. Also, need to take care to partition size-frequency data and CV of indices in the overlap period to minimize the impact of using data twice.

The CPUE presentation finished with a summary of things to consider for the CPUE analysis. Should multiple indices be used within each model region? If so, how should conflict be dealt with: iterative re-weighting or through the structural uncertainty grid (current preference is the structural uncertainty grid, although longer-term iterative reweight would be better but MFCL not set-up to do this). If an 'index' fishery approach is used for the DWFN CPUE, should it also be extended to AU and ES CPUE? What is the most appropriate approach for dealing with split CPUE indices if there is no other index to bridge the split? Should NZ CPUE be included in the assessment model?

Discussion was deferred until after the NZ and US CPUE presentations.

Presentation of the New Zealand CPUE analysis

Owen Anderson (NIWA) provided a presentation on recent work conducted on CPUE for swordfish in NZ waters (longline fishery). Swordfish CPUE has shown an increasing trend since 2004, which corresponds to the introduction of swordfish to the NZ quota system and it becoming a target fishery (i.e., targeting was not allowed prior to 2004). The analysis considered the NZ fleet fishing to occur primarily around the north island, where as the DWFNs focus more along the west coast of the South Island targeting blue fin tuna and some larger swordfish. Summary of catch and effort data showed peaks in catches around 2001 and 2011, peak effort in 2002 with much lower effort since 2005, and an increase to a peak of nominal CPUE (6 fish/1000 hooks) from 2011-2015, with a declining trend since. Higher catch rates occur in the warmer months (Q1, Q2).

The current analysis is similar to previous in applying a GAM model fitted to the CPUE data with quasi-Poisson error distribution for zero catch rates and over dispersion (20+ predictors explored). Zero catch sets declined from 1993 to 2011 and have started increasing recently. All vessel and core vessel series used over the period from 1993 -2019 (all years), with a separate series from 2004 when quota was introduced. The key predictors for 2004-2019 were: All vessels; Year-quarter, night fraction (proportion of set at night), light stick rate and vessel, and for the Core-vessels: Year-quarter, night fraction, light stick rate and longitude*latitude. Core vessel models have better fits.

Comments and Discussion on New Zealand CPUE presentation:

- ***Comment on the encouraging similarity of CPUE patterns between NZ and Australian data, and question on taking into account quota allocations within standardization, i.e., could it be capping or constraining CPUE?*** Have not explored the implications of quota allocation to CPUE standardisation, suspect it wouldn't have much of an effect.
- ***Are discards recorded and if so, are they taken into account, also have you looked at patterns in CPUE overtime across areas. Finally, is there a trend overtime in the proportion of effort***

targeting swordfish pre- and post-quota being implemented? Discards are recorded and counted, and areas fished vary during the year, but didn't separate the CPUE into spatial sub-regions for this analysis, targeting was considered in the analysis but didn't come out as a strong predictor.

- ***Question on the pattens of % zero catch sets, could this be related to changes in season or locations where fishing is occurring.*** Not really any major changes, seems to be the inverse of the CPUE data as would be expected.
- ***Question on why moon phase didn't come up as a strong predictor as it does in Australia?*** Not sure, perhaps the moon phase effect is outweighed by light stick use?
- ***Comment on light sticks, when were they starting to be used, how is it recorded?*** Fishing vessels self-record light stick use and have done since 2004.

Presentation of the Australian CPUE analysis

Rob Campbell (on behalf of CSIRO) presented an overview of the Australian swordfish CPUE analysis which is updated each year to be used in a harvest control rule to guide swordfish management in the Australian EEZ. Swordfish are fished as part of the Eastern Tuna and Billfish Fishery (ETBF). Targeted fishing for swordfish started in the mid-1990s out of Mooloolaba, southern Queensland. Peak effort in the ETBF occurred in the early 2000s, declined to the mid-2000s and has since stabilized. About 40 vessels operate at the moment and set about 8,000,000 hooks per year.

Information on gear has been reported in the ETBF since 1998, so CPUE standardization starts then, i.e., bait type, bait is dead or alive, start time of sets, hooks between floats, light stick usage, distance between floats, hooks per kilometer, mainline length. Data showed how some gear settings have changed overtime. Spatial issues were discussed (i.e., variation in where fishing has occurred overtime) and the preference to reduce the impacts of the spatial variation by restricting the CPUE data for the index to a core spatial area. A core area was defined with 7-9 large sub-strata that have homogeneous catch rates (i.e., catch rates tend to be higher further offshore). Data is in 1 x 1° squares. The core region generally accounts for over 90% of catch and 80% of effort. Analysis used a two stage GLM process; first stage models the probability of a positive catch, pS (Binomial, Logit link: 130,189 records) and the second stage models the mean size of the positive catch rates, μS (Gamma, Log link: 88,196 records). Various effects were fitted, Statistical: year*quarter, and quarter*area, Gear: start time of set, bait-type, hooks between floats, % of light sticks, mainline length, distance between floats, hooks per km, target species, Environmental: moon phase, bathymetry, wind speed, mixed layer depth*area, SST*area, SOI*area, Others: number other vessels in same 1 degree square by day, number of other vessels in each one degree cell by month. Effects were fitted as categorical variables using ranges of values to define categories, with moon phase as a continuous variable. Assigning target categories used a cluster analysis (i.e., He et al. 1997). The catch data includes both retained and discarded. A recent increase in discards is thought due a large influx of small swordfish. Results used to calculate the standardized index in each year, quarter and area strata. The overall annual index was calculated by first calculating the area-weighted sum of the standardised index across all areas and then taking the average across all quarters.

Results were shown by quarter and the annual indices by size class (recruit, sub-adult, adult and all sizes). Adult, sub-adult and all sizes indices showed declining trend from 1998 until the early 2000s after which CPUE increased through to 2008 then remained stable until 2014 after which it declined again. The all sizes and quarterly index suggest the start of an increasing trend from 2018, which seems driven primarily by a recent increase in the catch rates of juveniles. Information on relative effects of covariates was shown. More lights sticks = higher CPUE, lower HBF = higher CPUE, sets starting late afternoon = higher CPUE, moon phase – increasing CPUE from the new to full moon.

Comments and discussion on Australian CPUE presentation:

- ***Question regarding increase in discards in recent decade – could it be a response to E-monitoring?*** This can't be discounted. Used observer data to help classify the discards – which comprises the juvenile index, but discards should not influence the adult or sub-adult indices.
- ***Question regarding recent divergence between nominal and standardized CPUE (i.e., nominal dropping away, but standardised stable or increasing).*** Likely due to changes in the availability of squid bait (the preferred bait for swordfish) which has become less available and expensive in recent years and the model is accounting for this lower use of squid bait.

The CPUE session then returned to discussing the approach for the current analysis. The value of having reliable and comprehensive fishing gear, bait and other operational data was demonstrated by the Australian and New Zealand presentations. Unfortunately, very little information on these types of gear/operational factors is available for DWFN and EU vessels. Prefer to use covariates if you have them, and to do this may consider splitting indices to take advantage of more recent years when covariate data is more available.

Note the follow-up discussions (below) with Japan that have helped inform the CPUE analysis.

Proposed model development and approach for characterizing uncertainty

Some initial work has been done, including testing the new version of MFCL (2.0.8.0) and updating the biological assumptions through the ensemble model approach and specification of the joint prior. Some key things will be investigated, including; multi-sex, if time the SSMult-RE for the size frequency likelihood and how it interacts with estimated selectivities, and the alternative CPUE indices. The iterative re-weighting of standardized CPUE CVs for multiple indices may be considered if time. The proposed model stepwise was presented: 1. Clean-up 2017 doitall script, 2. Update exe to v2.0.8.0, 3. Update biological assumption i. Growth ii. M iii. L-W iv. Spawning potential, 4. Update CPUE approach - VAST, consider splitting/combining some indices (PAW discussion) 5. Lag between spawning and recruitment, 1 => 2 yrs, 6. Update data through 2019 i. Consider redefining EU/DWFN fisheries, ii. Consider wt. comp bin size, 7. Update composition data (Peatman approach?), 8. Refine selectivities to improve fit to composition data, 9. Additional steps pending results from investigations, i.e. SSMULT-RE.

Various sensitivity analysis were also proposed, including: Inclusion of high catches adjacent to the north east of the assessment region, movement assumptions (Use diffuse (σ very large) bivariate distribution for bi-directional movement rates in joint prior, Bulk Transfer Region 1→2 ~ exp(Normal(log(0.07), σ), Bulk Transfer Region 2→1 ~ exp(Normal(log(0.028), σ)). Implement a single region assessment assuming well-mixed population. Initial population assumptions, 1952 population is at unfished equilibrium, sensitivity to maximum F allowed in the catch equations.

The presentation finished with the proposed uncertainty characterization that will utilize the model ensemble framework combining joint prior with uncertainty axes if needed. Models will be screened based on convergence (gradient criteria & positive definite Hessian solution). Statistical and structural uncertainty to be combined across ensemble of models via parametric bootstrap.

- Joint prior
  - Growth
  - M
  - Spawning potential
  - Length-weight
  - Steepness
  - Movement
- Potential axes of uncertainty
  - Size frequency weighting (pending SSMULT-RE investigation)
  - CPUE (pending index fishery and iterative re-weighting investigations)

Comments and discussion:

- ***Question on the approach for considering diagnostics.*** Diagnostics will be provided in the assessment report and tracked with each step.
- ***Comment that the Bayesian ensemble is a good approach but the model estimations will still come down to the data. Suggestion to decide the data weightings before running the assessment grid due to conflict among data sets, better to try to reduce the conflicts.*** Will investigate the data first and consider pre-weighting approaches and other ways to decrease data conflicts.
- ***Comment on large increase in the CPUE in the 1970s, related to Japanese data.*** *Targeting makes a huge effect on swordfish catch rates, however, only a few species available for target cluster analysis - maybe ask Japan for more information on baits (e.g. squid etc.) and hooks between floats that can provide useful information on targeting*. Will follow-up with Japan.
- ***Further discussion on splitting indices, noting how it is difficult to connect two time blocks of CPUE together. Perhaps better to just break the indices. However, further comments suggest splitting can cause problems as the discontinuity can allow the model to do strange things. Suggestion of a logistic type ramp between split indices to allow a change of selectivity. Still no clear way forward on best approaches to splitting indices when there is no overlap period or other index to provide a bridge, Nicholas is kept awake at night by this so we need a solution!***

Closing remarks and acknowledgment by chair to end day 1.

Follow-up regarding CPUE analysis for south west Pacific swordfish

CPUE analysis

Further exploration of the data available for CPUE analysis raised issues regarding shifts in targeting practices by time and fishing areas, gear changes (i.e., kuralon to monofiloment mainlines) and changes in reporting procedures, that would be difficult to account for in the CPUE models. As such it was necessary to consider splitting indices both temporally and spatially, particularly for the Japanese (the longest time series of CPUE) and Chinese Taipei fleets.

A follow-up meeting with Japanese scientists (2/6/2021) was required to discuss the most appropriate splitting for the Japanese CPUE data. Several issues were raised:

1. Changes in reporting procedures in 1973-74 that likely influenced the quality of catch and effort data (i.e., improved reporting from 1974)
2. Changes in the mainline material from kuralon rope to monofilament in the early-mid 1990s
3. Difference in fishing/targeting practices between regions 1 and 2

To account for these changes, agreement was reached with the Japanese scientists to split the Japanese CPUE as follows:

- 1952-1974; Region 1
- 1952-1974; Region 2
- 1975-1993; Region 1
- 1975-1993; Region 2
- 1994-2019; Region 1
- 1994-2019; Region 2

Splitting between model regions 1 and 2 will involve separate calculation of the CPUE indices by region, i.e., applying the VAST modelling to region 1 and 2 separately for the Japanese and Chinese Taipei fleets.

The Chinese Taipei fleet appeared slower to change mainline materials. The CPUE for this flag will be split slightly later, but also showed differences in apparent targeting between region 1 and 2 that could not be standardised out due to lack of gear covariates. The Chinese Taipei CPUE will be split as follows:

- 1964-1997; Region 1
- 1964-1997; Region 2
- 1998-2019; Region 1
- 1998-2019; Region 2

Finally, the CPUE to be considered for other fleets are as follows:

AU: 1998-2019 (region 1 only), NZ: 2004-2019 (region 2), ES: 2004-2019 (region 2)

Bridging of the Japanese indices across the splits 1974 and 1993 will hopefully be possible using the Chinese Taipei CPUE.

There are now multiple CPUE series that could provide abundance indices in model regions 1 and 2. We will therefore be required to determine an approach for weighting these indices in the model fitting if the multiple indices for each region are ultimately retained in the model or consider including fits to individual CPUE indices as axes in the uncertainty grid.

DAY 2 – South Pacific albacore

Stock assessment overview presentation

Spatial/fishery structures and fishery data

The assessment of South Pacific albacore will be conducted with the MFCL version 2.0.8.0 and cover the entire South Pacific. As such it will be a collaborative effort between SPC and the IATTC, with Haikun Xu. The overview presentation was provided from the lead SPC assessment scientist, Claudio Castillo Jordan – SPC. He began with an acknowledgment of the various people and groups contributing to the assessment before a review of the previous assessment conducted in 2018 (Tremblay-Boyer et al. 2018). The previous assessment was restricted to the WCPO (including the WCPFC-IATTC overlap area) and involved a 5-region model structure, simplified from the previous 2015 assessment that used an 8-region structure. The 2018 assessment also introduced the index fisheries approach and the geostatistical standardisation of CPUE. The key result from the assessment, that included an uncertainty grid of 72 models (steepness, M, growth estimation, size frequency weighting and CPUE method), was the median spawning depletion ($SB/SB_{F=0}$) estimated at 52% (noting the interim TRP of 56%). Recommendations from the 2019 assessment included:

- Growth: Alternatives to Von Bertalanffy growth and increased otolith sampling for smaller individuals in southern regions
- Investigation into longline selectivity changes across the region accounting for oceanography and size-distribution
- Ongoing refinements to the geostatistical approach to standardizing CPUE (including vessel effects)
- Development of a sex-specific assessment model for South Pacific albacore, allowing sex specific settings for key demographic parameters, such as natural mortality and growth.
- Improve the weighting of the size data component of the likelihood through use of new methods to estimate effective sample size (i.e., SSMULT).

The 2021 assessment will have some notable differences to the 2018 assessment; specifically, a new regional structure incorporating the eastern Pacific Ocean (EPO), a new (refined) growth model, and will be implemented in a new version of MFCL. These changes will by necessity require some changes to fleet structures and of course the addition of a substantial amount of new data and model development work.

An overview of the South Pacific albacore spatial catch and effort history and catches by gear types was provided.

An information paper was circulated prior to the meeting to describe the proposed regional and fleet structure for the 2021 assessment. Presentation of this paper was provided by Paul Hamer (SPC) and Haikun Xu (IATTC), which covered the various regional structures used in previous assessments, information on migratory dynamics and spatial composition data. The information presented was used to provide support for a proposed four region model structure, with some stratification of fleets within regions (Figs. 2, 3).

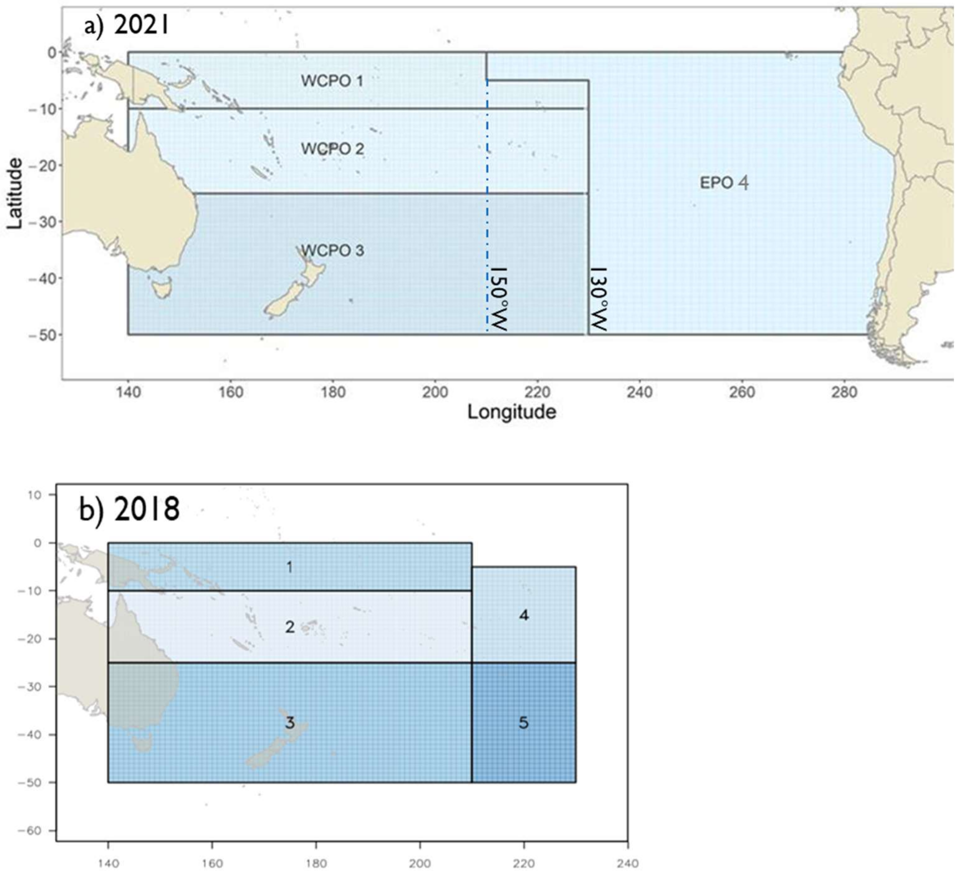

Figure 2. a) Proposed 4-region model structure for the 2021 South Pacific albacore assessment, encompassing the WCPO (Western and Central Pacific Ocean) and EPO (Eastern Pacific Ocean) regions. The boundary of the 'overlap' region between the WCPFC and IATTC areas is indicated by the dashed line at 150°W. b) 5-region model structure applied in the 2018 assessment restricted to the WCPO including the 'overlap'.

The 2021 regional structure, even with the addition of the EPO region, is simplified from the 5-region structure applied to the WCPO in the 2018 assessment (Fig. 2b). However, while 2018 model regions 4 and 5 are proposed to be removed from WCPFC/IATTC "overlap", this area is still important to consider as separate fishery strata because evaluation of different management options for fisheries in this ‘overlap’ area will likely be required in the future. To account for this, within each of the three WCPO regions proposed for the 2021 assessment separate fleet areas (areas as fleets) will be allocated for the areas of these region that are within the ‘overlap’ region. Further, for the EPO region an analysis was conducted of size composition data following the method of Lennert-Cody et al. (2010, 2013) to guide the allocation of fishery strata (areas as fleets) for the EPO region. This analysis suggested that three strata captured most of the within region variation in composition data (Fig. 3, Table 2).

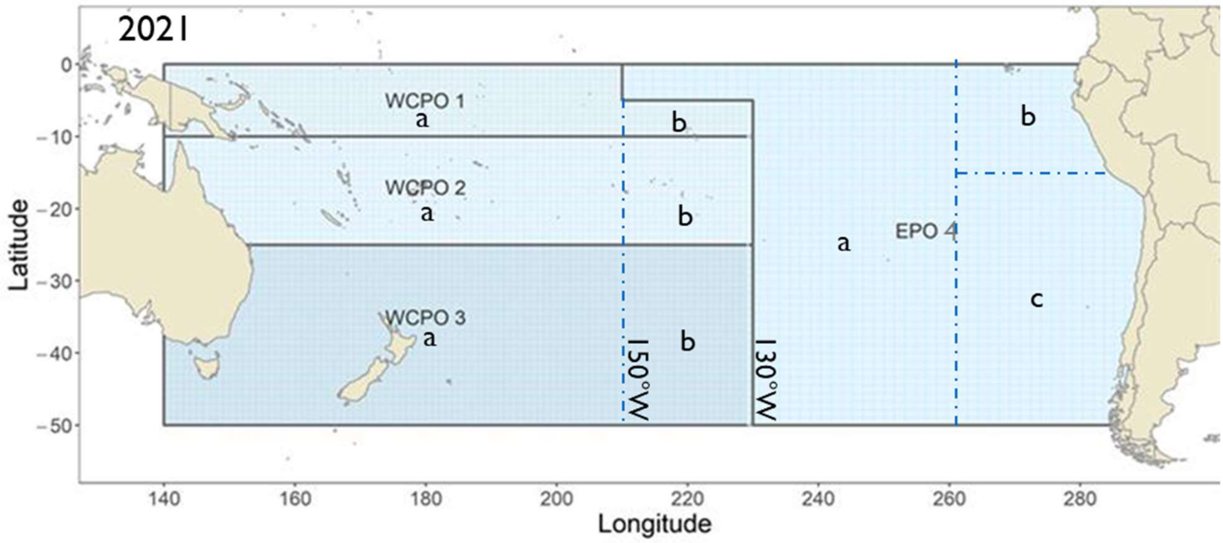

Figure 3. Proposed 4-region model structure for the 2021 South Pacific albacore assessment, showing the WCPO (Western and Central Pacific Ocean) and EPO (Eastern Pacific Ocean) regions, and fleet areas within regions indicated by a, b, c and the dashed lines. The boundary of the ‘overlap’ region between the WCPFC and IATTC areas is indicated by the dashed line at 150°W.

Table 2 Fishery definitions proposed for the 2021 South Pacific albacore assessment. The fisheries 1-21 indicate the main extraction fisheries, and fisheries 21-25 indicate the 4 index fisheries for which no extraction is allocated but are used to provide combined fleet abundance indices with shared selectivity for each region. LL = longline, DN = drift net, TR = troll, AU = Australia, NZ = New Zealand, DWFN = Distant Water Fishing Nations, EPO = Eastern Pacific Ocean.

Fishery Number	Gear	Model Code-Fleets	Flags	Model region	Fleet area
1	LL	1-LL-DWFN	ALL	1	a
2	LL	2-LL-PICT	ALL	1	a
3	LL	3-LL-DWFN	ALL	2	a
4	LL	4-LL-PICT	ALL	2	a
5	LL	5-LL-AZ	AU/NZ	2	a
6	LL	6-LL-DWFN	ALL	3	a
7	LL	7-LL-PICT	ALL	3	a
8	LL	8-LL-AZ	AU/NZ	3	a
9	LL	9-LL-DWFN	All	1	b
10	LL	10-LL-PICT	All	1	b
11	LL	11-LL-DWFN	ALL	2	b
12	LL	12-LL-PICT	ALL	2	b
13	LL	13-LL-DWFN	ALL	3	b
14	LL	14-LL-PICT	ALL	3	b
15	TR	15-3a-All-TR	ALL	3	a
16	DN	16-3a-All-DN	ALL	3	a
17	DN	17-3b-All-DN	ALL	3	b
18	LL	18-LL-EPO1	ALL	4	a
19	LL	19-LL-EPO2	ALL	4	b
20	LL	20-LL-EPO3	ALL	4	c
21	TR	21-TR-EPO	ALL	4	a, b, c
22	LL	1-L-INDEX	INDEX	1	-
23	LL	2-L-INDEX	INDEX	2	-
24	LL	3-L-INDEX	INDEX	3	-
25	LL	4-L-INDEX	INDEX	4a	a*

Combining the proposed South Pacific wide regional structure with the nested areas-as-fleets, resulted in 21 fisheries being defined for the 2021 assessment. Apart from the changes in the spatial structure of the fisheries, similar to 2018, for the WCPO the fisheries are defined based on gears (driftnet net, longline, troll) and flags, with groupings according to Pacific Island Countries and Territories (PICTs), Distant Water Fishing Nations (DWFN), Australia (AU) and New Zealand (NZ). For the EPO the fleets are all DWFNs and fisheries are defined according to the gear (driftnet net, longline, troll) and the length composition spatial patterns as discussed above, resulting in six fisheries. Note that only the longline gear fisheries are used in the index fisheries.

Haikun Xu provided a presentation on the application of the regression tree analysis of length-frequency data from longline fisheries in the southern EPO. The analysis provided the basis for the fishery stratification into three areas in the EPO region (Fig. 4). Noting the higher proportions of smaller fish in Area C off Chile, that also related to lower water temperatures in this region, consistent with the observations of smaller albacore in cooler southerly regions of the WCPO (WCPO model region 3).

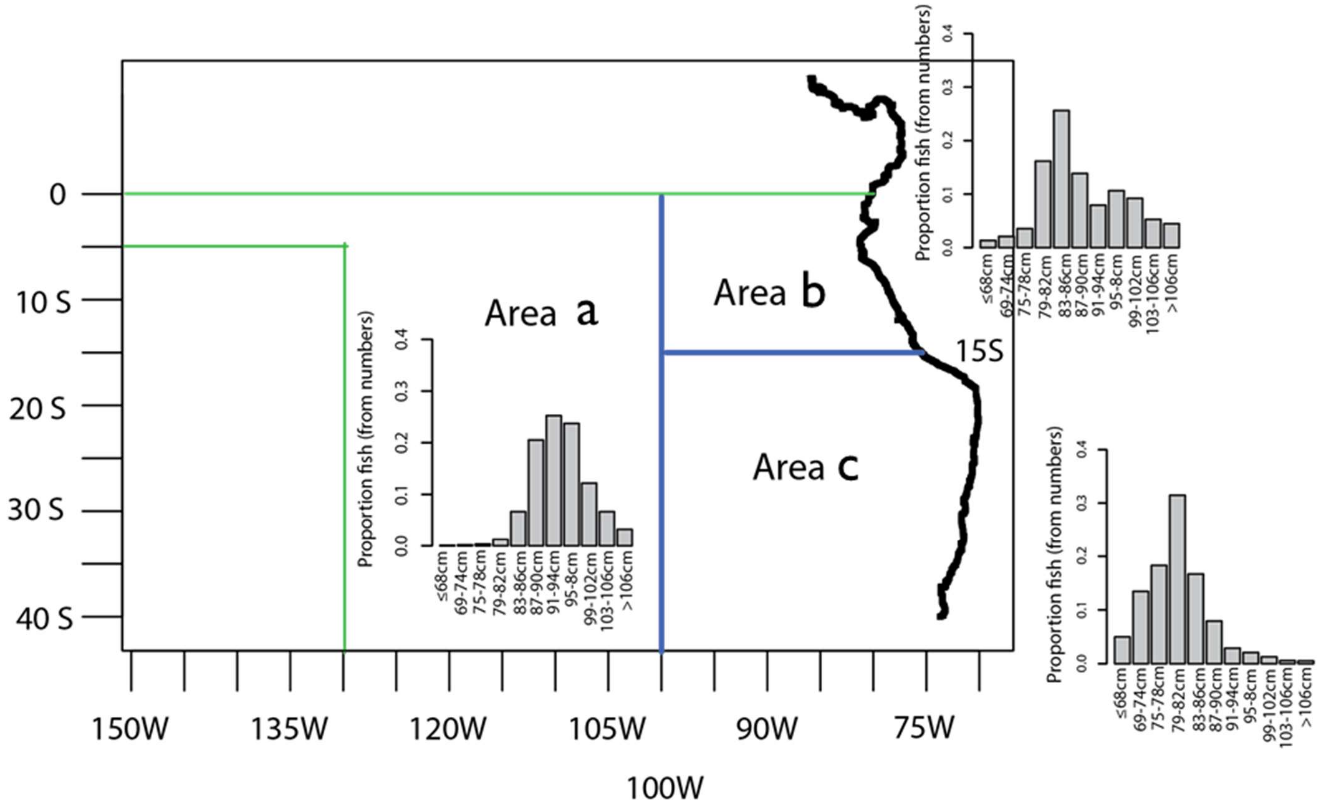

Figure 4. Proposed strata for fisheries in the EPO based on the regression tree analysis, with the indicative length compositions from the longline fisheries in each of the strata.

Comments and discussion:

- ***Clarification of how extraction and index fisheries were dealt with in the modelling was provided. Extraction fisheries don't influence the abundance index, to achieve this they have all their effort removed and the model estimates catches perfectly, or effort can be retained but given very low penalties.***
- ***Question on the need for seasonal selectivity and catchability in the EPO?*** The regression tree analysis suggested the best splits were in space rather that season and the seasonal variation didn't appear large. Conclusion was that it was not necessary to include seasonal selectivity or catchability.
- ***Has the performance of the classification tree been explored, i.e., by cross validation, separation stability, and how do you decide when to stop branching and how far to prune?*** Simulation testing was used to develop the method. As to splitting, other information is also considered such as available sample sizes and catches with different split levels, consider parsimony also. Decisions are not necessarily based on some statistical criteria, and we need to make some subjective choices based on other information.

- ***Question of the use of the Japanese fleet data only in the regression tree analysis***. It was acknowledged that other flags might show some variation in composition, and the increasing catches by China, but insufficient length composition data from other flags to be included.
- ***Question on the pattern of smaller fish and the split longitudinally for the EPO but latitudinally for the WCPO and the association of juveniles with cooler waters, also the lack of Japanese effort closer off the coast of South America, and in south east EPO (i.e., recent effort may be more due to other flags)***. The association of smaller albacore with cooler waters of South America is consistent with latitudinal pattern in the WCPO. Also, very low albacore catches reported by the Chilean fisheries closer to coast.
- ***Comments on the changes in model regional structures for South Pacific albacore over time, the switch to an areas as fleets approach in the late 2000s (2008 and 2012 assessments) due to lack of information on movement. Removing the regions greatly reduces parameters that need estimation, and despite smaller albacore being more common to the south of the WCPO there is a lot of Nth – Sth movement and the stock is probably pretty well mixed. The reason to have regional structure is to account for different regional trends, no strong evidence for this for albacore north and south in WCPO – the question posed as to why include the regions north to south as opposed to areas-as-fleets for the north - south and regions for east-west – like the approach for swordfish***. Very good points and need to be considered. Follow-up discussion on the size structuring of albacore nth-sth and the desire to account for the biology as much as possible, perhaps leaning towards spatially structured models when we know there is spatial structure, but this is an area that needs more research – i.e., when to go spatial or stick with areas as fleets. The proposed fishery definitions being grouped latitudinally will possibly be suitable for a single WCPO areas as fleets model – so we can consider trying this. Simulation is ultimately the best way to explore the implications of going spatial or areas as fleets. Issues with quarterly block movement models. Seasonal selectivity might be useful – if compositional data shows seasonal variations.
- ***Comment on North Pacific albacore approach to deal with movements longitudinally (east - west) which are quite important in influencing spatio-temporal patterns of availability – use an areas as fleets approach with a fixed vector of availability/selectivity with age from east to west. Tested this with an age structure production model. This approach allowed the impact of fishing to become clear, which was not so if the longitudinal vector for selectivity was not applied.*** Interesting approach to consider if a single region model, areas as fleets approach is used, not sure that MFCL can do this selectivity vector?
- ***Followed on with discussion of the Pacific blue fin approach – age specific selectivity to account for movement and length specific selectivity to account for contact selection – the age specific selectivity applied to all fisheries in an area, but length selectivity was specific to fisheries. Might be easier with ontogenetic movements.***
- ***Following up on the fleets as areas – should be relatively straight forward to implement a single WCPO region, areas as fleets model. But will need to consider what index to use – single or sub-area indices? Still keep east-west separation (WCPO-EPO). Could use the likelihood as a diagnostic to explore how the fit to various data sources changes with this simplification. Other things might also have to be changed to account for the seasonal differences in size composition***

that would not be accounted for by movement with a single region, i.e., seasonal selectivity and catchability. While a single region model for the WCPO might seem straight forward to implement from a fishery definition perspective, dealing with the seasonality of composition data will require additional work. It is possible but will be a matter of time available if we attempt it.

Fishery overviews and data inputs, including length composition

An overview of the available catch and composition data from each of the defined fisheries was provided. Data is available from 1960 – 2019 for this assessment. The catch and effort is consistently mostly distributed north of 40°S except for the region of southeast New Zealand and southeast Australia where some catch and effort occurs to 45°S. In the last two decades there has been a notable increase in catch and effort in the eastern WCPO and western EPO between 25°S and 40°S.

Summaries of the catch and size composition data by year (also by quarter for size composition) and flag were provided for each of the defined extraction fisheries. It was noted that composition by quarter is very consistent in the northern region of the WCPO (region 1 and 2) with modes around 90 cm, for the southerly region 3 most of the quarterly size compositions had at least two modes, at around 80 cm and 90-100 cm. The troll fishery off New Zealand generally has a mode around 60-70 cm irrespective of quarter. The EPO is more similar to the regions 1 and 2 of the WCPO for quarters 1, 2 and 4 with a single mode around 90-100 cm, quarter 3 has two modes more like region 3 in the WCPO, one at 90-100 cm and the other at around 80 cm.

Comments and discussion:

- ***Comment on the importance of being confident that the size composition data is reliable and consistently collected across time, unrepresentative variation in size composition will push the biomass around and can create conflict with CPUE trend. If size composition data conflict with the CPUE trend, best to place more weight on the CPUE trend.***
- ***Comment that the key thing from the size composition data is a good estimate of selectivity more so than it strongly influencing biomass estimation. It is reasonable to remove size composition data that is unreliable as you do not need large amounts to estimate selectivity. Better to focus on good selectivity estimation and fitting to CPUE.***

Approaches to using diagnostics for exploring the influence of different fishery composition data on biomass estimates were outlined.

- ***For the LL DWFN 2 in region 2 it was noted that as the composition data become more dominated by Chinese and Chinese Taipei data from 2000 onwards more smaller fish <60 cm and more larger fish >120 cm start appearing, what could be the reason for this?*** It might be possible that the Japanese fleet was discarding certain smaller fish for market reasons. Some confirmation of high grading of albacore by Japanese fleet off Australia in the 1980's. Question then becomes which period of compositional data is used for estimating selectivity for this fishery – perhaps the latter period with the broader range of size compositions?

- ***Further information provided that Australian port sampling data is available in weights but issues with whether weights are by individuals or batches and if individual fish measures are biased to larger fish. Data could be provided in necessary.***

A presentation on the approach and preliminary results of the size composition reweighting was provided by Tom Peatman. Presentation titled: ***'Reweighting albacore length compositions'***

Key points:

- For the extraction fisheries: reweighting is required to ensure that sampling biases in space, time, and the fleets providing data, are minimised so that size composition data better reflect the composition of the overall removals. Strata-specific samples are reweighted by catch.
- For the index fisheries: reweighting is required to ensure that the abundance indices reflect the changes in size composition of the population (i.e., the component vulnerable to the fisheries) through time. Strata specific samples are reweighted by relative abundance using CPUE.

The method was outlined, and some example results shown.

For the 2021 assessment the approach used for 2020 bigeye and yellowfin assessments (see SC16-SA-IP-18) will be used, which is broadly equivalent to that used for the 2018 SPA assessment (SC14-SA-IP-07).

It was noted that a common feature in the composition data for the WCPO PICT fleets was an increase in median lengths to around 90 cm in the mid-2000s. Also noted was the low spatial coverage for PICT fleets prior to 2000.

DWFN fleets have a longer time period of available size composition data (dating back to 1960s), but also suffer from low sample numbers and spatial coverage prior to 2000s.

Recommended that the EPO region will require using all the Japanese length frequency data to obtain reasonable coverage across region 4. For other fleets that have provided data more recently, these data are concentrated on the western portion of region 4. For the index fisheries the recommendation by the analyst was just to use the Japanese length composition data.

Spatial patterns in length composition for the EPO were noted (as for the areas as fleets discussion), this is an issue for the index fisheries approach as the CPUE is indexing different portions of the population in different areas. Several options were suggested to explore:

- One index fishery, using data from subarea 4a only
    - Remove variability when samples from 'new' flag-fleets are available
    - Not informative on compositions of smaller size classes
- Two index fisheries, one for subarea 4a, and one for subarea 4b + 4c
    - Index fishery in Subarea 4a tracking larger fish
    - Index fishery in Subarea 4b and 4c tracking smaller fish

Comments and discussion:

- ***Comment regarding the approach to modelling the composition data, reflecting on the issue raised that we do not really want the extraction fishery compositions influencing the population size estimates, perhaps we should be running several phases of estimation. Initial phase would use the composition data to develop the selectivities for the extraction and index fisheries affording high weight to the composition data, then in a follow-on phase severely down weight the size composition data for the extraction fisheries, with their selectivities then held fixed. Then just allow the composition data for the index fisheries to influence population size estimates.***
- ***Follow-up on this was provided outlining the approach applied using SS3 for some IATTC assessment where both CPUE and composition data is standardized with a spatial – temporal approach.*** We will look into this approach and its applicability to our assessments and any advantages over the current approach, unlikely to be used this time.

Tag-recapture data

A summary of tag recapture data for albacore in the South Pacific was provided. The tagging has occurred sporadically through the late 1980s - early 1990s, and late 2000s, and releases are highly concentrated in a couple of areas and mostly involve immature fish, also recapture numbers are low (approx. 210 fish). The tagging was used in the previous assessment as a sensitivity, only to inform movement (no influence on mortality estimation), with only a minor influence on management quantities. It will be considered again, but not expected to be important in the new assessment. There is no tagging data for EPO.

SEAPODYM as a source of movement rate information for the model

The limited information on movement from the tag recapture data means that other sources of movement information will be required. SEAPODYM[1] (Spatial Ecosystem and Population Dynamics Model) is being explored as an option for providing information on spatial movement rates across life stages for South Pacific albacore (Senina et al. 2020). SEAPDOYM is highly spatially resolved and provides predictions on spatio-temporal exchange of biomass by age class (in numbers and months), forced by environmental/habitat variables. The exchange rates among model regions can be predicted from SEAPODYM and used to inform transfers rates in the MFCL model. This concept was presented with the idea that an "average" matrix of probabilities for movement between regions by 'quarter' and 'age' could be produced by SEAPODYM. Uncertainty could also be included through MCMC on the uncertainty of the parameters that drive movement in SEAPODYM. It was proposed that a matrix of movement probabilities by quarter and age (with uncertainty) be an input to MFCL to provide external information of movement rates among model regions.

- ***What information do we have beyond the theory of SEAPODYM to support the predictions of SEAPODYM. Can we have more information on the tagging data.*** Tagging data limitations were discussed, just over 200 recaptures. SEAPDOYM has not included tagging data yet. Tagging data has been used in previous assessment to inform movement only, but is very limited.

- ***Discussion on the importance of good movement information for spatial models. If we want to use information from SEAPODYM to fix movement parameters, we really need to understand the assumptions and other information SEAPODYM is using to inform the movement.***
- ***Further comment on the tagging data – limited cohorts involved, also uncertainty in some positions of returns, that is compounded if the tag recaptures are so low.***
- ***Finally, don't have balanced recapture data, so can't make strong conclusions on movement from the tagging data.***

[1] SEAPODYM is a is a numerical model initially developed for investigating physical-biological interaction between tuna populations and the pelagic ecosystem of the Pacific Ocean. Using predicted environment from ocean-biogeochemical models, SEAPODYM integrates spatio-temporal and multi-population dynamics and considers interactions among populations of different species and between populations and their physical and biological environment (including intermediate trophic levels). The model also includes a description of multiple fisheries and then predicts spatio-temporal distribution of catch rates, and length-frequencies of catch based either on observed or simulated fishing effort, allowing respectively to evaluate the model or to test management options https://www.spc.int/ofp/seapodym/

CPUE analysis

Overview of the previous approach to CPUE analysis and the plan for the 2021 assessment was provided by Tiffany Vidal Cunningham.

The 2021 assessment will apply the R VAST package to conduct a spatiotemporal delta-gamma GLM from 1960-2019 to model CPUE. Splitting the time series at 1994 (with 1-2 years overlap) due to change in gear types, especially by the Japanese fleet, will be explored. Will also explore sensitivity of indices to number of knots, using bilinear interpolation. Proposed covariates include:

- YrQtr (index)
- Targeting cluster done at 'trip' level: flag, 5x5, month
    - 3 clusters across full spatial domain – ALB, YFT, BET
- Vessel id (random effect)
- Flag state and fleet category (DWFN, PICT, AU/NZ)
- O_2 at 200m as catchability covariate
- Sea surface height (proxy for fronts) as density covariate

Other considerations, include: splitting time series to enable use of vessel id (recent time period), flag as covariate – we will re-evaluate, along with fleet category, and subsampling with vessel id – also impose additional filtering to ensure reasonable coverage by vessels.

Presentation of the spatial-temporal patterns in catch and effort were presented. Key points included:

- Increased catch and effort in the south-central Pacific, especially in the EPO from 2000.
- Clear quarterly spatial patterns of catch, effort and CPUE, with higher levels in the WCPO between 25° S - 40° S (model region 3) in the second and third quarters.
- Higher CPUE tends to also occur in the latitude band from 25° S - 40° S.

Data on oceanographic covariates were presented: dissolved oxygen at 200 m, sea surface height (as a proxy for fronts, acknowledging various caveats). Also, the 16°C sea surface temperature mask applied in the previous analysis to demarcate the region to be included in the CPUE predictions. This would be applied in the new analysis, but would consider including the limited data outside the temperature masked zone.

Because of the lack of gear/vessel/bait covariates, targeting cluster would be used to account for variation in fishing operations in the CPUE model. Results of applying the K-means clustering algorithm were presented showing three targeting clusters that appear to represent: albacore, yellowfin, and bigeye tuna targeting. Some concern was expressed that the patterns in target cluster may reflect species distribution more so than gear effects (i.e., density v catchability affects), but it is still considered a worthwhile covariate, especially for the EPO. It was also noted that increased targeting of albacore was apparent in recent years.

Results of initial model exploration with low sampling rates were shown and discussed. Noting that the CPUE indices are used to inform regional weighting of abundance estimates, some preliminary comparisons of regional weightings for alternative standardisation models were presented. Some spatial biases in Darhma residual patterns were detected for the initial models.

Discussion points raised were: splitting of the time series (1960-1995, 1994-2019), SST mask treatment/exclusion – further exploration is warranted, targeting cluster – (useful or inappropriate?), additional gear/setting characteristics and data collection we could prioritize for the future, oceanography – variables of importance, metrics and resolution, and future considerations: length-based indices, follow-up on how and if these are feasible.

Comments and discussion:

- ***Comment on the importance of clustering to account for targeting changes overtime (i.e., when cold freezer vessels came in and tropical bigeye targeting increased), but that there are alternative methods to do this beside the K-means which provides a categorical cluster variable. Might be worthwhile to explore PCA analysis as it may perform better than the cluster analysis by providing a continuous variable of targeting variation.*** Have not had opportunity yet for exploration into alternative approaches for doing the cluster analysis, will look into the PCA approach.
- ***Comment on the potential for confounding of covariates – vessels (random), and fleet and clusters (fixed) – assumptions are different.*** The vessel random effect would seem important as we don't have information of the vessel characteristics, there could be some over parameterisation due to both flag and cluster included in the same models, as cluster could be partially correlated with flag.
- ***Comment on the critical need for operational/gear/bait information for CPUE standardisation. Despite this need being clearly apparent for many years the collection of these data is still lacking from many fleets and we need to keep reminding RFMOs that this needs to improve. CPUE is perhaps the most important input to many assessments but data improvements are not happening for some fleets.***

- ***Comment supporting the indices being split in the mid-1990s (shift from kuralon to monofilament mainlines). Question on whether hooks between floats (HBF) is available for recent time period and if so, why not use it?*** It does exist for the latter period, although still a lot of missing data, can potentially apply techniques to fill out the missing data, although not ideal. Concern that HBF, which is assumed to influence setting depth, is not a reliable indicator of setting depth more broadly in the WCPO since adoption of monofilament main lines.
- ***Follow-up that for the Australian fleet hooks per basket is a critical covariate and recommendation to try including it in the CPUE model.***
- ***Further discussion on clustering, pointing out that information could be lost by aggregating all fleet data for the analysis. Suggestion that it might be good to consider clustering at fleet level and then aggregating back up to better account for within fleet variation.*** Will look into this, along with the previous comment on clustering approaches.
- ***Comment that clustering with inclusion of more species might be more informative on changes in fishing strategies.*** Swordfish was included but chose three clusters, can explore this.
- ***Within the VAST framework you can include different species, could be worth looking into multispecies models.*** Did try to model the three species together with little success – perhaps should try again with a simplified, and reduced area model.
- ***Comment that PCA approach does have some issues – and the clustering approach is perhaps still better, but various different clustering methods. H-clust appeared to work better in a simulation study by Simon Hoyle, also noted the Fast clust feature to improve the efficiency.***
- ***Comment that that HBF can perhaps be more informative on a smaller scale, but can be less indicative of fishing depths over large scales and across fleets.***

New growth model – presentation from CSIRO

Jessica Farley from CSIRO presented an overview of the work done to improve the growth model for South Pacific albacore, by applying recently developed methods to estimate decimal age at length. It was hoped that applying the more refined approach to decimal ageing, that the conflicts between the growth models from otolith ageing and length composition modes could be resolved (i.e., otolith data suggested 15-20 cm per year growth on years 1-3, troll fishery length data modes suggested 10 cm per year). The work used previously collected and prepared otoliths from the WCPO (Farley et al. 2012, WCPFC-SC8-2012/ SA-IP-15). A total of 600 high-confidence otolith sections were re-read, and the annual zones measured. An additional 60 otoliths were prepared and read for daily age.

The results showed that the revised decimal age at length was now consistent with the length difference between three annual modes in the NZ length composition data. Results appeared to have resolve the inconsistency between the otolith length-at-age estimates and modes in the catch-at-size data for the New Zealand troll fishery, and supported use of the new age algorithm to estimate decimal age of South Pacific albacore.

Comments and discussion:

- ***Question on how the new decimal ageing algorithm could be used to estimate birth dates, with the view to identifying the main periods of successful reproduction.*** *This is possible at perhaps monthly - seasonal resolution.*
- ***The improved growth curve suggests that including the otolith data in the model and using conditional age at length growth estimation within the model should provide a more reasonable estimate of growth than was the case in previous attempts. Also, possible to fix the growth parameters, but preferable to let the model estimate based on all the data.***
- ***Comment on the spatial growth variation, that greater variation occurs east to west versus north to south. Have the authors considered how they can deal with spatially varying growth?*** MFCL cannot deal with spatially varying growth, this is an area that needs greater consideration in future model development. Also, an issue that we don't have small fish from the eastern region in the growth data set. Seems like we will have limited choice but to use the average growth model.
- ***Comment that maybe a weighted average by sampling region is more appropriate.***
- ***Furthers suggestion related to dealing with regionally varying growth included: down weighting the length composition data, have a smaller/younger plus group.***
- ***It was also noted in the earlier analysis of the albacore growth, that longitude was a significant effect, but as mentioned earlier, statistical significance does not necessarily equate to a significant influence on model estimations.***
- ***Comment that, encouragingly, spatial differences in L_{inf} are not that great and this parameter tends to have an influence on estimates of management quantities. However, this was followed with a comment that most of the fish that are caught are at the 4-6 yr ages where the length at age differences are the largest.***
- ***Comment that originally the NZ troll size composition was fitted at a monthly scale, but this was changed when the otolith growth – length frequency growth conflicts were noted. Now the two growth estimation approaches seem similar, worth to go back and try fitting the troll data at monthly scale.*** Monthly fitting to troll length data will be tried.
- ***Question on what month should be the birthday for albacore?*** Feb-Apr are the estimated birth months.

Biological assumptions, multi-sex v single sex

Presentation on the proposed biological assumptions was provided by Claudio Castillo Jordon. Most of the biological assumptions will follow those used in the previous assessment, with the exception of growth, that will use the new growth data. M was very influential in last assessment, may consider M from the north Pacific albacore (M-at-age; Teo, 2017), and explore other approaches to estimate with the new growth data, not decided on the approach yet, but expect M to be an axis in the uncertainty grid.

The previous assessment recommended development of a sex-specific assessment model for South Pacific albacore, allowing sex specific settings for key demographic parameters, such as natural mortality and growth. Plan to look into this option, but data is limited. Data on spatial distribution of samples where sex specific length composition data are available was shown, indicating that this data is concentrated in New

Caledonia, Fiji, Tonga and French Polynesia, where observer good programmes occur. Data available shows higher proportions of males for larger length classes. Female proportions start dropping below 50% on average from around 90 cm.

Comments and discussion:

- ***It was commented that although worthwhile considering the M estimate for North Pacific albacore, now that the new growth data is available, also should explore meta-analytical approaches to estimate M.*** This will be done and preferable to use the most stock relevant information.
- ***Follow-up on sex structured modelling, key issue is selectivity differences, what do you do if you don't have sex-specific length composition for some fisheries and not others, to estimate selectivity by sex. Various options for dealing with this were proposed.*** Response that the lack of sex specific data is a barrier, in the past for sex specific models we assume selectivity is similar by length and if growth is different this will result in different selectivity at age. As we don't have good coverage of sex specific data any sex-specific model we might try would likely be fit to aggregated data.
- ***Noted that there is no sex specific data for the EPO.***

Stepwise diagnostic development

New features to be explored for the 2021 assessment were summarised:

- Different spatial structure: south Pacific wide
- Recruitment per year (annually, quarterly, seasonal, orthogonal polynomial method?)
- Recruitment zones (region 3 and 4 – was restricted to southern WCPO region in 2018)
- New growth parameters (from CSIRO)
- Estimate all the growth parameters?
- Single or split CPUE time series?
- M using new growth?
- MFCL new version (v2.0.8.0), including testing of SSMULT for size data weighting.

An initial plan for the stepwise diagnostic model development was discussed. This is likely to change as the model development progresses. Key steps will involve introducing the new growth, new spatial structure, movement with SEAPODYM, recruitment distribution (annual, orthogonal), CPUE approaches.

In relation to uncertainty, plan to use the standard orthogonal grid, and following axis:

- M (NP ALB?, M=0.3, M=0.4?)
- Growth (Fixed – new and estimated)
- Steepness (h=0.65, h=0.8, h=0.95)
- Regional movement – with/without SEAPODYM, tagging?

Noting this may change or expand as the model development progresses.

Comments and discussion:

- ***Given M is so influential – and the meta-analysis has shown a wide range of M values from the various M estimators, should we be adjusting the range of M we use in the grid?*** We will need to consider approaches to narrow down the M range for the grid. Recollection we went to 0.3-0.4 based on NP albacore, but they have since changed, perhaps we should consider 0.3-0.5.
- ***Question on inclusion of different growth models in the grid or as sensitivity, i.e., North Pacific, Chen-Wells used in previous model.*** We would hope that applying the new growth data will mean we don't require to include the other growth models in the grid this time.
- ***Question on how the changes to this assessment will have implications for the albacore TRPs.*** TRP can be recalculated when the assessment is done, and as it is based on an agreed reference year where CPUE conditions were considered good, while the TRP actual value could change with the new assessment, it will still be based on the reference year.

DAY 3 – MULTIFAN-CL update, Southwest Pacific Blue shark assessment, length-weight conversion work for Bigeye and Yellowfin tuna assessment review update

Multifan-CL update

Nick Davies provided the MFCL development update, starting with an acknowledgement of Dave Fournier for his ongoing work as lead developer of MFCL. The presentation outlined the recent developments of MFCL, including features that have contributed to the new version 2.0.8.0, that is ready for production use but not yet public release.

The development features fall into seven areas:

1. Development of positive definite Hessian (PDH) diagnostics, including positivised eigenvalue diagnostic, and empirical evidence of the influence of negative eigenvalues
2. "Stitching" to allow parallel Hessian calculations
3. 128-bit precision
4. Catch-conditioned model
5. New movement parameterisations – with conversions
6. Natural mortality at age – minimization stability
7. Pre-minimisation conversion or recruitment parameterization

The development work in each of these areas were described in detail.

Feature 1: Briefly, the work on the PDH diagnostics was done to assist in understanding the cause and importance of non-PDH (non-positive definite Hessian) for assessment derived quantities. The example case was the 2020 bigeye tuna model that has 11,421 parameters to be estimated, but the non-PDH was due to a very small number of small negative eigenvalues. The approaches involved:

- Positivised Eigenvalue Diagnostic (PED) – as a diagnostic of the variance of the dependent variables
- Empirical evidence for the relative influence of the negative eigenvalues – alternative solutions using added scalars on the independent variables

Using these approaches, it was demonstrated that the independent variables estimated that were associated with the small negative eigenvalues in the bigeye model had next to no influence on the key derived management quantity ($SB/SB_{F=0}$). The new diagnostics can be used in a heuristic sense in situations where non-PDH solutions occur to explore whether the parameters responsible for the non-PDH solution have any influence on important derived quantities used for management advice. Also added a feature that allows analysts to identify which parameters are contributing to negative eigenvalues.

Feature 2: The Hessian calculation can be very time consuming for complex models, i.e., 70 hrs for the recent bigeye on a single processor. Scripts were developed for submitting parallel runs (i.e., parallelise the Hessian calculation over multiple processors), and a routine added to MULTIFAN-CL for stitching the Hessian components back together that takes < 1 minute. This reduces the Hessian calculation time dramatically depending on how many processors are available.

Feature 3: The current MFCL executable uses 64-bit precision. An experiment was conducted to see if an executable compiled with 128-bit precision could obtain a PDH when a 64-bit precision could not. The experiment using the bigeye tuna 2020 mode showed that continuing the minimization beyond where the 64-bit version stopped, but with 128-bit precision, could continue to reduce the gradient and function values, and did obtain a PDH. The 128-bit solution was re-run in 64-bit and also obtained a PDH. For a highly complex and ill-determined problem, the minimisation is therefore sensitive to the precision of the calculations. At higher precision, a PDH solution can be found. This feature is not proposed for production implementation, but rather for one-off experimentation as it is very computationally intense and slow to run.

Feature 4: Currently MFCL applies a catch errors method for estimating F for each fishing incident (catch). This involves estimating a large number of free parameters: effort and catchability deviates, average catchability, and a total catch likelihood needs to be calculated. To try to simplify the model estimation of F and reduce the number of model parameters that require estimation, a catch conditioned model has been developed that uses a Newton-Raphson fitting procedure to estimate the F that generates the observed catch, which is assumed accurate. This approach requires far fewer parameters. An example using the 2019 skipjack model showed the catch conditioned approach reduced the parameters by 70% and the method appeared to be working well. The catch conditioned feature requires more development work and is not expected to be available for production assessments until later in 2021, and therefore will not be used in the current swordfish and albacore assessments.

Feature 5: Trials of simplified models indicated movement coefficients are often influential components of negative eigenvalues. Two alternative parameterisations were developed that are more robust to ill-determined problems. Trials indicate better minimization stability with the new parameterization. Facility was developed for alternating among the parameterisations between fitted model solutions (the corresponding parameter values for all option are present in the *.par). This will allow analysts to explore alternate movement hypotheses with far greater efficiency.

Feature 6: To improve minimization stability for models that apply natural mortality at age it was recognized that implausible age-specific parameter values at the initial stages of minimization need to be avoided. This feature involves revising the initial values of M being used (initialise M age parameters = log(M)) and adjusting the bounds to avoid extreme values during initial minimization evaluations.

Feature 7: Similar to feature 6 this feature will allow analysts to more rapidly explore impacts of switching to the alternate orthogonal polynomial parameterisation for recruitment. It will allow conversion from an existing solution obtained using the "standard" mean+deviate parameterisation for recruitments, and to derive the corresponding orthogonal-polynomial parameters that closely approximate the absolute temporal-spatial recruitments. It uses the input *.par as the starting point for new minimisation with the orthogonal-polynomial parameterization, and thus involves just one quick step preceding a minimisation.

After the summary of the recent development work a review of the 2020-2021 workplan (mostly discussed above) was provided plus the workplan for 2021-2022. Remaining work to do in 2021 include finishing the benchmark testing of the new MFCL version 2.0.8.0, consolidating all the next features and drafting the documentation to support the new features. For 2021-2022, a key goal is to consolidate on the accumulated features in version 2.0.8.0. This will involve:

- Testing the implementation of examples that employ all the new features and refine the I/O and diagnostic reports.
- Final "baseline" MULTIFAN-CL version 2.0.8.# completed by 30 June.
- From Jul. to Dec. 2021, no further large-scale new developments are planned. Time will be spent to tidy the code; complete a backlog of bug fixes; attend to long outstanding tasks form the bigeye tuna independent review panel recommendations; and any "small-scale" requests in the tasks list.
- Provide support for MSE requirements and improvements.
- Catch up on the remaining documentation required for updating the MFCL Manual.

Comment and discussion:

- ***Question on including the Popes approximation approach.*** Yes, we are considering this, the beginnings are already in the code, just a matter of time.

Southwest Pacific Blue shark assessment

The next section of the PAW day 3 focused on the 2021 Southwest Pacific blue shark assessment. The assessment is being conducted in collaboration between Saggitus LTD (Stephen Brouwer) and Dragonfly Data Science (Philipp Neubauer and Kath Large).

Characterisation of the southwest Pacific blue shark assessment

Stephen Brouwer presented an introduction to the data available to inform the Southwest Pacific blue shark assessment, focused on longline, as there is very little data and low catches of blue shark from purse seine. The overview began with a summary of data coverage and information on life-history parameters and stock structure, noting the separation into two stocks north and south of the equator.

Longline observer records are available back to the early 1990s, and logsheet records from the mid-late 1990s although the number of records increases from the late 2000s. Therefore, catch information for blue shark is very poor across the earlier period of the longline fishery and catch reconstruction will be required. There are substantial length records for longline catches by sex from the 1990s onwards, but most data are from the last 20 years.

It may be possible to conduct an integrated assessment, but this might depend on how well we can reconstruct the catch history. Medium and low data approaches should be possible.

Tagging data, although limited, showed large-scale movements in the WCPO and did not indicate strong seasonal movement patterns, supported separation of northern and southern hemisphere populations, but is insufficient to infer population structure in the WCPO.

Data on monthly patterns of CPUE in the South Pacific, suggest higher CPUE tends to occur in the southerly areas 30° S -40° S in the first 3-5 months of the year.

Longline effort in hooks deployed for the South Pacific region has increased substantially since 2000, and was relatively stable (with interannual variations) from the 1970s to 2000.

Annual catch estimates held by WCPFC are only reported to the entire convention area (not by north and south Pacific) and are only available since the early 2000s. Logsheet reporting has started to improve since 2010. Early logsheet data really only available from Australia and New Zealand. Recent data is available Pacific wide.

As management has developed and more non-retention has been happening, reporting of fate and release condition has occurred since the 2000s.

Length composition data from the 1990s onwards shows an increasing trend in the median length which is thought to be a reporting artifact due to increased reporting by different flags. Sex ratio of the length composition seems consistent across time. To modes in the length composition, 110 cm and 200 cm, which may also be a flag reporting effect, with more smaller sharks in the length composition data from Australia, New Zealand and Japan. This was also reflected in the clear latitudinal trends in length composition, with smaller sharks predominating in samples south of 40° S, which would be mostly reported by the Australian and New Zealand fisheries. This pattern persists during the year.

Blue shark are mostly caught in the shallower hooks of a longline set, irrespective of size. Shallow sets typically have higher catches than deeper sets. Data on changes in gear settings, hooks between floats, total hooks per set etc., and bait were presented. Recent years show a switch to more fish baits and more hooks per set.

CPUE data (nominal) was presented to get an idea of the available data for the assessment. The data are patchy for many flags, but a few flags have more consistently available data, i.e. Australia, NZ, New Caledonia, US, Fiji.

Some discussion on CPUE trends and management changes – i.e., increased discarding since 2013 may be influencing recent CPUE trends for observers as sharks are being cut-off before observer record them.

Summary points:

- Blue sharks are wide ranging across the South Pacific Ocean and display weak size and seasonal movement patterns.
- Overall, there is a reasonable amount of data from 1990-2019, but the data by fleet are more fragmented.
- Aggregated data are submitted as annual totals for the WCPFC area only.
- Blue shark aggregated data should be reported by ocean area not simply WCPO, and where possible these data should be retrospectively corrected.
- Catch reporting has improved across all fleets over time.
- For most fleets after 2015 most blue sharks are released, and a high proportion of releases are alive and healthy at release.
- Some length data are available but not for all fleets.
- Blue sharks are landed in both shallow and deep sets, but most frequently caught in the shallow hooks and comprise a higher proportion of the catch in shallow sets. But the number of deep sets is much larger and therefore contains the most data.
- Relative to tuna, the catch proportion of blue sharks differs by fleet and is closely associated with set depth.
- Both observed and reported data are available for CPUE standardisation.
- Gear attributes (e.g. HBF) more likely to be informative than specified targeting information as targeting is poorly reported
- Past management interventions may complicate the CPUE standardisations.

Catch reconstruction and CPUE

Presentation on the challenges and approaches for catch reconstruction and CPUE analysis were presented by Philipp Neubauer of Dragonfly.

Initially it was noted that logbook reported catches are not reliable and probably still under reported in recent decades. For catch reconstruction it is planned to use the longline observer data and predict catches across all flags. For CPUE standardisation, plan is to use a subset of longline observer programmes that include the most consistent coverage of the fishery over space and time.

Catch reconstruction will follow a two-stage process (similar to the recent oceanic white tip shark assessment, Tremblay-Boyer et al. 2019). The first stage will develop a prediction model from observer catch rates and apply this to known longline effort across the WCPO. The second stage we may explore is the potential to predict global catches based on fin trade statistics, scaled and apportioned to the southern WCPO. This approach might be used as a cross check to the scale of the estimates, especially in the earlier years where observer data is limited.

The approach to reconstructing catch from observer catch rates was described in detail, including approaches to overdispersion and potential covariates (following the oceanic white tip analysis). Unlikely to be able to have separate models for target v bycatch fleets. Alternative models to consider could include: observer programme instead of flag, different configurations of oceanographic covariates, flag-year interaction, modelling of overdispersion with and without the addition of v to the negative binomial distribution. Catch rates are then projected from the observer models at the scale of the WCPO based on longline efforts. Example of the oceanic white tip catch reconstruction was discussed. Similar to the oceanic white tip we expect a reasonable uncertainty around the catch reconstruction, we can use this to develop alternative catch histories to capture this uncertainty in the assessment grid.

The application of the fin-trade method was also discussed, but for various reason is only expected to provide a cross check of the early period estimates for the primary method using observer CPUE.

CPUE standardisation for the abundance index will follow similar approaches to those used for the catch reconstruction, with particular attention to the management changes overtime.

Comment and discussion:

- ***Question about how to incorporate the uncertainty of the catch reconstructions into the assessment***. There can be two sources of uncertainty that we may need to consider depending on the results of the modeling. We may have the situation where various models may produce very similar results and we can pick a best model, and just include uncertainty in the prediction from that model. However, if we find several models that provide different catch trends that are equally plausible and have similar fits, we may decide to include the various models in the uncertainty grid with the addition of each model's uncertainty, we will have to wait and see. To some degree this depends on the aim of the uncertainty, do you want extremes or a kind of random draw across the posterior of the catch reconstruction distributions.
- ***Comment agreeing that the logbook data is unreliable and should not be used for the catch reconstruction. Question raised on the data filtering methods to remove low quality data for the standardisation. Noted that Australian and NZ data is likely the most reliable. Support for the primary method as described, but for the fin trade method – less confident in that, perhaps also estimate the catch of north Pacific blue shark to support the validation.*** Agree with these comments and will aim to retain the fleets with good reliable data. Also not sure about value of the fin-trade analysis based on previous work, may depend on time, and wouldn't be used in the model.

Blue shark biology and life-history

Kath Large of Dragonfly presented an overview of considerations for assessment planning, including:

- Stock identification and structure
- Overview of biology
- Previous stock assessments for blue shark
- Previous southwestern blue shark assessment (SC12, 2016)
- Summary of SC12 comments

- Proposed approach for 2021 assessment work

Current information (from tagging) suggests blue shark are separated into north and south Pacific stocks either side of the equatorial region. No evidence for stock structure within each of these stock regions.

Comparison of life-history information for blue shark in north and south Pacific, based on Clarke et al. (2015), was provided. Of note is the growth difference by sex, with females being smaller at age than males from about 5 years age. Differences in growth are apparent from studies focused on samples from the south-west and south Pacific. Also, some differences were noted between the north and south Pacific, which may suggest transferring biological parameters from the north to south Pacific stocks should be treated with caution. However, Clarke et al. (2015) indicated that if blue shark data are lacking for the South Pacific, the default option should be to fill the gaps with data from blue shark in the North Pacific, and this would be considered where appropriate. Important gap in data regarding the reproductive pattern was noted.

The previous (and only) southwestern Pacific blue shark assessment was conducted in 2016 based on data from 1994-2014, using Multifan-CL (Takeuchi et al. 2016). Two previous assessment have been conducted on north Pacific blue shark using Stock Synthesis (Kleiber et al. 2009, Rice et al. 2014).

The previous southwest Pacific blue shark assessment had the following key features:

- Multifan-CL: single stock, single region, 20 annual age classes with plus group, single-sex, 1994-2014
- Initial population: initial equilibrium age distribution based on average, age-specific, total mortality over first 5 years of assessment
- Fishery inputs incorporated at a quaterly scale, single annual recruitment event
- Recruitment assumed Beverton-Holt parameterization
- Growth was sex combined, averaging growth curve of each sex estimated by Hsu et al. (2011)
- Natural mortality fixed at 0.2 (annual)
- Age at 50% maturity at 8 years
- Size composition sample size, robust normal distribution
- 22 fisheries based on flags and fishing grounds
- Fishery dynamics length-based, time invariant for each fishery, with 5 selectivity groupings
- Two catch reconstruction scenarios: blue shark-to-all sharks ratio from fleet specific observer programmes, and all observer fleet CPUE series
- No discard mortality scenario used (fleets for which this would be relevant made-up small proportion of total catches)
- 3 x CPUE series
- Catchability, constant over time for the longline fishery with quarterly variation,
- Remaining fisheries with nominal effort had time-varying catchability using structural time-series approach (random walk steps taken annually, with deviations constrained by prior)

The structural uncertainties considered were:

- Catch reconstruction (2)
- CPUE (3)
- B-H steepness (3)
- Standard deviation of log deviates of recruitment from deterministic recruitment (2)

The outcomes of the 2016 assessment were inconclusive in relation the important management quantities. The assessment was viewed as a work in progress and not to be used as a basis for management advice. This outcome was suggested to be largely due to data limitations and data uncertainties and conflicts, particularly, in relation to catch history and CPUE data. A number of research and modelling recommendations were noted (see Takeuchi et al. 2016)., and these will be considered where feasible as the assessment is developed,

A key issue with the previous assessment was catch reconstruction – two different approaches used produced very different histories and very different scales of harvest. In the 2021 assessment it is proposed to focus on the catch reconstruction approach applied in the recent oceanic whitetip shark assessment (Tremblay Boyer et al. 2019). This approach is described previously. Similar to the oceanic whitetip assessment, discard mortality will be included, with different levels in the structural uncertainty grid that will lead to the different catch series in the uncertainty grid based on combinations of mortality on discards and mortality on individuals released alive (levels of total mortality at 100%, 43.65%, 25%), applied to median and 90th quantile catch levels.

The assessment model will be an age-structured model implemented in Stock Synthesis (SS3). Alongside, this we plan to develop a Bayesian dynamic surplus production model (see Neubauer et al. 2019) and use depletion-based catch-only simulations to construct useful priors on initial population size and productivity (see Neubauer et al. 2019). These priors can be included as axes in a structural uncertainty grid.

Possible axes for a structural uncertainty grid, include:

- growth and fecundity
- catch including combinations of discard mortality and post release mortality
- initial F
- B-H steepness
- natural mortality
- recruitment deviation
- prior on initial population size and productivity

Further background on the approach using catch-only simulations for constructing useful priors on initial population size and productivity was provided.

Comments and discussion:

- ***Comment that if large uncertainty in biological parameters for South Pacific blue shark exists you may use parameters from north Pacific blue shark, but in the presentation, you suggested***

the use of the grid approach for capturing uncertainty. As the first option we would use north Pacific information for biological parameters.

- ***Follow-up recommendation was to initially fix the biological parameters and focus on the uncertainty in catch and CPUE time series. You might look at running some sensitivity analysis on biological parameters borrowed from the north Pacific blue shark, and then decide on including in the final model uncertainty grid.*** *Agree this is a good approach.*
- ***Comment on data before 1994, large uncertainty as its not species specific, should consider two options: extrapolate species composition post-1994 to the pre-1994 period, and just use data post-1994.***
- ***Comment on challenge of fully size based integrated assessment, any thought on conducting a risk based assessment such as previously applied to porbeagle shark.*** Yes, we will be considering these types of approaches also.
- ***Comment of the use of trade-based information to contribute to catch reconstruction, and the need to make lots of assumptions in order to use this data, what is the feeling that the amount of assumptions required just makes these estimates too uncertain to be worth the effort.*** For the early years, i.e. 2000's they may have some use as a comparison (point estimate) to other methods, but as a time series don't think it is useful.
- ***Question regarding the scale of the population and potential for different productivity and different population trajectories in different areas of the South Pacific, how are you going to deal with mixing? And how will you account for differences in the productivity, i.e., small fish in the south versus north, will you use a spatial approach or a fleets as areas type approach as used in the previous assessment.*** Currently exploring the data and have not decided at this stage on the spatial or fleets approach. The observation of small sharks toward the higher latitudes and larger sharks towards the lower latitudes, might suggest a spatial approach could be suited, but need more time to consider the available data, CPUE trends etc.

Philipp Neubauer finished the blue shark assessment sessions with a presentation on some alternative assessment approaches that may be considered alongside the attempt at the integrated assessment. Making the points that:

- Integrated assessments generally preferred assessment option for most species.
- Often little/poorly representative composition data for sharks
- Potentially little to be gained from integrated assessments: productivity parameters tend to be fixed – which fixes reference points.
- Over-parameterised for poorly informative data - often leads to large uncertainty in estimates of R0/B0 (and undue prior influence for seemingly uninformative priors)

Applying some alternative methods with less data needs (less assumptions required) may help mitigate the implications of some of the major uncertainties that will impact the integrated assessment and provide some additional weight to provision of management advice. WCPFC project 92 considered alternative lower data methods, such as; Catch only "simulations"; Dynamic surplus production (DSPM) and Spatial risk assessments (SRA). The choice of which of these methods to apply depends on the objectives, i.e., stock status versus relative risk among species. A decision framework was presented based on project 92.

Considering conducting a Bayesian DSPM and possibly (if time and data) look at a SRA.

Detailed presentation of the approach and data needs to conduct the Bayesian DSPM was provided, including how to consider building uncertainty into the DSPM so that it is comparable to the integrated assessment.

The spatial SRA method (eSAFE), although unlikely to be applied, was also presented in detail.

Comments and discussion:

- ***Question on DSPM – a demographic analysis using similar biological inputs as used for the integrated assessment is used to get a prior for Rmax but then you don't consider the stock - recruitment relationship in that analysis, which influences the shape parameter of the surplus production model. In that case could it be better to use the ensemble approach presented for swordfish to sample the demographic parameters distributions as input to the integrated assessment priors and fix selectivity etc. to essentially have an age-structured production model that is more explicit about the assumptions made. If you do a surplus production model where you haven't chosen the shape parameter, you make huge assumption on the stock-recruitment relationship when you don't know what that is.*** Understand the point raised, but trying to keep things simple at this stage, might be possible to put a prior on the shape parameter rather than fixing it.
- ***Follow-up that putting a prior on the shape parameter still requires assumption of the stock-recruitment relationship and putting this through a demographic analysis with correct type of stock recruitment relationship, simpler to use the current integrated model. Run the integrated model then fix the selectivity parameters, throw out the composition data and then fit to the catch and index of abundance. If correlated priors, can use the approach discussed for swordfish.*** This is a good suggestion to think about, just not sure how far we will get with the DSPM work, given late start to this work.
- ***Question on if it is possible to complete both the integrated assessment and the DSPM how would you go about combining the results to provide management advice?*** Good question – probably a larger discussion on how to combine different modelling approaches in management advice. We would present the two sets of modelling results separately and could provide advice on the level of confidence we have in the management related outputs.

Work on conversion factors

Eric Chang from National Sun Yat Sen University, Chinese Taipei provided a presentation on work underway to improve conversion factors for bigeye tuna in the Pacific, in collaboration with Tzu-Lun Yuan and Jed Macdonald (SPC). This work was recommended from the previous bigeye stock assessment.

Chinese Taipei observer programme has collected bigeye length and weight data since 2008, with about 110,000 records distributed widely though the Pacific. SPC has around 330,000 observer length-weight records but these are mostly distributed in more southern and western regions. Combining the two data sets will provide a comprehensive spatial coverage of Pacific bigeye fisheries.

The presentation outlined:

- the data preparation approaches and filtering of likely erroneous measurements or outlier
- approach to check if more than one growth stanza. i.e., inflection points in the length-weight relationship, no evidence for growth stanzas/inflection points
- regional structured analysis of length-weight relationships, showing variation in the exponent on length (i.e., b value) in the length-weight relationship.
- analysis of deviations of regional and monthly b-values to overall value and Fulton's condition factor, noting some regional differences and north-south trends in condition factors
- development of a model to predict length from weight incorporating seasonal and regional effects

The study is in the preliminary stages, and requested advice on the following areas.

1. Defining the size ranges for the analyses
2. Estimating length-weight relationships separately for younger and older fish
3. Making samples sizes similar for size bins
4. Estimate length-weight relationships by regions or not
5. Excluding the EPO region
6. Using different combinations of datasets

Comments and discussion:

- ***The size range for the analysis could match that used in the stock assessment for the species***
- ***Estimating the relationship for different development phases – good to do if there is clear evidence for this, however, consider how the stock assessment can incorporate the separate length-weight conversion by life stage.***
- ***Regional estimation – depends on objective and assessment platform, if a spatial assessment may be worthwhile depends on stock assessment software, but perhaps better to use the GLMM approach.***
- ***Excluding EPO – if you are doing a Pacific wide assessment this will be needed.***
- ***Is this work also planned for yellowfin?*** Currently just bigeye but can consider yellowfin later perhaps.

- ***Sub-sampling for the length bins with similar sub-sample numbers per bin and bootstrapping this to fit the relationship to many sub-sampled data sets and estimate variance could be a good approach, also for the regional comparisons, suggest regional stratification of the sampling to have similar sample sizes in each region or proportional to area (i.e., limit spatial bias in the region wide relationship), and have you considered temporal variation in the relationship – i.e. over longer time periods or blocks of years in relation to environmental changes, stock abundance levels etc.?*** We will look into doing analyses to explore temporal variations and consider the other suggestions regarding sub-sampling.
- ***Useful to do a quick simulation to consider the possibility of biases due to selectivity of the different fisheries/gears.*** We can ask whether the data has associated data on gear types. Chinese Taipei data is only from longline. For SPC data it is mostly longline, might be some gaps, but may be able to infer gear from other data. Some data sets have higher spatial resolution – currently sharing data at 10-20° resolution, so we can look at some of the data at higher resolutions to explore some of the temporal-spatial variation

Yellowfin Tuna – follow-up work and peer review

Paul Hamer from SPC provide a short presentation on the plans for follow-up work on the 2020 Yellowfin tuna assessment and the peer review of this assessment requested through SC16.

Some key problematic areas with the 2020 yellow fin assessment were noted, including:

- Selectivity (in particular purse seine selectivity, early size/age classes)
- Tagging data (mixing period, tag reporting rates)
- New Growth – new otolith-based growth information had a major impact, interacted with selectivity – needed more time to explore complex effects of the new growth
- CPUE standardisation, lack of sensitivity to covariates, influences on regional scaling??
- Natural mortality – different plausible levels of M lead to really different and unexpected outcomes
- Limited data from which to estimate the spawning potential ogive, better data to inform gilled-gutted - whole weight conversion
- Conflict among data sources, thought the model was too complex and could do with some simplification (i.e. spatial structure)

It was also noted that some new features of MFCL were only just being completed (i.e., SSMULT) or in development (i.e., catch conditioning) and that these features could reduce parameter estimation greatly and influence data weighting – with consequent influence on model derived management quantities. These new features would expect to be applied to the next yellowfin assessment – but time is required to test and understand their influence in more depth. This would be part of follow-up work with 2020 assessment model.

It was noted that the lead assessment scientist on the 2020 yellowfin assessment, Dr Matthew Vincent, has left SPC returning to work for NOAA in the US. This may have implications for how quickly we can get onto follow-up work given the current two SPC assessment scientists are busy with the 2021 assessments. We will continue to liaise with Dr Vincent, but he will not be in a position to do any of the follow-up work.

The process for the peer review was outlined along with the timeline leading to the next yellowfin assessment in 2023.

2021: Yellowfin assessment follow-up work, and TOR for peer review provided to SC17

2022: Further follow-up work on the 2020 yellowfin and bigeye assessments. Expert review commencing at the start of 2022, including one week in Noumea with the review panel reporting to SC18.

2023: Next Yellowfin and Bigeye assessments, reported to SC19.

Three independent experts will be selected to conduct the peer review following a transparent process run by the WCPFC Secretariat, and consistent with the Commissions previously developed *"Process for the independent review of stock assessments"* (Attachment K of the SC122 summary report). It is expected, similar to the previous bigeye assessment review, that the peer review panel will spend a week in Noumea working with the SPC stock assessment team.

SungKwon Soh from the WCPFC Secretariat provided an update on the nomination of peer reviewers. 23 nominees have been received from CCMs and these will be reduced to the final 3 by the end of April.

Wrap-up

Some discussion of the future format of the PAW occurred, acknowledging that around 50 people attended each day (more than would be present in a face-to-face meeting in Noumea), including some experts that may not necessarily have been available or able to make it to Noumea for a face-to-face meeting. The question was raised on whether continuing the online format for future PAWs is being considered. The Chair and Principal Scientist of the Stock Assessment and Modelling team at SPC, made the point that the scientists in Noumea really value the in-person interaction with other assessment scientists given the relative isolation being based in Noumea, it provides significant opportunity outside of the meeting time to have more informal discussions on topics raised in the workshop and obtain advice on other topics of interest. We would look at running a hybrid style meeting when travel becomes possible again.

The meeting was closed by the chair acknowledging the work done by all the presenters, the SPC stock assessment team to prepare for the meeting and the valuable input and personal time provided by all the workshop participants.

References

Clarke, S., Coelho, R., Francis, M., Kai, M., Kohin, S., Liu, K. M., Simpfendorfer, C., Tovar-Avila, J., Rigby, C., and Smart, J. (2015). Report of the Pacific shark life history expert panel workshop, 28-30 April 2015. Technical Report SC11-EB-IP-13, WCPFC.

Farley, J.H., Williams, A.J., Davies, C.R., Clear, N.P., Eveson, J.P., Hoyle, S.D. and Nicol, S.J. (2012) Population Biology of Albacore Tuna in the Australian Region. WCPFC-SC8-2012/ SA-IP-15

Farley, J., Clear, N., Kolody, D., Krusic-Golub, K., Eveson, P., Young, J. (2016) Determination of swordfish growth and maturity relevant to the southwest Pacific stock. Working Paper WCPFC-SC12-2016/ SA WP-11, 12th Regular Session of the Scientific Committee of the Western and Central Pacific Fisheries Commission. 3–11 August 2016. Bali, Indonesia.

He, X., Bigelow, K.A., Boggs, C. (1997) Cluster analysis of longline sets and fishing strategies within the Hawaii-based fishery. Fisheries Research 31; 147-158.

Hsu, H., Joung, S.J., Lyu, G.T., Liu, K.M., Huang, C.C. (2011) Age and growth of the blue shark, *Prionace glauca*, in the northwest Pacific. ISC/11/SHARKWG-2/INFO02

Lennert-Cody, C.E., Minami, M., Tomlinson, P.K., Maunder, M.N. (2010) Exploratory analysis of spatial-temporal patterns in lengthfrequency data: An example of distributional regression trees. Fisheries Research 102: 323-326.

Lennert-Cody, C.E., Maunder, M.N., Aires-da-Silva, A., Minami, M. (2013) Defining population spatial units: simultaneous analysis of frequency distributions and time series. Fisheries Research 139: 85-92

Mangel, M., Brodziak, J., and DiNardo, G. 2010. Reproductive ecology and scientific inference of steepness: a fundamental metric of population dynamics and strategic fisheries management Fish and Fisheries 11: 89–104. doi:10.1111/j.1467-2979.2009.00345.x

Moore, B. (2020) Biology, stock structure, fisheries and status of swordfish*, Xiphias gladius*, in the Pacific Ocean - a review. Report for The Pacific Community (SPC). 46 pp

Neubauer, P., Richard, Y., Tremblay-Boyer, L. (2019) Alternative assessment methods for oceanic whitetip shark. WCPFC-SC15-2019/SA-WP-13. Report to the Western and Central Pacific Fisheries Commission Scientific Committee. Fifteenth Regular Session, 12–20 August 2019, Pohnpei, Federated States of Micronesia.

Senina, I.N., Lehodey, P., Hampton, J. and Sibert, J. (2020) Quantitative modelling of the spatial dynamics of South Pacific and Atlantic albacore tuna populations, Deep Sea Research Part II: Topical Studies in Oceanography 175: 104667. https://doi.org/10.1016/j.dsr2.2019.104667.

Takeuchi, Y., Pilling, G., Hampton, J. (2017) Stock assessment of swordfish (Xiphias gladius) in the southwest Pacific Ocean. Working Paper SC13-SA-WP-13, 13th Regular Session of the Scientific Committee of the Western and Central Pacific Fisheries Commission. 9–17 August 2017, Rarotonga, Cook Islands.

Then, A.Y., Hoenig, J.M., Hall, N.G., Hewitt, D.A. (2015) Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science 72 (1): 82-92. doi: 10.1093/icesjms/fsu136

Thorson, J.T., Munch, S.B., Cope, J.M., and Gao, J. (2017) Predicting life history parameters for all fishes worldwide. Ecological Applications. 27: 2262-2276. https://doi.org/10.1002/eap.1606

Tremblay-Boyer, L., Hampton, J., McKechnie, S., Pilling, G. (2018) Stock assessment of South Pacific albacore tuna in the Western and Central Pacific Ocean. Report to the Western and Central Pacific Fisheries Commission Scientific Committee, WCPFC-SC14-2018/SA-WP-05.

Tremblay-Boyer, L., Carvalho, F., Neubauer, P., Pilling, G. (2019) Stock assessment for oceanic whitetip shark in the Western and Central Pacific Ocean. Report to the Western and Central Pacific Fisheries Commission Scientific Committee. WCPFC-SC15-2019/SA-WP-06.

Tremblay-Boyer, L., Neubauer, P. (2019) Historical catch reconstruction and CPUE standardization for the stock assessment of oceanic whitetip shark in the Western and Central Pacific Ocean. Technical Report SC15-SA-IP-17, WCPFC.

APPENDIX 1: Agenda

Tuesday 30th March (Monday 29th US)	**DAY 1: Preparatory Workshop for 2021 southwest Pacific swordfish assessment** E-meeting (Zoom) Version 19/3/2021 **Times are all in New Caledonia time zone**	**Presenter initials and presentation numbers**
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	PH
09:30 – 10:30 *Session 1*	• Previous assessment summary • Proposed model spatial and fishery structures • Fisheries overviews and data inputs	NDB/TP **(D1-P1)**
10:30 – 11.00	BREAK	
11.00-12.00 *Session 2*	• Biological assumptions and ensemble model approach	NDB **(D1-P2)**
12.00-13.00	BREAK	
13:00 – 14:30 *Session 3*	• Two sex or one sex model • CPUE approach for 2021 assessment • CPUE analyses – New Zealand • CPUE analyses – Australia	NDB **(D1-P3)** OA (NIWA) **(D1-P4)** RC (CSIRO) **(D1-P5)**
14.30-15.00 *Session 4*	Stepwise diagnostic model development Preliminary model results Proposed uncertainty grid Other things to consider	NDB **(D1-P6)**
15.00-15.30	Discussion and wrap up day 1	PH/GP
Wednesday 31st March	**DAY 2: Preparatory Workshop for 2021 South Pacific albacore assessment** E-meeting (Zoom) Version 5/3/2021	

(Tuesday 30th US)		
09:00 – 9.20	Get online and intro to day 2	PH
9.20-10.30 *Session 5*	• Previous assessment summary • Model spatial and fishery structures for the new 'South Pacific wide' albacore assessment	CCJ/HX/PH **(D2-P1)**
10:30 – 11.00	BREAK	
11.00-12.30 *Session 6*	• Fishery overviews and data inputs • Length composition treatment for extraction and index fisheries • CPUE Index fisheries	CCJ/HX **(D2-P2)** TP TV **(D2-P3)**
12.30-13.30	BREAK	
13:30 – 15:00 *Session 7*	• New growth estimation work • Biological assumptions, and single v two sex? • Stepwise diagnostic model development and sensitivities • Proposed uncertainty grid • Other	JF **(D2-P5)** CCJ **(D2-P4)** CCJ/HX **(D2-P6)**
15.00-15.10	Discussion and wrap up day 2	PH
Thursday 1st April (Wed 30th US)	**DAY 3: Preparatory Workshop for 2021 southwest Pacific blue shark assessment** E-meeting (Zoom) Version 5/3/2021	
09.00-9.10	Get online and intro to day 3	PH
9.10-9.40 Session 8	• Recent developments and future work for Multifan-CL	ND **(D3-P1)**
9.40-10.40 Session 9	• Review of available data inputs and issues for southwest Pacific blues hark • Catch reconstruction discussion for southwest Pacific blue shark	SB/PN **(D3-P2)**
10:40 – 11.00	**BREAK**	

11.00-12.00 Session 10	• Blue shark biological and life history parameters • Review of previous southwest Pacific blue shark assessment • Approach for an integrated assessment in SS	KL **(D3-P3)**
11.30-12.30 Session 11	• Alternative assessment approaches	PN **(D3-P4)**
12.30-13.30	**BREAK**	
13-30-14.00 Session 12	• Further discussion on blue shark assessment (as required)	All
14.00-14-30 Session 13	• New work on bigeye tuna conversion factors • Overview of plan for yellowfin tuna assessment follow-up work and expert peer review	EC PH
14.30-15.00 Wrap up and Follow-up	• Workshop recommendations/key points circulated • Recommendations agreed • Meeting draft paper circulated for comments • Comments received • Meeting paper finalised for SC16 submission	PH

GP Graham Pilling, PH Paul Hamer, NDB Nicholas Ducharme Barth, CCJ Claudio Castillo Jordon, JH John Hampton, JF Jessica Farley, ND Nick Davies, TV Tiffany Vidal Cunningham, TP Tom Peatman, HX Haikun Xu, RC Rob Campbell, OA Owen Anderson, EC Eric Chang, SB Steve Brouwer, KL Kath Large, PN Philipp Neubauer

APPENDIX 2: List of participants

(NB – there may be some inaccuracy due to the online format, multiple people joining from the same link and people dropping in an out of the meeting for shorter periods)

Name	Affiliation
John Annala	Ministry for Primary Industries, NZ
Leyla Knittweis	Ministry for Primary Industries, NZ
Brad Moore	NIWA, NZ
Simon Hoyle	NIWA, NZ
Owen Anderson	NIWA, NZ
Brit Finucci	NIWA, NZ
Philipp Neubauer	Dragonfly Data Science
Kath Large	Dragonfly Data Science
Steven Brouwer	Saggitus LTD
Nick Davies	SPC consultant
Rob Campbell	CSIRO, AU
Jessica Farley	CSIRO, AU
Paige Eveson	CSIRO, AU
Ashley Williams	CSIRO, AU
Rich Hillary	CSIRO, AU
Don Bromhead	CSIRO, AU
Karen Evans	CSIRO, AU
James Larcombe	Department Agriculture Water and the Environment, AU
Wetjens Dimmlich	FFA Secretariat
Reuben Sulu	FFA Secretariat
Lianos Triantafillos	FFA Secretariat
Keith Bigelow	NOAA (Pacific Islands Fisheries Science Centre), US
Filipe Carvalho	NOAA (Pacific Islands Fisheries Science Centre), US
Jon Brodziak	NOAA (Pacific Islands Fisheries Science Centre), US
Michelle Sculley	NOAA (Pacific Islands Fisheries Science Centre), US
Steve Teo	NOAA (Southwest Fisheries Science Centre), US
Cole Monahan	NOAA (Alaska Fisheries Science Center), US
Matthew Vincent	NOAA (Beaufort Lab), US
Mark Fitchett	Western Pacific Regional Fishery Management Council (US)
Haikun Xu	IATTC
Carolina Minte-Vera	IATTC
Mark Maunder	IATTC
Eric Chang	National Sun Yat-sen University, TW
Yi-Jay Chang	National Sun Yat-sen University, TW
Ren-Fen WU	Overseas Fisheries Development Council, TW
Kai Mikihiko	National Research Institute of Far Seas Fisheries, JP
Hitoshi Honda	National Research Institute of Far Seas Fisheries, JP
Kei Okamoto	National Research Institute of Far Seas Fisheries, JP
Yasuki Semba	National Research Institute of Far Seas Fisheries, JP
Yuki Fujinami	National Research Institute of Far Seas Fisheries, JP

Hirotaki Ijima	National Research Institute of Far Seas Fisheries, JP
Sung Il Lee	National Fisheries Research and Development Institute, KR
Mi Kyung Lee	National Institute of Fisheries Science, KR
Jung-Hyun Lim	National Institute of Fisheries Science, KR
Glen Holmes	PEW
SungKwon Soh	WCPFC Secretariat
Elain Garvilles	WCPFC Secretariat
Ueta Faasili jr	WCPFC Secretariat
Francois Prioul	(Service du parc de la mer de Corail et de la pêche – SPNMCP), NC
Mickael Lercari	Service du parc de la mer de Corail et de la pêche – SPNMCP), NC
Lea Carron	Service du parc de la mer de Corail et de la pêche – SPNMCP), NC
Tim Adams	Gonedau
Juliette Konkamking	IRD, France
Claudio Castillo Jordon	SPC
John Hampton	SPC
Graham Pilling	SPC
Sam McKechnie	SPC
Lauriane Escalle	SPC
Nicholas Ducharme-Barth	SPC
Rob Scott	SPC
Finlay Scott	SPC
Nan Yao	SPC
Peter Williams	SPC
Liz Heagney	SPC
Tiffany Vidal Cunningham	SPC
Paul Hamer	SPC
Joe Scutt Phillips	SPC
Simon Nicol	SPC
Jed McDonald	SPC
Steven Hare	SPC

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.