SCIENTIFIC COMMITTEE
THIRTEENTH REGULAR SESSION

9-17 August 2017
Rarotonga, Cook Islands

Report from the SPC pre-assessment workshop, Noumea, April 2017

WCPFC-SC13-2017/IP-02

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Introduction

To help undertake stock assessments for the WCPFC, the Oceanic Fisheries Programme (OFP) of SPC has sought input from stock assessment scientists in the region through the SPC pre-assessment workshop process. The ninth pre-assessment workshop was held in Nouméa, New Caledonia, during the 24-27 April 2017.

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

John Hampton (OFP, SPC) opened the meeting and welcomed the participants. The agenda focused on approaches for the stock assessments of WCPO bigeye, yellowfin and southwest Pacific swordfish scheduled for 2017, developments to the MULTIFAN-CL modelling framework, and technical developments in WCPO Management Strategy Evaluation. Presentations were invited from all participants, with the majority made by SPC staff. The meeting operated under the terms of reference provided in Appendix 2, and was chaired by Steve Brouwer of the OFP Stock Assessment and Modelling section.

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

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

Developments in the MULTIFAN-CL software

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

Workshop discussions noted that between the tests of alternative size composition objective functions, the results for particular parameters varied widely. It was noted that this might result from the preliminary nature of the tests, which may include selectivity functions that were implausible. In the full stock assessments, the plausibility of estimated selectivities would be an important factor to examine. The choice of weighting or use of an objective function (e.g. self-scaling multinomial or Dirichlet) to be used would be a decision for the lead assessment scientist, but the advice from current tests indicated that the Dirichlet was appropriate and led to improved performance over previously used likelihood functions. The self-weighting nature of this approach allowed the data to suggest the appropriate weighting rather than having to make relatively ad hoc choices.

A recent addition to MFCL is the ability to generate "pseudo data" that will be used as stochastic input into Management Strategy Evaluation simulations. It was noted that in the generation of pseudo-observation data, a multinomial error was being used. However, actual observations of tag recapture and size composition data do not fully conform to a multinomial distribution. Future investigations in this area may include the potential to use a more dispersed distribution and options to include additional sources of process error (e.g. by sampling selectivity deviates) to better simulate patterns seen in the 'real' data.

The workshop suggested:

- **Consider using a more dispersed distribution/additional sources of uncertainty to generate pseudo-observed data, to better capture process error.**

WCPO Bigeye and Yellowfin stock assessment discussions

Initial discussions on the 2017 assessments focused upon bigeye and yellowfin. Given overlaps between the two assessments, presentations and discussions covered both stocks at the same time, and hence combined information is reported here. Where appropriate, stock-specific presentations are also described.

Overall approach used in the 2014 assessments

Sam McKechnie (OFP, SPC) presented the modelling approach used for the 2014 WCPO bigeye assessment, results and sensitivities. The workshop noted patterns within the total population likelihood profile for the 2014 bigeye stock assessment, influenced by confounding of parameters and data, and the approach used to achieve the 2014 model results. The potential to profile on parameters such as L2 when estimating growth within the model was discussed.

The workshop noted that there was the potential to develop a standardised bigeye CPUE index for the Australian fleet in Region 5. However, to ensure a long time series for this region, the CPUE index was currently estimated for a combined 'all flags' longline fleet, of which the Australian fleet is part. This approach was preferred to maintain the length of the time series.

Laura Tremblay Boyer (OFP, SPC) summarised the 2014 WCPO yellowfin assessment, results and sensitivities. The workshop questioned whether catches of yellowfin west of region 7 were included within the model. It was noted that for the 2014 assessment the western boundary was shifted westward (to 120° E) to include Vietnamese catch, and it was felt that any catch further west, in the continental shelf area, would be minimal. The conflict seen between the tagging data and CPUE data in Region 8 in the 2014 assessment was noted, and that the nominal CPUE series for LL-All-8 was used. The potential conflict between length and weight data within the model for longline fisheries, and potential uncertainties within the length data, were reasons for the weight data being included preferentially for longline fisheries. However it was noted that for particular fisheries, data collection had changed from weight to length, which led to some length data being included in recent years of the model.

Biological assumptions for 2017 bigeye, including growth

Jessica Farley (CSIRO, AU) presented recent work on age, growth and maturity of bigeye within the WCPO. It was noted that the temporal stratification of a quarter within the assessment meant that the estimation of a decimal age was particularly important. A birth date of 1st July was assumed, based on the available information. Male and female growth appeared comparable, as did alternative growth formulations. Spatial patterns in growth were seen, with fish in both the far-east and -west appearing to be larger at-age. It was noted that the tagging data offered an additional source of growth information. Analysis of maturity indicated 50% maturity at 103 cm, 2.85 yrs.

The workshop noted that there were some differences from the current results and a historical study from the east coast of Australia. This partly resulted from the use of an alternative birthday. Using a comparable approach to the current study, the results were more comparable. There was the potential to use that data within estimates for the assessment, and some comparison plots were developed for the workshop.

Sam McKechnie presented the proposed biological assumptions to be considered within the 2017 bigeye stock assessment. The difference in growth patterns between those estimated within the 2014 assessment and otolith-based estimates were noted. Potential sources of usable tag increment data were discussed. The age-based maturity and natural mortality assumption within MULTIFAN-CL was noted, and the implications of the change in assumed growth discussed. The workshop suggested potentially fixing the value of natural mortality as a constant at ages older than age 4 within the mortality-at-age assumption. It was noted that the resulting pattern was not dissimilar to the pattern resulting from the Lorenzen M estimation. The workshop discussed the approach to estimating spawning potential within the bigeye and yellowfin assessments, consistent with the assumed growth functions. The impact of changing the growth function on all the biological parameter forms was noted.

The workshop suggested:

- **That growth uncertainty be examined through alternative scenarios based upon the 2014 'reference case' assumption, the otolith-based growth function for bigeye, and an externally estimated growth function.**
- **That use of available tag increments to validate the growth pattern identified through otolith analysis would be of interest.**
- **That for both growth and maturity, observations east of 150°W should be filtered out, and only observations consistent with the assessment region should be used, and for estimation of maturity only data from Regions 3 and 4 should be used.**
- **That the additional otolith analyses from the east coast of Australia should be considered for inclusion where they can be re-analysed with an approach comparable to the current study.**
- **That data for fecundity (egg production) as well as spawning frequency from the WCPO would be useful to improve the spawning potential-at-age estimates.**

Tagging data

Takayuki Matsumoto (NRIFSF, Japan) described the data for yellowfin and bigeye from the Japanese tagging programmes that could be used within the 2017 stock assessments. A total of 4,648 bigeye and 14,866 yellowfin tuna have been tagged, including fish released as part of ongoing tagging programmes that target skipjack to the southwest of Japan (194 bigeye and 1,831 yellowfin tuna). The majority of bigeye recaptures were within Region 1, with a few recaptures within Regions 2, 3 and 4. A greater proportion of yellowfin moved south into Region 7, as well as Regions 3 and 8. Reporting rate information was not available. The movement pattern was suggested to contribute to the basis for an alternative regional structure, with the northern boundary of Regions 3 and 4 moving south.

The workshop noted that tagging for these species in the 2000-2010 period was annual, but in one month of each year in the east of Japan. The potential for seasonal movement or a seasonal pattern in the fishery was noted, which might explain some of the spatial patterns seen in the movement data.

For the 2017 assessments, the workshop noted that the same filtering approach as used for the SPC tagging data should be undertaken on the Japanese tagging data, and preliminary analyses examining this have been carried out. These would be described later in the workshop.

Keisuke Satoh (NRIFSF, Japan) presented studies into patterns within the Japanese longline size data for bigeye and yellowfin. The species composition and gear configurations over time were presented, with the potential for a shift to albacore targeting in the 15-20°N band suggested by changes in the gear configuration. The workshop noted that the change in species composition around the early 2000s to greater albacore dominance might be influenced by species retention as a market was developed for albacore at that time. For distant water fleets, the long time periods at sea might result in greater levels of albacore discarding. These factors could influence the species composition trends seen, and can be evaluated. In turn, the move by Chinese Taipei to targeting albacore using 'American style' longline gear with greater hooks between floats (HBF) but a different main line material was noted. Given that this fleet frequently copies the Japanese vessel fishing pattern, a similar shift might be seen within the

Japanese data, and may influence the patterns seen. The workshop suggested confirming any such change within the information on gear configuration available to Japan.

Bigeye CPUE standardisation analyses indicated that exclusion of data north of 15°N, combined with information on the gear configuration and oceanography, provided different CPUE patterns. This was also suggested as a potential basis for changing the bigeye area definition in the assessment model, with the northern tropical boundary of Region 3 moved to 15°N to take account of the potential change in albacore targeting. The workshop suggested that a similar effect would be achieved by having an albacore cluster within the CPUE standardisation approach within each region, and clear albacore clusters were seen within these Regions within the analyses presented to the CPUE Workshop in the previous week.

The workshop suggested that there was the potential to exclude CPUE data points early in the time series, where those points represented limited quantities of information, given their strong influence on trends. In turn, as noted within the CPUE workshop, information on gear characteristics can be very influential within the GLM standardisation. Adding, for example, an interaction between longline material and HBF, given the discussions on gear configuration above, warranted exploration. There was also potential to use the cluster analysis approach within the 15-20°N band and compare the results to those from GLMs incorporating gear configuration information, to see where clustering identified the same information that gear configuration data provided.

Sam McKechnie summarised the SPC tagging information available for the bigeye and yellowfin assessments. The origins of the Coral Sea 'Region 9' were discussed, noting that some of the returned tags corresponded to old fish and provided some valuable information on fish longevity. The workshop noted that if the non-usability percentage differs across regions, there was the potential for the movement estimates to be affected, but it was expected to be slight. The assumption is made that the usable tags represent a random (unbiased) sample of the total releases. A major source of 'non-usability' is fish that move outside the model region into the EPO. The fact that similar results for WCPO were obtained within the Pacific-wide model suggested any resulting bias was minor. The reduction in bigeye tag recoveries in recent years was noted.

The Japanese tagging programme has the potential to supplement the assessment input data in Region 1 where tagging data are currently absent. As previously noted, the rules applied to the 'SPC data' would be equally applied to these data.

The workshop noted that some tagging events tended to hit the bounds of the prior distributions for reporting rates. As potential sensitivity analyses, the options to change the bounds, to examine the likelihoods for the individual tagging programmes to examine the influence on population scaling, and to modify the variance (over-dispersion) for specific fisheries, thereby modifying the weighting in the fit, were noted to examine the impact on assessment results. There was also the potential to retain the information from tags for movement, but down weight their influence on mortality.

The workshop suggested:

- **That the level of unusable tags should again be included within documentation provided to SC.**
- **Primarily running the assessment model with the 'SPC tagging data', then examine the effect of inclusion of the Japanese tagging data.**
- **For cases where reporting rate hits the upper bounds, sensitivity runs as described above should be considered to evaluate the impact on assessment results.**

Sam McKechnie presented the Hawaiian tagging data for bigeye and yellowfin. SPC filtering approaches would lead to many of those tag recaptures being removed from the data set, and other issues were noted with the recapture fisheries (e.g. the small handline fishery, which was not included within the 2014 assessment).

The workshop suggested:

- **That the Hawaiian tagging information be excluded from the 2017 bigeye and yellowfin assessments.**

Spatial structure

Sam McKechnie presented the proposed preliminary spatial structure of the WCPO bigeye and yellowfin assessments, corresponding fisheries and the considerations that would be required if the proposed changes to the spatial structure are made. The pattern of tagging data in the central Pacific indicated very few fish moved outside 10°N to 10°S, noting that this pattern was influenced by the lower level of fishing effort outside that region. This suggested that a better biological assumption may be to move the northern boundary of Regions 3 & 4 down to 10°N, although this might have implications for the modelled longline fleets.

The workshop questioned the basis for setting the boundary at 20°N within the 2014 assessment, given the spatial patterns of catches given in the Williams and Terawasi paper and the tagging data. A 10°N boundary between Regions 1 and 3 and 2 and 4 would better spatially encapsulate the purse seine fishery, a key fishery within the region, be more consistent with the tagging information, and with oceanographic features.

It was noted that consideration of the age/size pattern of tag movements seen within the tropical region was warranted, given that the majority of recaptures were likely within the purse seine fishery, whose selectivity tends toward smaller fish. The movement of fish from tagging may not, therefore, fully reflect the population structure, given the stock size structures, distribution of effort by gear, and their associated selectivities.

The workshop examined the consequences for modelled fisheries (catch, size data, etc.) of moving the boundary between Regions 1 and 3, and Regions 2 and 4, down to 10°N. For both bigeye and yellowfin, there were very limited impacts on the purse seine and pole and line fisheries. One area that required

further study was potential shifts in the size data for different components of the existing modelled longline fleets, given the size data from 'offshore' longline fleets indicated a greater proportion of larger fish that might need to be captured separately in the model (in the new Region 1). Consequences of a changed regional structure for CPUE and tagging data still needed to be examined. It was noted that the change would have potential implications for future skipjack assessments.

The workshop suggested:

- **Exploring the new regional structure, moving the boundary between Regions 1 and 3 and Regions 2 and 4, down to 10°N, for use in the bigeye and yellowfin assessments. The impact would be examined through a one-step change.**

Purse seine catch estimates

The latest collaborative work between SPC and NRIFSF Japan on Project 60 (purse seine catch composition) was presented by Tom Peatman (OFP, SPC) and Keisuke Satoh. Japanese species compositions in logbooks, landing slips (with and without market sampling correction), and grab sampling (with and without correction for selectivity bias) were compared. Logbook, landing slips and observer grab-sample data were available for 777 trips from 2010 to 2015. Grab sample derived species compositions were less biased than those from logbooks, with bias further reduced with correction for grab selectivity bias. Additional market sampling data were available for 96 of these trips. Corrected and uncorrected grab sample derived species compositions for these 96 trips were similar to landings compositions, both with and without market sampling correction.

It was noted that historically, aggregate data from Japan provided to SPC were assumed to have been species composition corrected, but this assumption was incorrect and hence adjustment was necessary. Two approaches were proposed to calculate historic species compositions: using corrected grab samples, the approach used for other purse seine fleets; and using landings slips data (preferably with market sampling correction). Keisuke Satoh presented work examining potential adjustments to the Japanese landing slips data for small yellowfin and bigeye, based on market sampling data. A reduction in the proportion of yellowfin (and increase in the proportion of bigeye) within the size category <1.5kg was noted in the early 2000s.

The workshop asked how the landing sales slips for small fish were dealt with in Japan, given the difficulty in distinguishing species at small sizes. It was noted that this depended on the market, with yellowfin and bigeye less than 1.5 kg grouped in 'yellowfin' market categories, though these mixed species market categories account for a small proportion of landings. Small skipjack are assumed to be correctly identified. The workshop also asked about the variability in corrected grab sample-based catch compositions at the trip level. It was noted that trip-level catch compositions based on corrected grab samples were quite variable compared to landings compositions.

The workshop suggested exploring approaches that retain the best attributes from both sources of data when estimating Japanese species compositions, i.e. the potential to use the corrected landings data, to

estimate trip-level species compositions, and then usie set-level corrected grab samples to apportion the trip-level estimates by set association and spatial strata. It was also noted that as market sampling has approximately 10% coverage, the high coverage observer sampling for the small size fish could be used to correct the landings data species composition for small fish for each trip.

Given the Japanese fleet primarily unloads in port and fully enumerates landings, this was a good basis for the study. The workshop noted the potential to undertake a similar exercise for some other fleets (e.g. potentially the US fleet).

Catch data summaries and uncertainty

Sam McKechnie noted that there was a request arising from the Commission meeting to capture uncertainties in bigeye longline catch levels within the stock assessment. Sangaa Clark (PNA Office) provided a scenario of longline underreporting based upon the MRAG IUU study. The scenario suggested a 4% under-reporting before the catch limits came in under CMM2005-01 (which started in 2006), incrementing from that level up to an additional 27% bigeye catch within the longline fishery by 2012 (as estimated within the MRAG report) between these years. The workshop noted that refinements in this approach should include applying this uncertainty to the fleets from which the observer data were obtained within the MRAG report.

The workshop noted that other options to better enumerate total removals could also be considered in future, including uncertainty in purse seine catch estimates (partly incorporated through the observer-based species adjustments), estimates of dead discards in all fisheries, small scale fishery catch within the Pacific Islands, and depredation of tuna on longlines (estimated at 10-15% of catch in some fisheries). The potential to examine the differences between logsheet and landed catch estimates for some fisheries was noted.

The primary focus of the workshop discussion was on bigeye tuna. However, the workshop noted that there were also potential estimates of misreported catch for yellowfin. Those values, such as previously used estimates of uncertainty in ID/PH catches, could be included within catch uncertainties scenarios for yellowfin.

For both bigeye and yellowfin, the workshop felt that further information behind the estimation of catch uncertainty was required to support developed scenarios. Those scenarios should be distributed to workshop attendees.

<u>The workshop suggested:</u>

- **That a one-off sensitivity analysis for catch uncertainty be performed.**
- **For bigeye, this should be along the lines of the approach suggested by the PNAO. Any catch differential should be applied to the same fleets as examined within the MRAG IUU report.**
- **For yellowfin, an examination of catch uncertainty should also be considered. This may replicate previous analyses of uncertainty in the catches of the Indonesian/Philippines fishery.**
- **That the proposed catch time series be circulated to the workshop participants.**
- **That FFA make the MRAG IUU report available to the SC.**

CPUE time series

Laura Tremblay-Boyer of OFP presented updated CPUE indices for bigeye and yellowfin model regions. The discussions held at the CPUE workshop were summarised. The proposed approach was to use the full Pacific-wide operational data set, with two approaches: the 'traditional GLM' + clustering, and the geo-statistical approach. Preliminary results from the geo-statistical GLM for bigeye and yellowfin (with and without oceanographic effects) were presented.

The importance of a long time series of data was noted, but the shorter time series of information available on vessel ID was highlighted. Approaches to deal with the lack of vessel information earlier in the time series were described. The workshop was interested in a proposed approach using supervised classification to estimate 'pseudo-vessels' based on gear characteristics, location, time and species composition. The potential for changes in the length of trips over time to influence the analysis was highlighted. Further collaborative work on this between SPC and Japan was encouraged, but Japan was asked to provide a rough estimate of the number of vessels in the early data set, before the 15th May. The workshop also noted that vessel data were available for three key fleets (JP/KR/TW) prior to 1979 from the Pago Pago data.

The two approaches ('traditional GLM' and geo-statistical approach) each included different components, e.g. error distributions, covariates, inclusion of vessel effects, data sub-sampling schemes, etc. and the most appropriate combinations would be considered as model sensitivities.

The workshop discussed the potential to include the thermocline depth information within the 'traditional GLM' model exploration, so that a more direct comparison could be made between the two approaches, a likely question at SC.

The workshop suggested:

- **That in the interest of time, the assumption of an 'average' vessel by fleet for the historical period was recommended to deal with the lack of historical vessel information.**
- **If time allows, undertake a supervised classification approach to identifying vessel effects, in collaboration with Japan.**
- **The potential to include the vessel as a random effect within the traditional GLM should be considered.**
- **That it would be useful to see how the inclusion of the thermocline scales abundance between model Regions (for the more recent time series where oceanographic information is considered more reliable).**
- **That nominal CPUE trends be presented by cluster, as per the previous analysis report.**

Additional CPUE indices for yellowfin

Keith Bigelow (NOAA, US) presented an updated CPUE index for yellowfin tuna developed for domestic Philippines purse seine and handline fisheries operating in the Philippines EEZ and the western high seas pocket (Region 7). The resulting model was Yr×Qtr + vessel. Changes in the handline fleet prior to 2008

were noted, and that these changes could not be captured within the GLM. The increasing trend found prior to 2008 may not represent abundance. For the purse seine fishery, changes in the geographic area fished were noted, and hence inclusion of area within the model was not favoured. The proposed model was again Yr×Qtr + vessel.

Laura Tremblay-Boyer presented a potential approach to develop a CPUE index for Region 8 of the yellowfin model, based upon purse seine vessels fishing in the archipelagic waters of Papua New Guinea. Changes in the behaviour and composition of the fleet have been seen since the last yellowfin assessment. The approach used for the skipjack to the CPUE was proposed for development of the yellowfin CPUE series.

Size data

Keisuke Satoh presented some of the changes in longline size information for the Japanese fleet around 1990 as provided to IATTC, which may result from data collecting system changes. A similar analysis of WCPO data was performed. The recommendation was to use the commercial vessel length data for the Japanese fleet when required for the assessment, despite the low numbers, rather than that from the training vessel. The need to update the size data from Japan to SPC was noted. The workshop thanked Satoh-san for the analysis.

The workshop noted the relatively limited data available from the commercial data. The spatial distribution of the two fleets, with commercial vessels operating closer to the equator in Region 4, might explain some of the differences found between the two fleets.

The workshop suggested:

- **That, given the absence of information on commercial/training vessel in the data set available to SPC, Japan re-submit these size data combined with information on vessel type for use in the 2017 assessment, if possible by 15th May 2017.**

Model structures and key sensitivities

WCPO bigeye

Sam McKechnie (OFP) presented the proposed developments from the 2014 bigeye assessment model, and suggested key sensitivity runs to be examined within the 2017 assessment. Key axes likely to be included within the uncertainty grid were: steepness, mixing rate, natural mortality (if the Lorenzen M estimate was considered biologically plausible, the model converges and diagnostics were reasonable, that would likely be used as the 'reference case', and alternative M estimation approaches used in the grid), growth data sets (e.g. high L2 v low L2, fixed parameters, internally estimated), with alternative CPUE or data weighting options.

The workshop noted that a further possible axis of uncertainty (or one-off sensitivity) was how tagging data at the reporting rate bounds was treated within the assessment (see discussion above), to identify whether the approach was influential on the assessment results.

The workshop queried the data weighting approach for 2014. The size data were down-weighted as part of a grid analysis. It was noted that with recent MFCL developments, weighting can now be largely internal, through e.g. Dirichlet for size data and the over-dispersion parameter for tagging data. In theory, the data would inform on the variance, but external weightings, as done for the bigeye assessment may be required and if influential, may need to be included in the grid or examined in the developmental stepwise process. The plan was for diagnostics to be available on the weighting impact of the Dirichlet approach.

The potential regional weights arising from the geo-statistical model were examined. Early results suggested that inclusion of the thermocline covariate influenced regional weighting, but that further analysis was required, including use of the more recent time period only (where oceanographic estimates were considered likely to be more realistic) and alternative thermocline values.

The workshop asked whether the retrospective forecasting approach presented at SC12 was planned for the upcoming assessment. Retrospective analysis is now considered to be a 'standard' diagnostic approach, but retrospective forecasting, which examines the validity of projections that are made from assessments that may be subject to retrospective bias, was not planned.

WCPO Yellowfin

Laura Tremblay-Boyer presented developments from the 2014 yellowfin assessment model, and suggested key sensitivities to be examined within the 2017 yellowfin assessment. The workshop discussed the values of steepness used within the assessments, comparing the values to those used within other related tRFMOs. The potential to apply model weighting within the range of values examined was noted. In turn, the workshop noted that since the ISSF workshop on steepness which informed the values used within WCPFC assessments, no new information on plausible values was available. It was also noted that the independent review of the bigeye assessment supported the use of a range of plausible values.

The workshop noted that the uncertainty grid components would be developed as the modelling progressed. Discussions on the weighting of alternative scenarios were also held under the 'Presentation approach for stock assessment results'.

Southwest Pacific swordfish assessment

Yukio Takeuchi (OFP, SPC) presented the proposed approach for and progress towards the 2017 southwest Pacific swordfish stock assessment. The new growth and maturity information, and move to a sex-structured assessment model, was described. Fishery data up to the end of 2015 would be included where possible.

Biological analyses

Jessica Farley presented results from the re-analysis of swordfish growth and maturity in the southern WCPO. The new otolith-based growth curve from the Australian study was recommended. The calculation of decimal age from the study was discussed. Available information indicated that spawning was in the austral summer, and marginal increments were around April. Decimal age calculation was therefore possible, but would primarily be required if the assessment time step was quarterly.

The workshop suggested:

- **That given uncertainty in the growth function estimated from fin rays, only the new Australian sex-specific growth curves derived from otoliths should be used within the 2017 stock assessment, and the corresponding maturity ogives.**

CPUE indices

Yukio Takeuchi presented the available longline CPUE data trends by fishery. The workshop noted that there were large changes within the New Zealand fishery since 2013. Up to that year, only 10% of swordfish was taken in a target fishery. From 2014, 50-60% of the catch was taken by small domestic longliners fishing in the NE coast of the North Island targeting swordfish, of which 10% of vessels are observed, rather than the southwest coast where the Japanese fleet used to fish and where 80% of vessels were observed. This had implications for any potential New Zealand CPUE time series. The workshop noted that the previous assessment did not include the NZ CPUE series due to historical changes in targeting, but it was hoped that additional years of data might allow a series to be developed. Although changes from 2013 might still limit the time series, there were a few additional years of data, and this time series should be examined.

The Chinese Taipei CPUE series was discussed. The workshop noted that the operational data is now available and the use of clustering might improve the CPUE analysis.

Rob Campbell presented the Australian catch estimates from alternative sources. The catch disposal record was the best source of catch to use when considering metric tonnes. Estimates of catch in numbers were comparable between data sources, and these data would be used within the assessment.

The workshop suggested:

- **That noting the changes within the fishery, the New Zealand data be examined for development of a CPUE time series up to the end of 2014.**

Size data

Yukio Takeuchi summarised the size data available for the SW Pacific swordfish stock assessment, in particular the sex-separated length information for New Zealand, Australia and Chinese Taipei.

Noting that swordfish sex ratio may vary across space (e.g. paper to SC4 on sex ratio by zone from Spanish data), in particular in the northern area, the workshop questioned the spatial coverage of the sex-separated size data. Currently the spatial distribution of data may be spatially limited to NZ/AU EEZs, but that from the Chinese Taipei fleet may inform for Region 2. However, it was also noted that a key driver behind the used of the sex-separated model was to capture the information on sex-specific growth and identify whether this led to differences in stock status estimates. Dependent upon how the assessment develops, there was the potential that the sex-separated data available may need to be aggregated, with just sex-specific growth dynamics captured. It was also noted that the assessment model structure currently has only two regions – west and east - with no potential to capture north/south dynamics. Further information would be required to capture these spatio-temporal patterns within the model.

Rob Campbell presented the length information and sex information observed from the Australian fishery. Sex ratios were close to 50:50 males to females, and that ratio appeared reasonably consistent over latitude. In terms of the length data 'quality' indicator used, it appeared that measurements classed as being of 'unknown' quality were reasonably accurate and could be used within the assessment. Given low sample sizes, information on sex ratio for fish smaller than ~60cm could be ignored.

The 100% implementation of the electronic monitoring within the Australian fishery will mean that the availability of sex information may be reduced in future. The workshop noted that New Zealand was also moving in this direction, but how EM would 'replace' on board observers in that fleet was not clear.

Model structure and key sensitivities

Yukio Takeuchi presented some preliminary results from the two-sex model for swordfish and a consideration of model runs and key areas of uncertainty to be examined in the 2017 assessment. The difference between spawning biomass and spawning potential in the two sex model was noted.

The workshop discussed the stepwise approach to updating the assessment, and suggested updating the data to 2015 within the old model, before moving to the 2-sex model with the old growth curve and updated data, and then with the new growth curve. The workshop also noted that four alternative natural mortality options could be considered as only the otolith-based growth curve was recommended for the assessment.

Rob Campbell presented information relevant to the assessment model. First, based upon the regions used for the 2013 swordfish assessment it is noticeable that there is a distinct high catch region between Australia and New Zealand and another high catch region up in the north-east corner of the eastern region. This pattern may be indicative of some sub-structuring of swordfish populations across this region. Indeed, genetic studies and tagging programs suggest that the catches in this north-east area are more likely be associated with a separate population of swordfish occurring the north-eastern

region of the Pacific. Given this concern, it was suggested that a sensitivity be conducted with the catches in this north-east region excluded - perhaps by limiting the assessment region to below 10°S. Second, the tracks of swordfish tagged with smart tags between Australia and New Zealand suggested limited movement across the 165°E line. A sensitivity run with very limited movement (e.g. zero) across the boundaries of regions 1 and 2 in the assessment model was therefore suggested. Third, issues related to changes in hook type in the Australian fishery – from J to circle hook around 2008 for turtle mitigation – were noted, with likely differences in the catch rate of large fish and hence selectivity either side of that year, but no clear impact on catchability. The workshop asked whether it was possible to separate out the hook type within the data, but this was not possible.

The workshop discussed the suggested alternative spatial structure, whereby the northern boundary was moved south to 10°S. While movement of the eastern boundary was discussed, the decision was to retain the eastern boundary used within the 2013 assessment.

Noting the use of a sex-separated assessment, the workshop clarified the approach to be used to calculate the biological reference points. Spawning potential was to be calculated based upon female biomass only. While the yield curve would be sex-combined, the stock-recruitment relationship would be based on only the female spawning biomass.

<u>The workshop suggested:</u>

- **That the two-sex assessment approach was strongly supported.**
- **That, within the stepwise approach to swordfish model development, a run be performed with the 'old' sex-combined model with updated data (to 2015), before moving to the 2-sex model with the old growth curve and updated data, and then with the new growth curve. This allows the sex-aggregated and sex-disaggregated models to be compared with the same data;**
- **Including a sensitivity run assuming no diffusion between west and east in the assessment, as performed in the 2013 assessment, along with the two other scenarios on diffusion used in the 2013 assessment ('standard' diffusion assumption and double that diffusion rate).**
- **That for the Australian fleet, the fleet's selectivity be time-blocked at 2008, to take into account the potential impacts of changes in hook type.**
- **considering the suggestion to change the spatial structure of the model, excluding data from north of 10°S in the current structure, and an additional run that combines this alternative structure with a zero-diffusion scenario, as a one-off sensitivity analysis.**

Presentation approach for stock assessment results

Following the discussions on the skipjack stock assessment at SC12 in 2016, alternative approaches to presenting the results of stock assessment, which did not focus on a 'reference case' assessment model run, were presented by Graham Pilling (OFP, SPC). The workshop noted that a move toward the provision of probabilistic stock status advice was appropriate, although the uncertainty would need to be characterised well. The uncertainty could be captured through the structural uncertainty grid that retained plausible results and removed biologically unlikely extreme model runs, or for which appropriate expert weightings for each run were developed so that less biologically plausible runs were down-weighted in the results. A procedure to select the axes of uncertainty and model weighting was discussed, noting that it was most appropriate for these to be defined prior to results from the assessment being available. The workshop also noted that the 'base case' or 'reference case' run, which would likely be the most biologically plausible run, would be used to present the model diagnostics at SC as usual. The run would also be used as the basis for the comparison of the one-off sensitivity runs.

The workshop also discussed the need to ensure the approach was consistent with the move of WCPFC toward harvest strategies for advice, and the work to be undertaken through Management Strategy Evaluation. It was noted that flexibility should be retained, as progress on management procedures may provide new information that requires alternative approaches to be used.

The workshop suggested:

- **That encapsulating the uncertainty within stock assessment results was important.**
- **That the discussion of the axes of uncertainty and their weighting was an appropriate role for the PAW where information could be available in time.**
- **That a move toward the provision of probabilistic assessment advice was appropriate.**

Model weighting approaches

The workshop discussed the potential relative weights of individual model runs for each species that could enhance the computation of the median and other quantiles of important stock assessment results, or for use in stochastic projections. The weights developed for the previous assessments at SC10 were presented and discussed. The workshop noted that these weights and the multiplicative approach used to define weights where multiple axes of uncertainty were included assumed that each uncertainty axis was independent of the other. Without a definitive list of uncertainty grids for the 2017 assessments, the workshop could not define relevant weights at this time.

The workshop suggested:

- **That once further development of the 2017 assessments had occurred, a table of the uncertainty grid axes and a proposed weighting scheme be circulated to workshop attendees.**
- **That the reasoning behind the proposed weights be documented.**

Technical developments in WCPO Management Strategy Evaluation

Rob Scott (OFP, SPC) presented planned activities to underpin the WCPFC Harvest Strategy activities scheduled within the work plan. Approaches to developing a time-efficient and 'realistic' assessment approach for the management procedure were presented, including A4A and cut-down MULTIFAN-CL assessments. It was noted that how resulting reference points feed into the relevant harvest control rule will need to be considered. The approach to generating the pseudo-data for the MSE modelling was described.

The workshop discussed the performance of the estimation method used, and concentrated on the 'cut down' MULTIFAN-CL model examined for skipjack. Suggestions for improving the speed of computation included: rather than re-estimating the model in each time step from scratch, the use of 'realistic' parameter values estimated in the most recent assessment would allow the model to begin in a known parameter space; particular parameters could be fixed (e.g. movement parameters, selectivities; the key parameter estimation processes that takes time can be identified); using an annual, rather than quarterly, time step; length bins in the length frequency data could be expanded; and tagging data could be pooled at a coarser level. In turn, increasing computing resources such as the access to the University of Wisconsin Condor framework could increase performance.

The workshop noted that there was some risk in having the operating model and estimation method based upon the same approach (MULTIFAN-CL). It was noted that ultimately the estimation model evaluated within the management procedure would, on agreement, form the basis of actual advice to WCPFC.

On the aspect of pseudo data generation, the workshop again noted the potential to better capture the variability in size data than assuming a multinomial distribution alone, via e.g. sampling from selectivity deviations.

It was noted that an empirical or statistical estimation model could have very different performance within an evaluation framework depending on their respective abilities to capture stock dynamics. If biases resulted, but were consistent, a robust HCR could perform well. For example, longline fisheries whose standardised CPUE could provide an indicator of abundance may work well for south Pacific albacore fisheries. In contrast, empirical indicators may work less well fir the purse seine fishery with expected effort creep, schooling of fish, development of high tech FADs, etc.. However, their performance could be examined.

The workshop noted that WCPFC13 adopted a 'maximum permissible' level of risk of falling below the LRP of 20%, and that management procedures that led to a greater than 20% risk would not be considered further. Those management procedures that led to risks lower than 20% would be retained for consideration, and the risk level included as a performance indicator.

The workshop noted that the Commission had agreed a work plan for 2017. There was a need to update that plan to adjust for the realities of delivering the work, and to ensure the Commission was aware of that change in timescale.

The workshop suggested:

- **That there was a need to update the Commission work plan on harvest strategies to adjust for the realities of delivering the work, and to ensure the Commission was aware of changes in timescale.**
- **That it would be an advantage to have a functioning example of the MSE for review by SC13, and in particular ready for demonstration at the Commission meeting this year.**

John Hampton described a new New Zealand-funded project that aims to support activities underpinning the WCPO Harvest Strategy. The target start date was 1st May 2017. Key elements are development of the MSE technical framework and stakeholder engagement and capacity building.

The workshop asked how expert input would be gained. The idea was that a similar group to PAW would provide both high level technical inputs and advice, and also aid considerations of outreach. The timing of such meetings was under consideration.

The workshop noted that a critical component of the Harvest Strategy process was effective consultation and dialogue. To this end, an informal advisory group on consultation could be important as part of the proposed stakeholder engagement process.

The workshop suggested:

- **That an advisory group on consultation should be considered as part of the stakeholder engagement strategy development.**

Final remarks

Steve Brouwer thanked participants for a fruitful workshop and indicated that a draft workshop report would be circulated for comment among meeting participants prior to finalisation and submission to SC13. The participants wished the assessment team luck!

APPENDIX 1: List of Participants

Name	Affiliation
John Annala	Ministry for Primary Industries, NZ
Rob Campbell	CSIRO, AU
Jessica Farley	CSIRO, AU
Sangaa Clark	PNAO
Tim Adams	FFA Secretariat
Keith Bigelow	NOAA, US
Eric Chang	National Sun Yat-sen University, TW
Hung-I Liu	Overseas Fisheries Development Council, TW
Keisuke Satoh	National Research Institute of Far Seas Fisheries, JP
Takayuki Matsumoto	National Research Institute of Far Seas Fisheries, JP
Hidetada Kiyofuji	National Research Institute of Far Seas Fisheries, JP
Francisco Abascal Crespo	IEO, Spain
Sung Il Lee	National Institute of Fisheries Science, KR
Doo Nam Kim	National Institute of Fisheries Science, KR
Jiangfeng Zhu	Shanghai Ocean University, CN
SungKwon Soh	WCPFC Secretariat
John Hampton	SPC
Laura Tremblay-Boyer	SPC
Sam McKechnie	SPC
Yukio Takeuchi	SPC
Rob Scott	SPC
Graham Pilling	SPC
Steve Brouwer	SPC
Lauriane Escalle	SPC
Peter Williams	SPC
Tom Peatman	SPC

APPENDIX 2: Terms of Reference

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

Terms of Reference

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

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

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

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

Appendix 3. Meeting photo