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Report from the SPC pre-assessment workshop, Noumea, April 2013

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OFP
Secretariat of the Pacific Community, Noumea, New Caledonia

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Oceanic Fisheries Programme, Secretariat of the Pacific Community

Introduction

To help us undertake stock assessments for the WCPFC, OFP has sought input from stock assessment scientists in the region. The sixth pre-assessment workshop was held in Nouméa, New Caledonia 8-12 April 2013.

Fourteen scientists from twelve organizations participated in the workshop as well as OFP-SPC staff: Francisco Abascal, Owen Anderson, Tony Beeching, Keith Bigelow, Steve Brouwer, Rob Campbell, Shui-Kai Chang, Alfred Cook, Sung Il Lee, Sang Chul Yoon, Pamela Maru, Sam McKechnie, Miki Ogura, Hiroaki Okamoto, Netani Tavaga, plus John Hampton, Shelton Harley, Joel Rice, Aaron Berger, Carola Kirchner, Nick Davies, Tim Lawson, and Simon Hoyle.

The agenda focused on approaches for the stock assessments for swordfish and silky and blue sharks, developments in response to the bigeye review, and methods for evaluating management options and reference points. Presentations were invited from all participants, with the majority made by SPC staff. The meeting operated under the terms of reference provided in Appendix 1 and was chaired by John Hampton, Head of the Oceanic Fisheries Programme.

This report briefly describes the various presentations made and focuses on important issues discussed by participants and any specific recommendations. 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 PowerPoint presentations prepared by SPC can be provided on request.

Southwest Pacific Swordfish

New Zealand Swordfish CPUE series

Owen Anderson presented the CPUE analysis for the New Zealand domestic longline fishery for swordfish, updated using the five years of additional data available since the last analysis. Following the methodology of this earlier analysis, a GAM model was used to allow smoothed fits of model covariates and a quasi-Poisson error distribution was used to deal with the large number of zero catches and over-dispersion of the data relative to the Poisson distribution.

In addition to categorical variables and covariates based on the operational data records, SST, SST anomaly, SSH, and current velocity variables were calculated from satellite data for the start position and date of each set.

Three sets of indices were constructed: one based on all vessels and covering the period from 1993 to 2012; another based on a core set of vessels and the more recent fishery, 1998 to 2012; and a third series based on the same core set of vessels and the period subsequent to the introduction of swordfish into the New Zealand Quota Management System (QMS) and for which information on light stick usage and bait type was available for each set, 2005 to 2012. The first two series updated those used in the previous assessment and closely matched them for the overlapping years. The longer series showed seasonally fluctuating CPUE and an increasing trend until about 2001, followed by a decrease to about 2004, then steadily increasing CPUE (and increasing seasonal fluctuation) through to 2012. The two shorter series showed very similar trends to the longer series for the overlapping years.

The main explanatory variable in each model, in addition to year.quarter, was night-fraction (the proportion of the set during the hours of darkness) and CPUE increased with night-fraction in each model. Other factors with a significant influence in the models were target species in the first model, vessel and SST in the second model, and rate of light stick usage in the third model.

The increasing index since 2004 (when targeting of swordfish became legal) may be due partly to increasing targeting of swordfish, and/or an increase in swordfish abundance. The relative influence of each factor is unknown.

<u>The workshop noted:</u>

- that many of the covariates offered to the model are correlated, and proxy for the process of increases in fishermen's ability to target swordfish.
- These models conflict with the CPUE series for this area based on the Japanese and EU longline fleets, neither of which indicate a significant increase in CPUE in recent years.
- The large change over the time series in the targeting for swordfish by the New Zealand fishery, associated with its introduction to the quota management system. It was not considered likely

that all of this increased targeting ability is fully represented by the covariates offered to the GAM.

The workshop recommended:

- against using the index for the reference case model, but to include it as a sensitivity with low relative weight.

The workshop made the following suggestions for future analyses of New Zealand domestic CPUE:

- Explore delta/lognormal models to deal with the large number of zero catches.
- The fishery has shifted from a by-catch to a target operation, and spatial effects might be important since fishermen's ability to target specific areas has improved through time. Categorical spatial variables should be considered for the model.
- Model aggregation effects (e.g. number of hooks per unit of longline length).
- Investigate influence of changes in hook type on CPUE using observer data.
- Examine the effect of distance to nearest seamount on CPUE.
- Reconsider the criterion for "core vessels" to account for the effects of drop-outs in recent years.

Australian Swordfish CPUE series

Rob Campbell outlined the data and methods used to standardize the CPUE for four target species (yellowfin tuna, bigeye tuna, broadbill swordfish and striped marlin) caught by vessels operating within the longline sector of the Australian Eastern Tuna and Billfish Fishery (ETBF). The time-series of data begins in mid-1997 when logbooks began collecting information on the gear settings used in the ETBF and continues to the end of 2011. Standardized CPUE indices (with catch being the sum of retained and discarded fish) are calculated for three different size classes of fish (Small, Prime and Large) as well as an index for all sizes classes combined. Retained catch for each trip is apportioned to each size class using size data (individual weight data) collected from processors receiving fish landed in the fishery while discards are apportioned based on observer data. Size data for swordfish have been collected for around 80% of all retained fish. A combined delta (binomial) log-gamma model was used to standardize the CPUE with the main effects consisting of year, quarter, area (7), hooks-per-hook, bait-type, start-time, percentage of hooks with light-sticks as well as several environmental effects (including moon-phase, sea-surface temperature, mixed-layer-depth, sea-height, wind-speed) together with two additional effects which account for competition between vessels within each 1-degree square. All effects except moon-phase were fitted as categorical variables with the Year, Quarter and Area effects fitted as either a full 3-way interaction or the sum of both Year*Quarter and Quarter*Area interactions. The standardized index for swordfish for the combined size class displays a steady decline between 1997 and 2003 after which the index increases to 2007 then remains relatively flat through to the end of 2011. A more complete description of this work was provided to SC8 (see SC8-SA-IP13).

The workshop noted:

- That swordfish tend to be caught as individuals rather than aggregated like other species, so the GLM distribution should reflect this property.
- That the number of hooks per km has increased over the time series. It may be reasonable to assume that swordfish are uniformly distributed with respect to the fishing gear, adding hooks doesn't necessarily increase the catch but rather reduces the number of fish caught per hook.
- That the aggregation indicator uses number of vessels in each 1x1 square, which may be confounded with effort. It may be preferable to replace this with an aggregation index that is not confounded with effort, such as the Gini coefficient.
- That the shift to higher CPUE that occurred after 2004 was not attributed to "highlining" (only efficient vessels remaining in the fishery) but rather to reduced fishing pressure. Effective management was introduced in 2003, and subsequently fishermen felt there was recovery from the previous condition of presumed local depletion.

The workshop recommended:

- That standard errors be provided for the year-quarter indices to be input to the model.
- That the Australian index should be input to the model and used for the reference case.

The workshop made the following suggestions for future analyses of Australia domestic CPUE:

- That a cluster analysis be considered to investigate possible shifts in targeting among species.
- That analysts should determine whether circle hooks been introduced to the fishery during the time series, as this may have altered swordfish catchability.
- That alternatives to the delta log-gamma distribution could be considered for the GLM.

Progress towards the stock assessment

Nick Davies presented the progress towards the 2013 South Pacific swordfish stock assessment. This included an overview of the 2008 stock assessment, a reference to recent tagging work undertaken since 2008 that has recommendations for a revised model spatial structure, a description of changes made to the model, and a proposed design for the structural uncertainty grid to be used in the 2013 stock assessment.

The workshop noted:

- That although the EU index excludes operational covariates such as hooks per set and hooks between floats (HBF), there are strong assurances that these factors have remained relatively constant over time.
- That shifts in targeting may have occurred (evident in large shifts in relative proportions of SWO:BSH), but the proportion of swordfish in the catch is most likely related to latitude. Operations have shifted to higher latitudes in recent years resulting in lower proportions of SWO caught per set. The index has been standardised relative to lat-long and this effect should have been explained in the GLM.

The workshop recommended:

- That the acronyms for fisheries that include effort by distant water fishing nations should be changed to DW_##, rather than JP_DW_##.
- That size trends in the Australian longline fishery should be further investigated for latitudinal effects.
- That the growth curve estimated from Australian data should be excluded and preference given to the growth curve estimated from swordfish caught near Hawaii. Comparison of ageing protocols has determined that the ages used in preparing the Hawaii growth curve were more reliable (WCPFC-SC4-2008/BI-IP-2)[1].
- That the CPUE index based on EU swordfish-targeted effort should be included in the model reference case and in the grid.
- That an attempt should be made to derive a CPUE index for the Japanese charter fleet operating in southern zone of area 2 (New Zealand south of 40°S), and that this be included in a sensitivity model run if a satisfactory index is found.
- That the CPUE series based on aggregated Taiwanese catch and effort data should be further investigated, and indices based on SPC-held operational data considered.
    - TW to provide two aggregate catch and effort data sets: one including and the other excluding vessels that target bigeye, and going as far back in time as possible. Given the time constraints, these datasets should be provided by end of the April 2013 if at all possible.
    - That the Taiwanese CPUE index obtained be included in the reference case model and all sensitivity model runs.

The following fishery definitions are proposed. These have been modified (as requested by the PAW) to remove the specific reference to Japan in the combined Distant Water fisheries. They are not yet revised to reflect the time-related split in the DW_2C fishery, because this was not "seen" by the PAW.

Fishery	Label	Flags	Area
1	DW_1N	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS	1N
2	DW_1C	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS	1C
3	DW_1S	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS	1S
4	AU_1	AU	1N, 1C, 1S
5	SP_1	ES	1N, 1C, 1S
6	Other_1	AS, BZ, CK,FM,FJ,PF, GE,GU, IN, ID, KI, MH, NC, NZ, NU, PW, PG, PH, WS, SB, SU, TO, TV, USAS, USMC, USHW, US, VU, VN	1N, 1C, 1S
7	DW_2N	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS	2N
8	DW_2C	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS	2C
9	DW_2S	CN, CNOS, JPDW, JP, JPOS, KRDW, KR, TWDW, TW, TWOD, TWOS	2S
10	NZ_2	NZ	2C, 2S
11	SP_2	ES	2N, 2C, 2S
12	Other_2N	AS, AU,BZ, CK,FM,FJ,PF, GE,GU, IN, ID, KI, MH, NC, NU, PW, PG, PH, WS, SB, SU, TO, TV, USAS, USMC, USHW, US, VU, VN	2N
13	Other_2C	AS, AU,BZ, CK,FM,FJ,PF, GE,GU, IN, ID, KI, MH, NC, NU, PW, PG, PH, WS, SB, SU, TO, TV, USAS, USMC, USHW, US, VU, VN	2C

[1] After the workshop, scientists from both Australia and the USA contacted us about the PAW conclusions regarding swordfish growth curves. We have asked these scientists to provide us a short summary of their recommendations and then will determine what changes should be made to the assessment plan discussed at the PAW.

A design for the structural uncertainty grid was recommended as follows:

Assumption	Ref. case	Sensitivities
Steepness	0.8	0.65; 0.95
Movement (diffusion rate)	0.11	0.0; 0.25
Growth rate / maturity / mortality options	GHML	GHMHS GHMH GHMLS
CPUE series	Area 1: JP_1C, AU_1 Area 2: TW_2C; EU_2	Area 1: JP_1C, AU_1 Area 2: • TW_2C only • TW_2C, NZ_2 • TW_2C, NZ_JPC_2
Size data relative weighting	AU, NZ = *nsamp*/40; Other = *nsamp*/100	AU, NZ = *nsamp*/80; Other = *nsamp*/200
Selectivity	Option 1 (???)	Option 2 (???)

Growth rate/maturity/mortality

The options to be considered are as defined in Table 2 and Table 3 of WCPFC-SC4-2008/SA-WP-6 (REVISION 1) and are:

GAMH	Slow growth, 10+ maturity, relatively high M
GAMHS	Slow growth, 10+ maturity, relatively high M with spawning effect
GAML	Slow growth, 10+ maturity, relatively low M
GAMLS	Slow growth, 10+ maturity, relatively low M with spawning effect
GHMH	Fast growth, 4+ maturity, relatively high M
GHMHS	Fast growth, 4+ maturity, relatively high M with spawning effect
GHML	Fast growth, 4+ maturity, relatively low M
GHMLS	Fast growth, 4+ maturity, relatively low M with spawning effect

CPUE series

The options to be considered are defined as:

JP_1C	Japanese longline in area 1 central zone (20-40degS)
AU_1	Australian longline in area 1
TW_2C	Taiwanese longline in area 2 central zone (20-40degS)
EU_2	Spanish longline in area 2
NZ_2	New Zealand longline in area 2
NZ_JPC_2	Japanese charter vessels operating in New Zealand area 2

South Pacific blue shark stock assessment

Joel Rice presented the progress towards a south Pacific blue shark stock assessment. This will be the first assessment of blue sharks in the Southern WCPO, and as such there are many unknowns. Blue sharks are primarily caught as bycatch, albeit with some significant targeting & mixed fisheries (Swordfish / Shark). CPUE data exists but catch data generally is of poor quality. Despite this the goal of this assessment is to establish and examine key areas of uncertainty and stock status. The current model parameterization includes CPUE trends for 8 fisheries based on operational data for AUS & NZ (JPN vessels in these waters), observer data spread throughout the PICTS, longline length composition data based on SPC-held observer data, and total catches (which are considered preliminary estimates).

The workshop noted:

- That blue shark catch estimates were available from four sources 1) aggregate catch and effort data; 2) Annual catch estimates to the WCPFC; 3) Observer reports; and 4) operational catch and effort data.
- That the above data sources all have very low and unbalanced coverage in terms of fleets, areas, and times, but are particularly poor for catch estimates pre-2000.
- That throughout the time-series of catch data there have been likely changes in retention and reporting which probably vary by fleet.
- Therefore that any approach to estimates total removals was going to have to include all four data sources and a mixture of statistical and imputation methods to fill in the gaps.

The workshop recommended:

- That SPC focus its shark resources for SC9 on NP BSH assessment in association with the ISC, shark mitigation analyses, and the revised silky shark assessment.
- That work on SP BSH should focus solely on the determination of plausible catch and CPUE series so that these can be reviewed at SC9 to determine the feasibility of conducting a SP-BSH assessment.

Silky shark stock assessment

Joel Rice presented an update on progress since SC8 towards an updated assessment for silky shark in the WCPO. He described stock status based on a large number of model runs (that include different assumptions and data sets) to capture uncertainty. In response to requests from SC8, the analysis has addressed concerns over the partial inclusion of the Hawaii-based longline data; and addressed the conflict between the purse seine CPUE and other CPUE series that seems to have been driven by our exclusion of unidentified sharks from the data set. These were most likely silky sharks, and their inclusion has reduced the conflict. We have also included two alternative longline series, one derived solely from Hawaii-based longline data, and a second derived from Japanese research and training vessels. The conclusions from this updated assessment are: the stock status depends strongly on which

CPUE series is assumed to represent trend in abundance. The revised stock assessment is slightly more optimistic that the one presented to SC8, though across all combinations of CPUE series, 58.5% of the runs are in the red quadrant, 20.5% are in the orange quadrant and 21% are in the green. Almost all the 'green runs' are for the target longline series, and these runs do not provide plausible estimates of population biomass.

The workshop noted:

- That the purse seine indices previously used were subject to strong bias in the early years due to the use by observers of a grouped shark category rather than reporting by species.
- That the SPC_LL index was based on SPC-held observer data (but excluding HW data).
- The reliability of the different CPUE indices is variable.
- That the plot of total time series of longline effort – highlighting the years covered in the assessment was useful for the report.

The workshop recommended:

- That the presentation to SC9 include brief summaries of the CPUE series and how they were derived. This should include plots standardized to the mean of the series and presentation of the confidence intervals on the year effects.
- That SPC consider an alternative purse seine CPUE series based on numbers of silky sharks per mt of SKJ adjusted for the estimated biomass of SKJ.
- That the paper for SC9 include breakdowns of key results (e.g. tables and Kobe plots) with the following:
    - Separately for each CPUE and catch series.
    - SPC_LL and the JP_RTV combined.
    - For all model runs combined.

Shark bycatch mitigation

SC8 recommended that mitigation measures may provide the best opportunity to improve the status of silky and oceanic whitetip shark stocks, given the large estimated impacts of non-target longline fisheries. Initial analyses for WCPFC 9 were based on all longline observer data held by OFP where the observer reported at the trip level on the use of wire traces. Caveats about this data include the fact that only 22% of the total observed trips had this information and that there were very few records for some years and some critical fleets (e.g. distant water fleets). This paucity of data is reflected in the uncertainty in the estimates of overall wire trace use in WCPO tuna longline fisheries.

Specific objectives are to update the estimate of the prevalence of wire trace use wire in the WCPO fishery, which were previously only estimated to 2009. We will expand analyses of shark CPUE data to include more recent data, including new data from the US Hawaii fishery, and examine the potential effects of additional mitigating factors, with particular emphasis on circle hook and shark line use (and any interaction with wire trace effects). Secondarily, we will run similar models to look at impacts of

wire trace on target tuna species CPUE. These analyses will determine the expected percent change in catches with bans on wire trace, shark lines, J hooks (individually and in combination). These estimates can be combined with condition and fate data, CPUE models and prevalence data to estimate total mortality under a range of mitigation scenarios. Long-term, this information would be useful in forecasting population level responses to alternate management options.

The workshop noted:

- That it was useful to combine analyses of factors' estimated impacts with estimates of the factors' prevalence in the fishery, as had been done with the wire trace work. It was noted that this might not be possible for all important factors impacting shark catch rates.
- That it might be useful for SC9 to consider the need to design and implement experiments to address shark bycatch mitigation.

The workshop recommended:

- That future analyses include all available observer data sets – noting that some communication with national observer data contacts may be necessary.
- That future analyses explicitly consider both the location of fishing, and deep versus shallow longline setting.
- That future analyses should consider potential interactions between leader type and hook type.
- That SPC work with national data contacts and industry representatives to collate information on occurrence of wire trace use – particularly for fleets with little or no observer coverage.

Harvest Control Rules (HCRs) and Reference points (RPs)

During this session four main themes were presented and discussed: Changes to MULTIFAN-CL to support HCRs and RPs; the most suitable reference time period; F-based reference points; and the characterization of uncertainty.

Summary of MULTIFAN-CL presentation for RPs/HCRs work

Nick Davies presented the recent developments made to the MULTIFAN-CL population modelling software used for undertaking work on RPs and HCRs. These related to improvements to stochastic simulations that include: projections under zero fishing mortality; incremental simulation functionality for HCR testing; constrained distributions for regional recruitment deviates; and stochastic recruitments applied as deviates to the predictions of the Beverton-Holt stock-recruitment relationship (BH-SRR) in each projection run.

HCR overview

Aaron Berger recapped the concepts of reference points and harvest control rules and presented some preliminary results. He illustrated this with evaluations of skipjack harvest control rules. Three alternative structural 'sliding' types of harvest control rule were examined for each of three candidate target reference points (40%, 50%, and 60% of $SB_{F=0}$.).The alternative 'sliding' control rules performed similarly for each target reference point examined in terms of several standard performance indicators (catch variability being the only exception). There were, however, notable differences in performance

indicators among the harvest control rules 'tuned' to the different target reference points. The analyses were repeated with effort creep included, which had significant implications for future status. Harvest control rules must therefore be designed to cope with changes in fishing power through time.

Suitable reference time period

Aaron Berger presented an analysis that focused on the definition of time periods for reference biomass levels, which is the level of adult population present if we never fished ($SB_{t1\text{-}t2,F=0}$) averaged over a time period thought to best represent current and likely future average environmental (ENSO~ 10 year cycle or PDO ~20-30 year cycle) and stock productivity/biological (generation time, historic information) conditions. The length of the time period had minimal influence on the $SB_{t1\text{-}t2,F=0}$ estimate for the skipjack, yellowfin and SP Albacore projections, but for the bigeye and striped marlin the length made a substantial difference.

The workshop noted:

- That a 25 year period might not be a reasonable length (too long to be considered 'recent').
- That the 'moving window' time period was preferred to the fixed, expanded and renewable time window option.
- That the estimated recruitment trend for bigeye might be an artifact of something not understood (i.e. there might be a bias in the assessment) and that information from a fishery targeting juveniles might provide a better understanding of recruitment.
- That the identified time period may not be applicable over the entire suite of models considered for a given assessment; however, it may not make too much of a difference since the estimated performance statistics are presented on a relative scale.

The workshop recommended:

- That the generation time of the individual species could be used as a guideline.
- That the same approach be applied to other stocks such as those conducted by the ISC where the PDO effects may be greater than for the tropical tunas.

F-based reference points

Aaron Berger presented progress made on F-based limit reference points, using two different approaches for accounting for uncertainty with SP Albacore as an example. The objective was to find the F for the fishery that would result in a 5 and 10% probability of the stock falling below the LRP $20\%SB_{2001\text{-}2010,F=0}$ in 2030. The resulting estimates of fishing mortality were presented in relation to both F_{SPR} and F_{MSY} reference levels.

The workshop noted:

- That when risk is to be captured the tails of the distributions are important.
- That care should be taken on the possible mismatch between models on the MSY quantities.

The workshop recommended

- That further work should include an analysis that selected no more than 10 models from the structural uncertainty grid and these should span the productivity and stock status 'space'.
- That a 'run21' type approach should be applied to an SP-ALB run to evaluate sensitivity.
- That the same type of approach used for SP ALB be applied to BET and YFT (i.e., using stochastic runs across a subset of grid models).
- That SB limit should be presented in relation to SBMSY.
- That 5% and 10% risk levels be used for the analyses until managers advise otherwise.

Characterizing uncertainty

Aaron Berger presented some ideas towards a common approach for describing uncertainty for the evaluation of management control systems, given the advantages and challenges inherent in these approaches. The output of a stock assessment is a structural uncertainty grid, which collates the results assimilated across all model assumptions. The assumptions are based on meta-analysis, expert opinion, information contained in the scientific literature, or any other relevant approach. It was put to the participants to decide on a particular method for incorporating uncertainty given the objectives of the analysis and computing constraints.

The workshop noted:

- That the risk-based approach for management (HCR and RP) rules out the single model approach, since it does not capture model uncertainty.
- That consistency and plausibility in the approach are vital and therefore objective criteria must be considered, which includes the development of guidelines for which models to include from the structural uncertainty grid.
- That a representative set of models that adequately captures the uncertainty in the assessment needs to be chosen.
- That it may be possible to apply a 'fractional factorial' approach to reduce the number of runs by a factor of 2^n.
- That a meta-analysis may be used to weight different models, but it is difficult to be objective.
- That the variability among different model runs across the grid is typically much greater than parameter uncertainty within models.
- That the critical components of likelihood profile distributions when it comes to evaluating risk are the tails.

The workshop recommended:

- That a hierarchical approach towards uncertainty estimation should be devised:
    1. Select models from the grid that capture the extent of structural uncertainty.
    2. Run stochastic projections for a chosen subset of models from the grid, with the selection based on fractional factorial design, expert opinion, meta-analysis, and/or plausibility.

- That stochastic projections could incorporate uncertainty in recruitment, effort deviates, and the age structure in the 1st year of the projection period.

Purse seine catch composition

The USA contracted the Center for Independent Experts (CIE) to conduct a review of purse seine catch composition in the WCPO. During 22-25 October 2012, two CIE reviewers (Joe Powers and Patrick Cordue) participated in a panel review at SPC. Keith Bigelow presented the Terms of Reference for the reviews which were agreed upon by the USA and SPC-OFP. Bigelow also presented conclusions and recommendations of the two reviewers.

Terms of Reference were:

1. Evaluate and provide recommendations on the statistical methods used to estimate species and size composition (skipjack, yellowfin and bigeye tuna) in the purse seine fishery, with particular attention to the following issues:

a. The need for, and approaches to, simultaneous estimation of catches for all three species,

b. simultaneous estimation of the size and species composition.

c. factors that influence the size and species composition, e.g., season, location, set type, and vessel flag.

d. Approaches for interpolation (e.g., statistical versus substitution) where sample data are low or absent, especially for the estimation of historical catches.

e. Approaches to characterize uncertainty in estimates of the catch by species;

f. The ability to provide reliable estimates of catch by species at different levels, e.g. the set, the trip, vessel flag, assessment region.

g. Approaches to analyze the paired spill and grab sample trials.

2. Based on the findings of (1) above provide recommendations for:

a. Protocols for the sampling of species and size composition by scientific observers aboard purse seine vessels; and/or

b. Recommendations for future experimental work that would lead to the determination of new sampling protocols.

Joe Power's main conclusions and recommendations were:

1) There is a need to move away from the model based estimation procedure toward the experimental design based multinomial estimation.
2) There is a need for developing a purse seine set-simulation template to be used to examine the robustness of estimation to bias and variance and to evaluate alternative sampling protocols.
3) The impact of layering in the brail needs to be evaluated through simulation and experimental sequential sampling of brails.
4) Mixed sampling protocols and associated estimation procedures should be developed to encompass the cost efficiency of grab type samples and the less biased but more difficult spill samples.

Patrick Cordue's main conclusions were:

1. The grab-sample design leads to estimates of species mix and length frequencies which are biased.
2. Spill samples, when properly scaled within set, can be used to produce (nearly) unbiased estimators of species mix and length frequencies.
3. The current methods of correcting for the grab-sample bias using paired spill-sample and grab-sample data is based on an indefensible model and the "corrected" grab-sample estimates should be discarded (as should estimates of length frequencies and catch histories which are based on the faulty corrections of grab-sample data).
4. Current methods of estimating catch histories for periods when there is little or no observer data are unnecessarily complicated and based on inappropriate models.
5. Simpler, substitution methods can be used after defining appropriate strata by analysing the observer data at the set level.

Patrick Cordue's main recommendations were:

1. A simulation model should be developed for testing alternative observer sampling designs with a view to implementing a design based on spill sampling.
2. Given guidance on the required levels of precision for bigeye, details that need to be worked out include:
   - how to stratify within sets
   - how to stratify in time and space
   - what average size of spill samples/frequency of brail sampling is best
   - how best to achieve a random/uniform distribution of selected brails
   - how best to scale set-level estimates to stratum-wide estimates
3. The documentation of the design should include a full set of equations (and simulation results if needed) which show that estimators of length frequencies and catch by species are (almost) unbiased for individual sets and for strata.
4. Historical data need to be reanalysed to produce defensible estimates of catch histories and length frequencies for use in stock assessment and for other purposes.

Tim Lawson gave a presentation on "Progress and Plans to Address the CIE Review of Species and Size Composition of the Purse Seine Fishery". The main points were as follows:

- Regarding the estimation of the selectivity bias in grab samples collected by observers, using paired spill and grab samples, Lawson (WCPFC-SC8-2012-ST-WP-03 (Rev. 1)) examined the relationship between availability and length, and used this relationship to approximate a correction to the historical grab sample. Cordue developed a multinomial model to determine correction factors. The multinomial approach is computationally intensive, hence Cordue developed a simpler model wherein the correction factors are ratios of the proportions of the numbers of fish in the grab and spill samples. Following a recommendation of Dr Brian McArdle of the University of Auckland, who worked with the OFP for two weeks in February 2013, a simulation study will be conducted to

examine the accuracy and reliability of the two methods (Lawson's availability at length method, and Cordue's ratio method) of analysing the paired samples.

- Both CIE reviewers were concerned about the possible effects of layering within sets, which occurs in both associated and unassociated sets (Lawson 2012, WCPFC-SC8-2012-ST-WP-03 (Rev. 1)). The simulations may therefore also examine layering, extending the simulations presented in Dr Powers' report.
- Regarding the estimation of the species and size composition of the catch by purse seiners, 1967–2012, post stratification, which was recommended by the CIE reviewers, will be developed and examined for years for which the observer coverage is moderate to high, i.e., from 2010 onwards. However, for years for which the observer data coverage is low or zero, post stratification will be considered, but it is expected that GLMs may still be required. Simulations should help to determine the levels of observer coverage that are appropriate for each approach.

Other progress and plans were discussed concerning: the inclusion of the species composition reported on logsheets in the GLMs used to predict the historical species compositions; scaling of the length frequencies based on the catch in strata of year, quarter, 5x5 and school association; the Noro project to compare species compositions from (1) logsheets, (2) grab samples, (3) spill samples, (4) cannery receipts and (5) port samples of landing categories; and an experiment to take spill samples more frequently than every tenth brail, with a smaller bin.

The workshop noted:

- That bigeye tuna catch estimates were likely to be the least reliable given their low representation in purse seine catches and that early estimates (prior to observer data) could be particularly unreliable.
- That for the stock assessment one option could be to set the bigeye purse seine catches to missing in the early years and let the model predict these based on effort data, but noting that catchability of bigeye tuna with floating objects could have been different before the development of the man-made objects in the drifting FAD fishery.

The workshop recommended

- Continued implementation of the recommendations from the three reviews.
- That the catch composition of different floating objects (i.e., logs and drifting and anchored FADS) be re-examined to determine if these fisheries may need to be separated to support the use of MULTIFAN-CL to predict early purse seine catches of bigeye.

Bigeye Review

Summary of MULTIFAN-CL presentation for progress towards completing the recommendations of the BET Peer Review Panel

Nick Davies presented progress towards developments to the MULTIFAN-CL population modelling software as recommended by the BET Peer Review Panel. The high priority development that adds

dimensionality for multiple sexes is well advanced, and the development to add a multinomial likelihood term for age-at-length data is in progress. The development that permits low penalty weight to be applied when fitting the spawner stock-recruitment relationship has been completed. Other developments will be completed during the remainder of 2013.

The workshop recommended:

- For the work done in 2013, include the Peer Review Panel's recommendation "l" to add the option for a likelihood relative weighting to be added to the tagging data term.
- To raise in priority the testing of the new feature for length-based selectivities so that this facility may be applied in the next set of tuna assessments.
- Use swordfish or striped marlin as the test data sets for the development that adds dimensionality for multiple sexes, because these species exhibit high sexual dimorphism.

Longline CPUE and C.V. calculations

Simon Hoyle presented a discussion of estimation of time-varying CVs for CPUE indices. The bigeye review made the following recommendation (#12): "A more appropriate method should be used to calculate the CVs for the Japanese CPUE indices (e.g. Francis' canonical method or prediction-based methods)". In recent years indices for SPC stock assessments have introduced time-varying CVs, based on standardization of Japanese longline operational catch and effort data using delta lognormal models. The 2011 stock assessments assumed that the first period of the time series had the same CV as the least precise of all the CPUE indices. He suggested using predictions from the positive component of the GLM to estimate the uncertainty in each time period, and applying this CV to the overall index. The average CV would then be adjusted to allow for process error and observation error that could not be estimated by the analysis. A similar method was applied in the 2012 south Pacific albacore assessment. This method differs from the 2011 approach only in the use of the 'predict()' function.

The workshop recommended:

- That the use of CVs from the negative binomial model could be explored.
- That the bootstrap and analytical methods could be compared.
- That using 'predict' is appropriate for producing time-varying observation error CVs.

Spatial variation in longline CPUE trends within regions and fleet contractions

Simon Hoyle presented information on analyses in response to the following bigeye review recommendation: "Future analysis of operational CPUE data should focus on how to identify targeting and investigate year-area interactions and the implications of increasing numbers of year-area cells without data." Japanese longline catch and effort data are used to generate indices of abundance for the longline fisheries in each region of the stock assessment. However, Japanese longline effort initially expanded spatially, particularly during the 1950's and 60's, and has contracted since the 1980's. There is also evidence that trends in catch rate are variable within regions. Preliminary efforts to address these issues were described, including investigation of spatio-temporal patterns in catch and effort by

Japanese and other longline fleets, and exploration of alternative methods for estimating abundance indices. These alternative methods included a) investigating spatial variation in temporal trends; b) spatial smoothing; c) spatio-temporal smoothing; and d) rule-based infilling of missing cells. A proposed workplan involved i) estimating abundance time series using the current approach, spatial analyses independent by year, and rule-based infilling; and ii) investigating the scale of potential effects on assessment results by modelling them in MULTIFAN-CL.

The workshop noted:

- That when producing spatial CPUE surfaces it would be useful to including data from more fleets than just the Japanese longline, and to use flag as a covariate.
- That environmental data could be used to improve predictions for areas with missing data.
- That when estimating the spatial pattern of CPUE using GAMs, constraining the number of variables in the GAM may help to avoid over-fitting.
- The utility of applying rule-based infilling for western R3 and areas R2, R5, R6, since there are areas without effort on the edges of the regions.
- That it would be useful to explore trends within a core area in each region, where there has been effort consistently over long periods.

The workshop recommended:

- Continuation of the work plan identified in the presentation.
- Testing the effects of any alternative indices developed through this work in conjunction with other review recommendations.

Analyses of JPLL targeting changes

Simon Hoyle presented information on a second group of analyses in response to the following bigeye review recommendation: "Future analysis of operational CPUE data should focus on how to identify targeting and investigate year-area interactions and the implications of increasing numbers of year-area cells without data.". This talk was presented on screen but not made generally available for download, due to an agreement with Japan to obtain approval before sharing analyses resulting from collaborative work. The presentation discussed alternative explanations for the bigeye recruitment trend, including changes in targeting towards bigeye, underestimation of abundance, and poor fits to size data. The presentation focused on targeting-related issues. Plots of species composition in the JPLL catch by decade were presented in order to provide some context for the changes in the fishery through time, and to generate hypotheses that might explain the broad-based increases in bigeye catches compared to yellowfin. The relative prices of bigeye and yellowfin do not appear to have changed substantially since the mid 1970's. Analyses were presented in the following areas: effort concentration; clustering; spatial variation in catch rate at different scales; GLM standardization of species composition that included vessel effects and HBF; and vessel behaviour including the degree of movement after catches of different sizes. The change towards bigeye targeting in the 1960s and 70s is well known, but there was no clear evidence for further changes in the post-1975 period. A work plan was proposed that

involved writing up the Japanese analyses; investigating potential effects of JPLL target change in the 1960s and 70s; applying to SPC-held operational data similar analyses to those applied to JPLL operational data; and generating indices from SPC-held data within regions 3, 5, and 6, after cluster analysis where necessary.

The workshop noted:

- It would be useful to apply cluster analyses before estimating CPUE in non-equatorial regions, where targeting methods are more distinct than in equatorial areas.
- The utility of examining reported mainline type as a covariate that interacts with HPB.

The workshop recommended:

- Continuation of the work plan identified in the presentation.
- Applying similar targeting analyses to SPC-held operational data.
- Investigating opportunities to apply these methods to operational data held by CCMs that presently do not submit operational longline data to WCPFC.
- Repeating analyses for shorter periods within which there are similar line types (e.g. mono).
- Reporting to SC the relative coverage of SPC-held operational data for CCMs and how the use of these data could be improved through collaborations.

Spatial structure and tag mixing

Simon Hoyle presented progress and plans towards revising the bigeye assessment spatial structure and tagging data, in response to problems with tag mixing identified during the 2012 independent bigeye review.

The bigeye review made the following recommendations in this area: "7) To better address the assumption of homogeneity in tag-recapture data, split Region 3 into two regions and examine whether Region 5 should be split into two regions for tagging off eastern Australia", and "13) Drop the region 5 tagging data unless the model can be re-structured to make the area where the Australian tagging took place in region 5 a separate region".

The presentation described how unmixed tag data can affect assessment outcomes. It described the role of reporting rates (RR) in both indicating lack of mixing and influencing its effects, particularly when RR parameters are estimated at the 0.9 boundary. Tag mixing and reporting rates in the bigeye assessment were discussed, for the poorly mixed RTTP and CS tag releases in region 5, and for other release groups. The model was shown to be constrained by poorly mixed tags even after removing the region 5 tag releases. Plots of tag recovery displacements by time at liberty suggested that many or most R5 releases were recaptured very close to their release point, even after many years. Displacements were also small for tags released in the IDPH area, and largest for tags released in R4. However, analyses of mixing need to take into account both the spatial distribution of catches, and the reliability of catch position

reporting. Newly developed methods to test for mixing were presented, including tag density plots, and statistical tests for mixing among tag release groups.

The following work was suggested in order to address the recommendations from the bigeye review: drop region 5 tags or split region 5; split region 3 into two regions at the IDPH boundary; consider splitting region 4 into two regions; determine an appropriate mixing period for each release group, using statistical tests; and review the data and assumptions to ensure that reporting rate parameters do not hit the 0.9 boundary.

The workshop noted:

- That AU archival tagging work shows low mixing rates for Coral sea (region 5) releases.
- That AU reporting rates may be high in the Coral Sea.
- That bigeye movement may be affected by environmental conditions.
- That tag density plots (spatial distribution of tags per mt of catch) could be used to look at rates of tag mixing in western and central Pacific releases.
- That it may be useful to consider tag displacement by both time at liberty and longitude.
- That simulation could be used to investigate the relationship between the observed displacements of tags and the spatial distribution of the catch.
- That it may be useful to estimate a logistic curve for movement at age, since movement rates may change with age.

The workshop recommended:

- A SC9 priority should deal with region 5 tags, and reviewing mixing rates for all bigeye tag releases. YFT may be included in this process.

Size data

Simon Hoyle presented progress and plans towards revising the size data that is used in the bigeye assessment in response to the 2012 independent bigeye review. Recommendations from the bigeye review included the following: “8. Further explore methods for weighting purse seine length frequencies by catch”; “9. Further explore methods for the calculating longline size-composition data by weighting spatial data by long-term average catches.”; and “10. Length-frequency data for the Japanese longline fishery should be omitted from the reference model until these data are better understood and can be shown to be compatible with the associated weight-frequency data”.

The presentation outlined the background to each recommendation, and suggested the following work. 1) Considerable progress has already been made towards ensuring that PS size data are weighted by catch. Longer term it may be useful to weight PS size data by long-term catch, and to check the effects of changes on selected model configurations. 2) Regarding the longline size data, there is a need to

finalize and test code for reweighting size data by long-term catch. Simulations are needed to test the effects of using this approach. It would also be useful to estimate appropriate effective sample sizes for each fishery. 3) In the short term Japanese length frequency (but not weight frequency) data will be omitted from the bigeye and yellowfin assessments, and SPC scientists will liaise with Japanese scientists about possible investigations.

The workshop noted:

- That it would be useful to examine the spatial and temporal patterns of size data from JP research vessels, training vessels, and commercial vessels.

Final remarks

John Hampton thanked participants for a fruitful workshop and indicated that a draft workshop report would be circulated for comment among meeting participants prior to finalization and submission to SC9.

APPENDIX 1: Agenda

	Monday	Tuesday	Wednesday	Thursday	Friday
0900	Introduction	**Blue shark stock assessments** Progress towards an assessment for the north Pacific Ocean (Joel)	*Longline CPUE – suggestions for further work*	**Bigeye review – the future** Suggestions for priorities for years 2 & 3	Review suggestions to include in wkshop report
0930	**Southwest pacific swordfish:** Progress towards the stock assessment (Nick)		**Bigeye review – spatial structure** Progress & plans towards revising the assessment structure plus other approaches to address tag mixing (Simon & Simon) *Suggestions for further work*		
1000		*Suggestions for further work*		**Silky shark assessment** Presentation of work completed since SC8 (Joel)	
1030	NZ presentation of their inputs (CPUE)	Progress towards an assessment for the south Pacific Ocean (Joel)			
1100	AU presentation of their inputs (CPUE)		**Bigeye review – size data** Progress & plans towards revising the size data in the assessment (Simon) *Suggestions for further work*	**Mitigation of shark longline catches** Present WCPFC9 analysis & outline plans for further analysis (Joel)	
1130	EU presentation of their inputs (place-holder)	*Suggestions for further work*		*Suggestions for further work & collaboration*	
1200					
1300	*Suggestions for further work*	**Purse seine catch & size composition** Presentation of the CIE review (Keith)	**Bigeye review – MULTIFAN-CL** Progress & plans towards implementing changes to MULTIFAN-CL (Nick) *Suggestions for further work*	Follow up work or homework assignments	
1330	**Harvest control rules & reference points** Review of SC/WCPFC requests (Shelton)	SPC progress towards addressing the review (Tim) *Suggestions for further work*			
1400	MULTIFAN-CL dvpmts to support this work (Nick)		**TUMAS workshop** Instructional workshop on the installation & use of TUMAS for evaluating management options		
1430	Operational use of reference points in HCRs – examples using skipjack tuna (Aaron)	**Bigeye review - overview** SC9 Advice (Keith?) SPC overview of review recs (Shelton) Data access (John)			
1500	Towards a common approach for describing uncertainty (Aaron)	**Bigeye review – Longline CPUE** Longline CPUE – CV calculation (Simon)			
1530	Definition of time period for reference biomass levels (Aaron)	Longline CPUE: spatial variation & contraction analysis (Simon)			
1600	Progress on F-based limit reference points (Aaron)				
1630		Longline CPUE – targeting analyses (Simon)			
1700	*Suggestions for further work*				

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 an Information 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 CCM'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.