SCIENTIFIC COMMITTEE

NINTH REGULAR SESSION

Pohnpei, Federated States of Micronesia

6-14 August 2013

Implementing the recommendations from the bigeye tuna assessment review

WCPFC-SC9-2013/SA-WP-08

SPC-OFP

Secretariat of the Pacific Community, Noumea, New Caledonia

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Secretariat of the Pacific Community - Oceanic Fisheries Programme

Summary

This paper provides an overview of progress in implementing the recommendations from the bigeye tuna assessment review. It provides our analysis of the recommendations in terms of different work areas (and areas of responsibility), provides a summary of major work undertaken towards the high priority recommendations (which are fully documented in other SC9 papers), and provides a brief commentary / update on progress towards all recommendations.

WCPFC prioritized the importance of implementing the review recommendations in December 2012 through an agreement to fund an additional position at OFP for three years to focus on this work plus a one year agreement for additional funds to develop MFCL.

We have again reviewed the list of recommendations and categorized them to more easily allow identification of a) the priority that should be associated to them; and b) who is responsible for them. Implementation of many recommendations are outside the control of SPC, and some are even outside the control of the SC and Commission as they relate directly to data held by individual members.

Work in 2013 has mostly focused on three key priority areas raised in the review: 1) analysis of longline catch and effort data with respect to changes in targeting and the spatial extent of the fishery; 2) the extent of mixing of tagged fish; and 3) developing the capability in the MFCL to model the sexes separately. This work has resulted in four information papers for SC9[1]:

- SA-IP-07 [*Recent developments in the MULTIFAN-CL stock assessment software*]: reports developments to MULTIFAN-CL, in particular those undertaken as part of the BET review (sex-structure development) and to support the reference point and harvest control rule work (projections).
- SA-IP-05 [*Longline CPUE series that account for changes in the spatial extent of fisheries*]: reports analyses of operational and aggregate longline catch and effort data using a range of imputation methods (substitution and spatial smoothing) to predict CPUE in strata that were not fished in a given time period. These approaches will form the basis of abundance indices generated for the 2014 bigeye tuna assessment.

[1] Papers on purse seine species composition (SC Project 60) and bigeye tuna biology (Project 35) are also being presented to SC9 and will drive improvements in the next assessment.

- SA-IP-04 [*Target changes in the tropical WCPO Japanese longline fishery, and their effects on species composition*]: reports a joint analysis of Japanese held longline operational catch and effort data with respect to targeting.
- SA-IP-06 [*Tagging data and the spatial structure of WCPO tropical tuna assessments*]: examined the impact of various tagging data sets on the biomass trajectories from the bigeye and yellowfin tuna assessments and also examined spatial and length-specific patterns in estimated displacement and tag recovery density (i.e., number of tags recovered per unit of catch). Several suggestions are provided to improve both the modeling of the data and the overall assessment, in terms of other data issues potentially being masked by the tagging data.

For the remainder of 2013 and the lead-up to the next assessment for bigeye tuna, we will focus on a) developing a full set of longline CPUE series that incorporate the potential impacts of targeting changes and changes in the spatial/temporal distribution of fishing effort – including some simulation work that can assist in determining which series are most appropriate; b) examining alternative spatial structures for the BET assessment; and c) further developing MFCL with respect to some of the other important recommendations.

SC9 should consider the following:

- The critical need for access to Japanese operational longline data to complete work in some key priority research areas for 2013. While highly beneficial current arrangements are likely to be insufficient for the breadth of work required to progress satisfactorily, and it may be necessary to develop contingency plans such as analyzing SPC-held operational longline data and/or aggregate catch and effort data;
- Noting the point above, the desirability of a workshop before the end of 2013 or very early in 2014 to analyze all available operational catch and effort data for longline vessels;
- The critical role that the 2014 Pre-Assessment Workshop will have to play in providing feedback on new modeling approaches and data inputs; and
- The proposal in ST-WP-06 to use data through the end of 2012 for the 2014 bigeye assessment and only including the 2013 data later in the year (when it is more complete) for projection analyses.

Introduction

In May 2012 a panel of Drs Jim Ianelli and Mark Maunder and Professor Andre Punt undertook an independent review[2] (Ianelli et al. 2012) of the 2011 bigeye tuna stock assessment conducted by SPC (Davies et al. 2011). The review was conducted 'on-site' at SPC Headquarters in New Caledonia and was funded by WCPFC. During the review numerous models runs and analyses were undertaken and the panel provided 27 key recommendations.

The review report was considered by the WCPFC Scientific Committee (SC) in 2012. SC8 provided some priorities around the recommendations and also requested that the Commission provide a special additional budgetary contribution in order to fund the implementation of the review recommendations.

At WCPFC 8 in December 2012 the Commission agreed to fund an additional position at OFP for three years to focus on this work plus a one year agreement for additional funds to develop MFCL.

This paper is the second in what is planned to be a series of papers describing progress in implementing the review recommendations. It will only provide an overview of progress, with the main technical analyses being contained in information and working papers of the WCPFC SC (including assessment documents).

In the first paper, provided to SC8, SPC indicated its general agreement with all review recommendations and noted the benefits that the work on these would have for wider application, to yellowfin and skipjack assessments in particular.

This paper will provide our updated analysis of the recommendations in terms of general areas of work and responsibilities, summaries progress on the priority areas, provide a full and 'living' record of progress against all recommendations with a focus on indicating what work might be done for the next bigeye stock assessment in 2014, and highlight any specific recommendations for the SC and Commission (as appropriate) to consider in 2013.

Categorization of review recommendations

The report of Ianelli et al. (2011) split its recommendations into 12 recommendations specifically relating to MFCL (27 a-l) and 26 others. To assist SPC in responding to the set of 26 general recommendations we divided them into the following seven categories:

1. Best practice, i.e. general things that we should do in future assessments
2. Analysis of existing data held by SPC
3. Analysis of existing data not held by SPC
4. Recommendations for the next assessment if the research above does not yield satisfactory a conclusion

[2] This was the second formal independent review undertaken of a stock assessment conducted by SPC-OFP in the past two years. The earlier review was a desk review coordinated by the Center for Independent Experts based at the University of Miami.

5. Further data collection / research activities
6. Assessments to be undertaken
7. MFCL developments, i.e., recommendations that should have been put with the other MFCL recommendations

Table A1 provides our assignment of these recommendations to each category described above, some general comments on each recommendation, and an indication of what progress will be made on it prior to the next bigeye assessment in 2014. Some items are placed under more than one category, e.g. if the application of the recommendation would be 'best practice', but further development in MULTIFAN-CL is required first.

Progress since SC8

Work on the review in 2013 focused on three key priority areas raised in the review: 1) analysis of longline catch and effort data with respect to changes in targeting and the spatial extent of the fishery; 2) the extent of mixing of tagged fish; and 3) developing the capability in the MFCL to model the sexes separately. This work has resulted in four information papers for SC9 which are summarized later in this report.

Following the funding decisions made at WCPFC9 in respect of the review implementation, SPC advertised for a Fishery Scientist to fill a major role in implementing the review recommendations. Dr Sam McKechnie was the successful candidate from a field of five applicants and started with SPC 1 May 2013[3].

The key MULTIFAN-CL developments identified by SC8 formed the basis for the contract with our key MULTIFAN-CL developer (Dr Dave Fournier). While work on these areas has been undertaken continuously since SC8, in late October Nick Davies travelled to Victoria, Canada to work directly with Dr Fournier on these developments.

We used the Pre-Assessment Workshop held in Noumea in April 2013 (OFP 2013) as a key point to provide an update on progress on the key areas and seek advice on the work made and future directions.

Summary of SC9 papers

Davies et al. (2013; SA-IP-07) describes progress against a subset of the full suite of MULTIFAN-CL recommendations (see Annex 1):

- Posting for release a completed development and implementation of a 'multi-sex' version of MULTIFAN-CL, with application to example multi-sex stock assessments. (recommendation "f")
- Completion of the development and implementation for time-varying selectivities and a scheme to estimate seasonal variability in selectivity coefficients. (recommendation "a")

[3] As Sam is such a nice guy [didn't have anything better to do], he attended the PAW in April 2013 before his formal employment began.

- Completion of the development and implementation for conditional age-at-length data to be included in the likelihood function. (recommendation "e")
- Completion of the development and implementation of an output table which lists all of the likelihood components by fleet and automates the process of computing effective sample sizes (and other summary statistics related to the model fit). (recommendation "g")
- Completion of the development and implementation for assuming a multinomial likelihood for the compositional data in the first phases and only transition to the robust normal likelihood in the later phases. (recommendation "j")

Of the five listed above, that relating to the multi-sex application has the highest priority and has comprised the majority of work done to date in 2013. Substantial progress has been made on this task and is reported in the next section of this report. Work towards the other recommendations will be done later in 2013 and early 2014.

The generalization of MULTIFAN-CL to multi-sex OR multi-species had its own set of challenges, in particular the estimation of the spawner recruitment curve (or curves) and yield quantities. The model was developed and tested using simplified bigeye and yellowfin tuna models with the initial aim being to ensure that when the multi-species model was run it gave similar results to when the models for each species were run independently (Figures 1 and 2).

McKechnie et al. (2013) reports analyses of operational and aggregate longline catch and effort data using a range of imputation methods (substitution and spatial smoothing) to predict CPUE in strata that were not fished in a given time period. This work was motivated by the observation that there have been large changes in the spatial extent of the Japanese longline fishing fleet in the WCPO which may have consequences for the reliability of CPUE indices (Figure 3; bottom panel). The Japan-held operational catch and effort data were not available for this analysis so the analyst relied on SPC data holdings. This was best for region 3, so the analyses focused on this region and both bigeye and yellowfin tuna were included. Spatial smoothing (see Figure 4 for an example) and a set of imputation rules were applied to calculate alternative CPUE series and the analysis also utilized data for other flags though the use of flag and vessel effects to assist in filling in gaps (see Figure 5 for an example).

Most approaches produced indices relatively similar to the currently-used indices for the WCPO BET/YFT assessment region 3. There were exceptions however, and several of the indices showed more promising performance than others. The next step will be to formulate robust methods, such as cross-validation and/or simulation studies, that will allow formal comparison of the indices. It would be very valuable to undertake further analyses with refined methodology on more complete datasets of operational longline data that are not currently held by the SPC.

Hoyle and Okamoto (2013) reports a joint analysis of Japanese held longline operational catch and effort data with respect to targeting. At the time of writing, this paper was still under review by the Japanese Fisheries Agency so no further details are provided here, but an update should be available for the presentation to SC9.

Hoyle et al. (2013) provided a detailed examination of the tagging data for bigeye and yellowfin tuna in terms of spatial and length-specific patterns in estimated displacement (Figure 6 and 7) and tag recovery density (i.e., number of tags recovered per unit of catch; Figure 8), and the impact of various tagging data sets on the biomass trajectories from the bigeye and yellowfin tuna assessments (Figure 9). Several suggestions are provided to improve both the modeling of the data and the overall assessment in terms of other data issues potentially being masked by the tagging data.

Given the impact of the tagging data on the assessment results, and while work is being done to better model these data, we recommend that a parallel investigation of the impact of other data sources in the BET assessment be undertaken, using models with more influential tagging data excluded.

What to expect for the 2014 bigeye tuna assessment[4]

Considering the work that has been summarized above and more fully described in the relevant information papers, the following changes are likely to feature in the next bigeye tuna stock assessment:

- Inclusion of available age/length data from the bigeye biology studies to improve the estimation of growth;
- Seasonal selectivity – particularly for fisheries outside the tropical region;
- A range of longline CPUE indices based on alternative methods for imputation of unfished areas;
- Extensive sensitivity analyses examining the influence of the tagging data including:
    - Alternative modeling of mixing periods
    - Exclusion of data from particular release groups
    - Some new alternative spatial structures
- Alternative approaches to model the domestic fisheries of Indonesia and the Philippines that could include:
    - Alternative catch histories
    - Greatly reduced CV's on catch estimates (if possible given the lack of reliable effort data)
    - Alternative spatial structures
- Longline catches modeled in terms of weight instead of numbers to align better with catch limits. (Note: in the past longline catches for major fleets were only provided in terms of numbers of fish).

In addition we hope to see continued improvement in the purse seine catch estimates following the independent review of this work undertaken in 2012 (Lawson 2013) and also improvements in data for Indonesia and the Philippines through the GEF WPEA project (see Indonesia (2013) as an example of work undertaken).

[4] Some of these changes will also feature in the yellowfin and skipjack assessments

Key matters for the consideration of the Scientific Committee

There are three important issues discussed below that warrant the consideration of SC9, these relate to the Pre-Assessment workshop for 2014, access to operational catch and effort data and fall-back positions, and the cut-off for data to be included in the 2014 bigeye assessment.

Pre-Assessment Workshop in 2014

It is clear from the proceeding section that there will be several new model and assessment features for the next assessment and given the complexity and extent of these it will be difficult to fully review and have SPC respond to any requests within the short SC10 meeting. Therefore the Pre-Assessment Workshop that is typically held in April will have a critical role to review progress made and provide guidance to SPC to ensure a smoother review of the work at SC10. It will be important that the status of this meeting is clear and funding is available for interested participants, in particular those from Developing States and Territories.

Access to operational catch and effort data for longline vessels

An important issue for assessments of both bigeye and yellowfin tuna in the WCPO has been the reliance on Japanese longline CPUE as the important abundance indices and the associated inability of Japan to provide the operational data to either WCPFC or SPC due to domestic regulations. To date, progression of research is this area has occurred through collaborative research between SPC and Japanese scientists that involved the SPC scientist travelling to Shimizu, Japan for a period of typically two weeks (see Hoyle and Okamoto 2011; 2013) for two recent example of this collaborative work.

The collaborations have been fruitful (but typically frenetic) and identified amongst other things the preference for using operational data instead of aggregate data for constructing indices and the inclusion of vessel effects in the standardizations. However this approach does have the disadvantage for SPC that we can only examine these data during this small time window and cannot progress this work during the remainder of the year, e.g., ideas cannot be further progressed. This is particularly the case in terms of implementing the bigeye review recommendation 16.

We would encourage Japan and other important longline flag states such as Korea, Chinese Taipei, and China to consider efficient and effective means to make these data available for analysis. SPC is particularly encouraging of collaborative research where national scientists work together with SPC scientists. To this end, we propose a workshop be held before the end of 2013 or very early in 2014 to analyze all available operational catch and effort data for longline vessels. It would involve scientists from all major flag states (plus any interested observers).

If it is not possible to get sufficient access to the Japanese data and/or that of other flag states[5], back up options include:

[5] Data for Korea will be particularly important for region 4 of the assessments (central tropical Pacific).

- Using the previously calculated CPUE series – we will be missing recent years and will not be able to progress the research recommendations regarding targeting and spatial extent of fisheries
- Using SPC-held operational data – for Region 3 SPC's operational data holdings of the DWFN-flag data covers a high percentage of hooks set from their aggregate data (Figure 1) , though the data is biased towards within-EEZ operations and the holdings are very low outside region 3.
- Using aggregate catch and effort data – it has been shown that these series are biased, but the analysis could be expanded to use data for more than one fleet to help address the spatial extent issue.

Data to use for the 2014 assessments

Finally, Harley and Williams (2013) proposes that the 2014 stock assessments for bigeye, yellowfin, and skipjack tunas being undertaken using data through to the end of 2012 rather than through to the end of 2013 as would normally be the case. Then reasons for this are three-fold:

1. WCFPC members usually provided their aggregate catch/effort and size data by the 30th April deadline, but in some cases have acknowledged the data for the most recent year provided are provisional. It is often the case that more complete data, particularly for distant-water longline fleets, are provided after the SC meetings. Significant changes to the most recent year's data has occurred on several occasions after the SC in recent years and therefore left the assessment potentially vulnerable to bias;
2. In recent years, the first 'cut-off' for finalizing the previous year's data for the assessments, has not been possible until the second week of July; and
3. As this is within 15 days of the due date for the submission of Working Papers to the Scientific Committee and subsequently the assessment documents are often rushed and sometimes late, giving the Committee insufficient time to review the documents prior to the SC.

By finalizing the data for the assessment later this year it would allow the assessment work to begin in late 2013, the bigeye review tasks to be undertaken using the data that would be used for the 2014 assessment, allow the Pre-Assessment Workshop to have a more thorough review of the model and its data, and for the timely submission of the assessment Working Papers to the SC.

More complete data for 2013 would still be available for inclusion in any projection analyses that are undertaken after the SC to support the Commission's consideration of management measures.

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Davies, N., Fournier, D., Hampton, J., Hoyle, S., Bouyé, F., and Harley S. (2013) Recent developments in the MULTIFAN-CL stock assessment software. WCPFC-SC9-2013/SA-IP-07.

Harley, S., and Williams, P. (2013) Consideration of data to use in the 2014 stock assessments for bigeye, yellowfin, and skipjack tunas. WCPFC-SC9-2013/ST-WP-06.

Hoyle, S. D., Okamoto, H. (2011) Analyses of Japanese longline operational catch and effort for Bigeye and Yellowfin Tuna in the WCPO. WCPFC-SC7-2011/SA-IP-01.

Hoyle, S. D., Okamoto, H. (2013) Target changes in the tropical WCPO Japanese longline fishery, and their effects on species composition. WCPFC-SC9-2013/SA-IP-04.

Hoyle, S. D., Kolody, D., and Nicol, S. (2013) Tagging data and the spatial structure of WCPO tropical tuna assessments. WCPFC-SC9-2013/SA-IP-06.

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Lawson, T. (2013) Update on the estimation of the species composition of the catch by purse seiners in the Western and Central Pacific Ocean, with responses to recent independent reviews. WCPFC-SC9-2013/ ST-WP-03.

McKechnie, S., Hoyle, S., and Harley S. (2013) Longline CPUE series that account for changes in the spatial extent of fisheries. WCPFC-SC9-2013/SA-IP-05.

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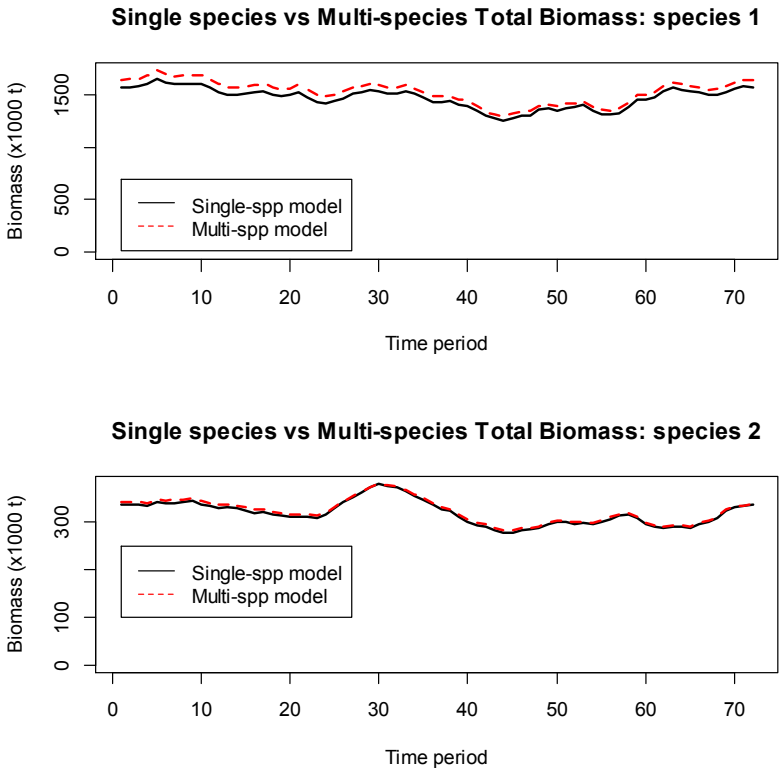

Figure 1. Comparison of biomass estimates for two species derived from a fit to single-species data (Single-spp model), and from a fit to multi-species data (Multi-spp model) (From Davies et al. 2013).

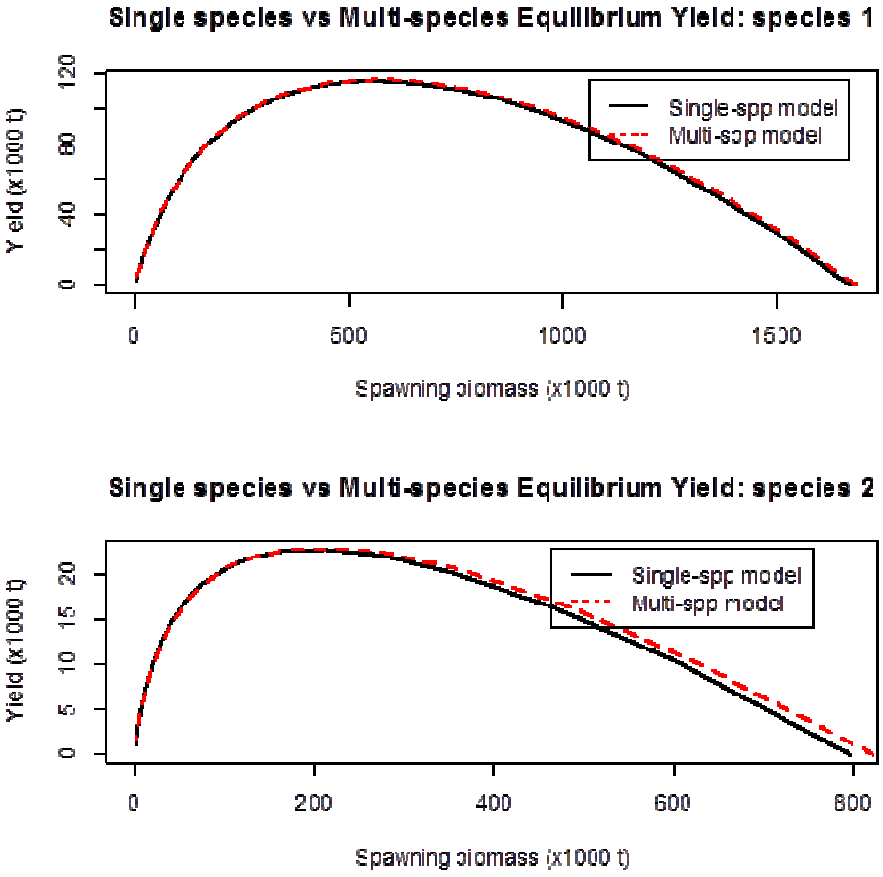

Figure 2. Comparison of equilibrium yield estimates for two species derived from a fit to single-species data (Single-spp model), and from a fit to multi-species data (Multi-spp model). (From Davies et al. 2013).

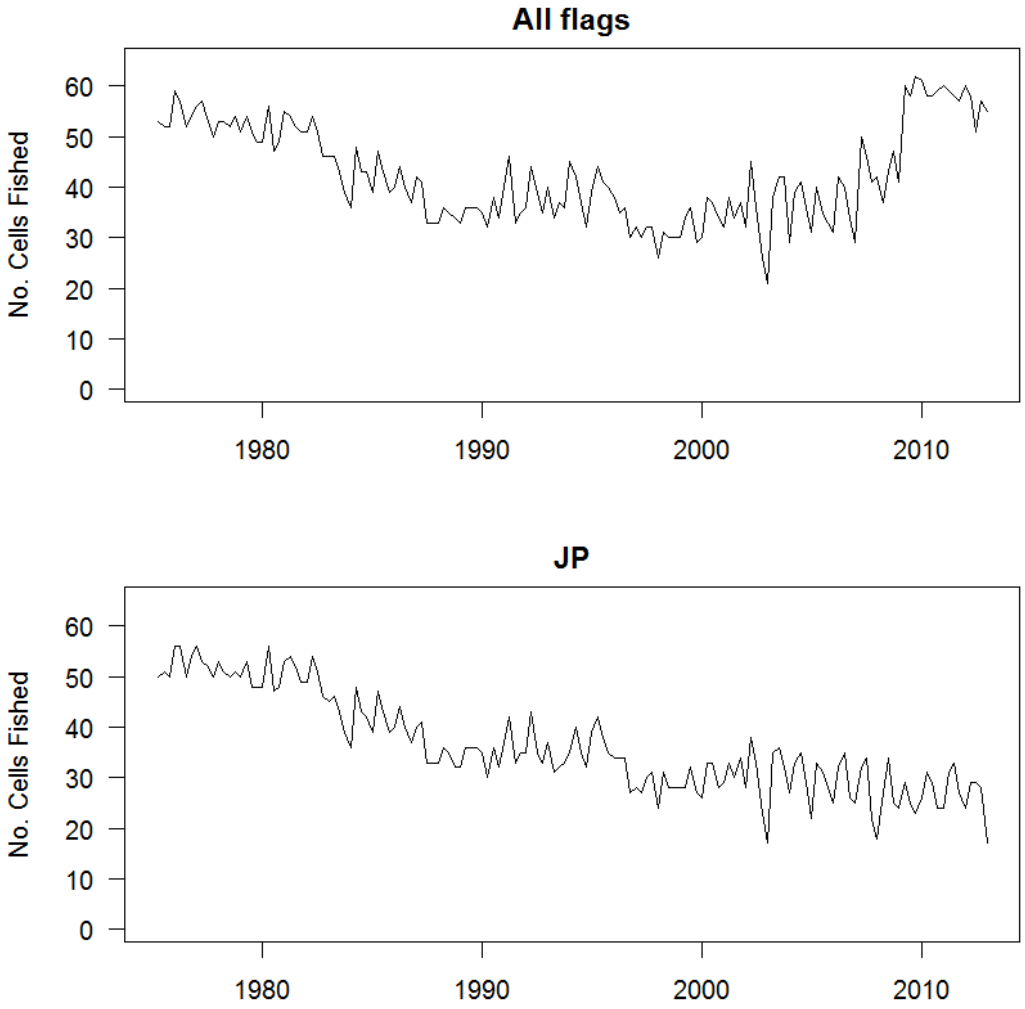

Figure 3: The number of 5×5° spatial cells in region 3 fished in each year-quarter by longline vessels of all flags (top panel) and Japanese longline vessels (bottom panel) for the aggregated dataset. (From McKechnie et al. 2013).

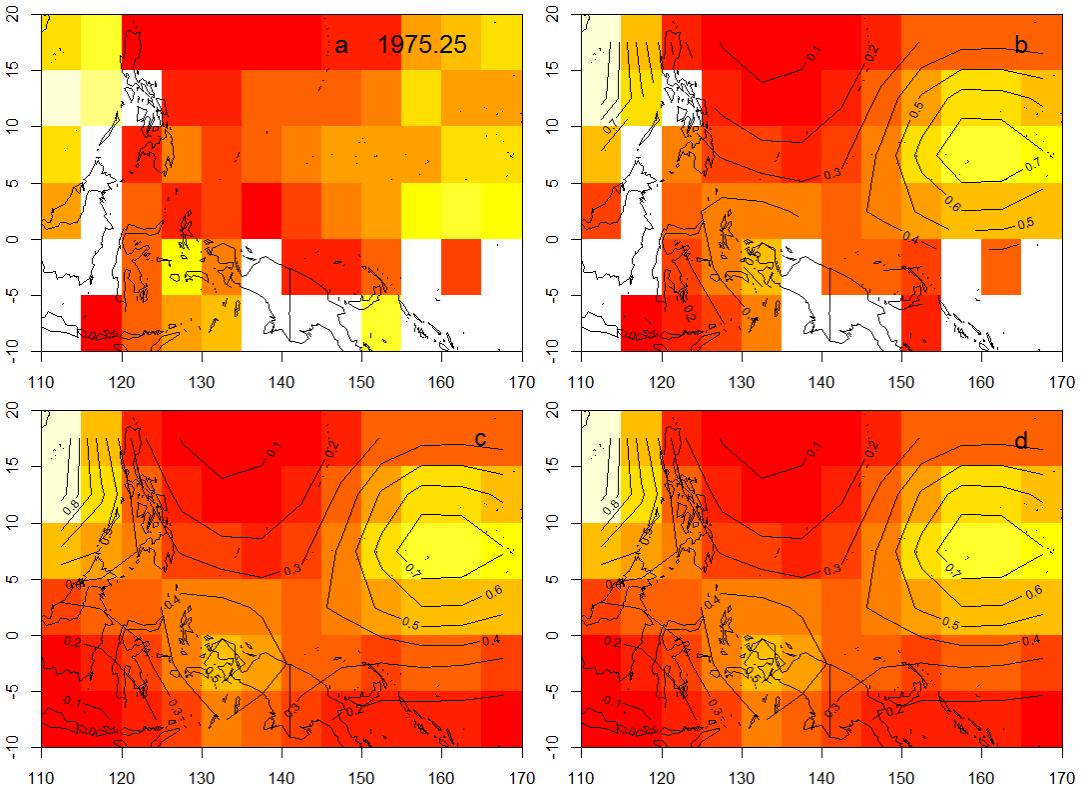

Figure 4: An example of the GAM-based method of spatially imputing CPUE values for cells that were not fished in the 1st quarter of 1975, for the aggregate data for Japanese longline vessels in region 3. Panel a shows the observed CPUE data for each 5° spatial cell, panel b shows the fitted values resulting from the GAM, panel c shows the CPUE surface for all cells (fished and un-fished) before constraints are applied and d shows the same as c but after the constraints have been applied (in this case the constraints did not affect the surface). The sum of the CPUE values over all cells in panel d is the index of abundance for that year-quarter. The contour lines and colours indicate the relative CPUE with red being lowest through to yellow being highest. (From McKechnie et al. 2013).

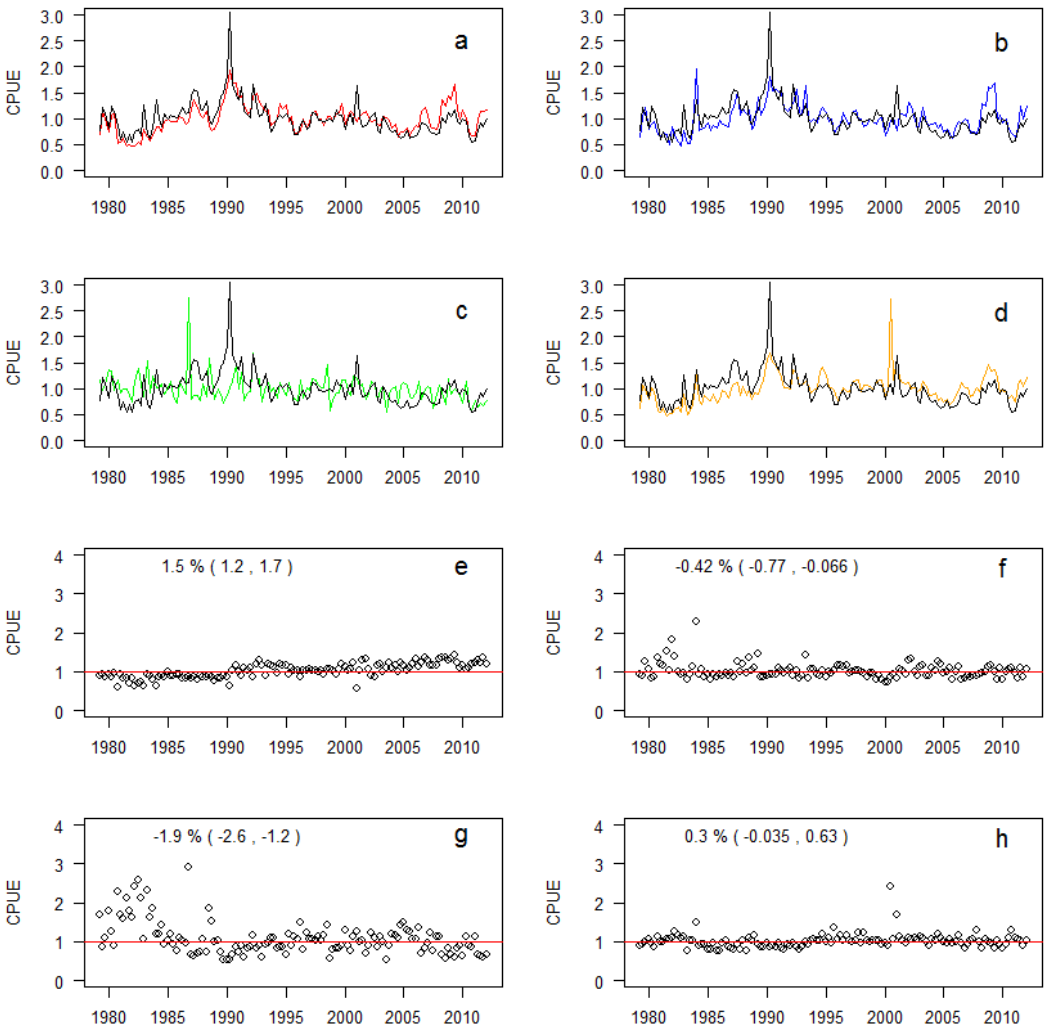

Figure 5: Indices of BET CPUE in region 3 for the SPC-held operational-level data for vessels under all flags. The black line in each panel is the nominal CPUE index. The red line in panel a is the traditional index, the blue line in panel b is the GAM-based index, the green line in panel c is the Carruthers index when all cells are retained, and the orange line in panel e is the hybrid index when all cells are retained. Panel e shows the ratio of the traditional index to the nominal index, panels f, g and h show the ratio of the GAM-based, Carruthers and hybrid indices, respectively, against the traditional index. The numbers in panels e-h are the annual trend in the ratio estimated using a linear regression model fitted to the log ratios, with the 95% confidence interval for this trend given in brackets. (From McKechnie et al. 2013).

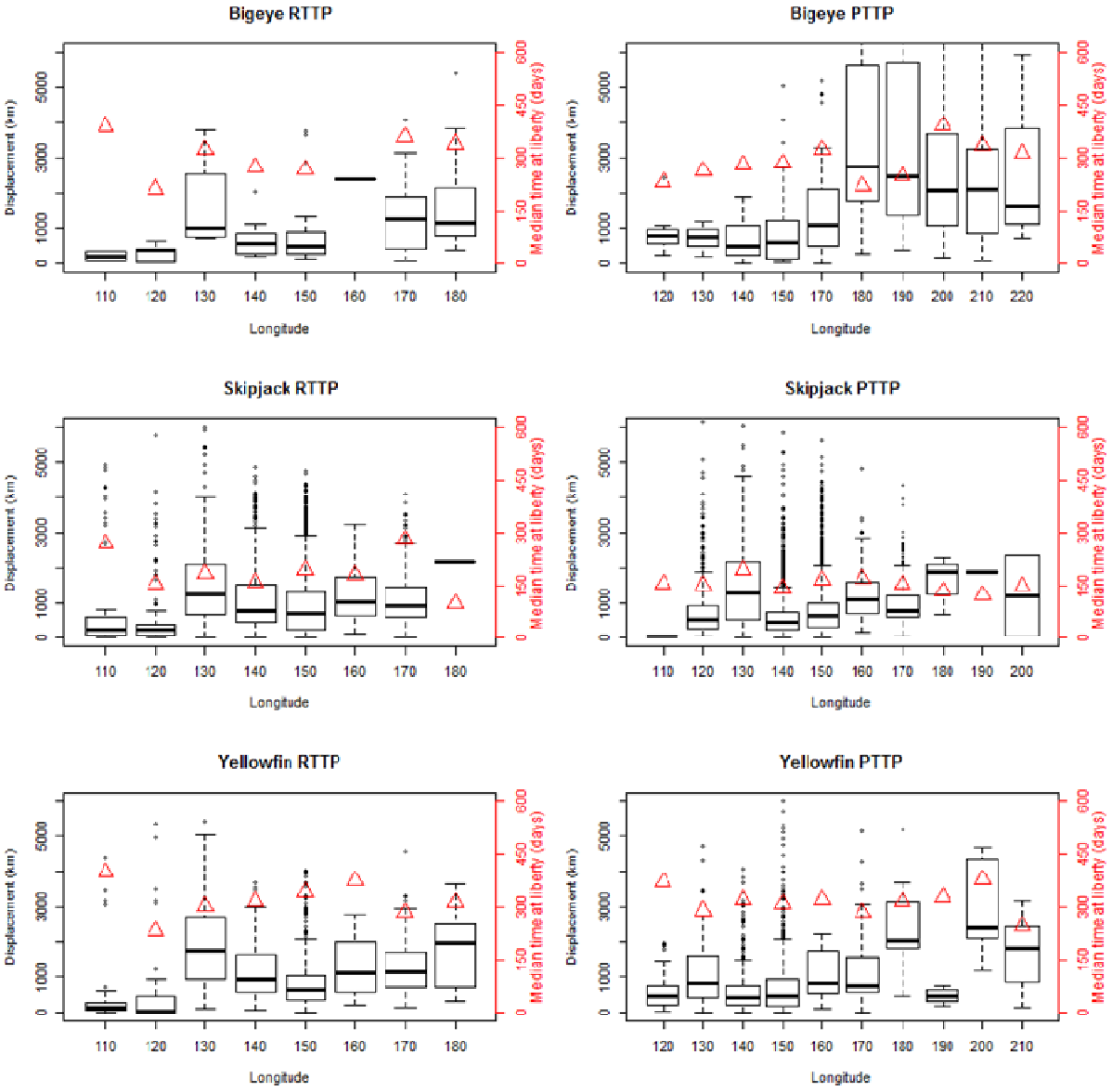

Figure 6: Box plots of observed displacement by release longitude for skipjack, bigeye, and yellowfin tunas for fish with > 183 days at liberty (91 for SKJ), excluding R5, for the RTTP (above) and the PTTP (below). The red triangles represent median times at liberty in days for each longitude group (10 degrees). Longitude labels represent the lower bound of the group. (From Hoyle et al. 2013).

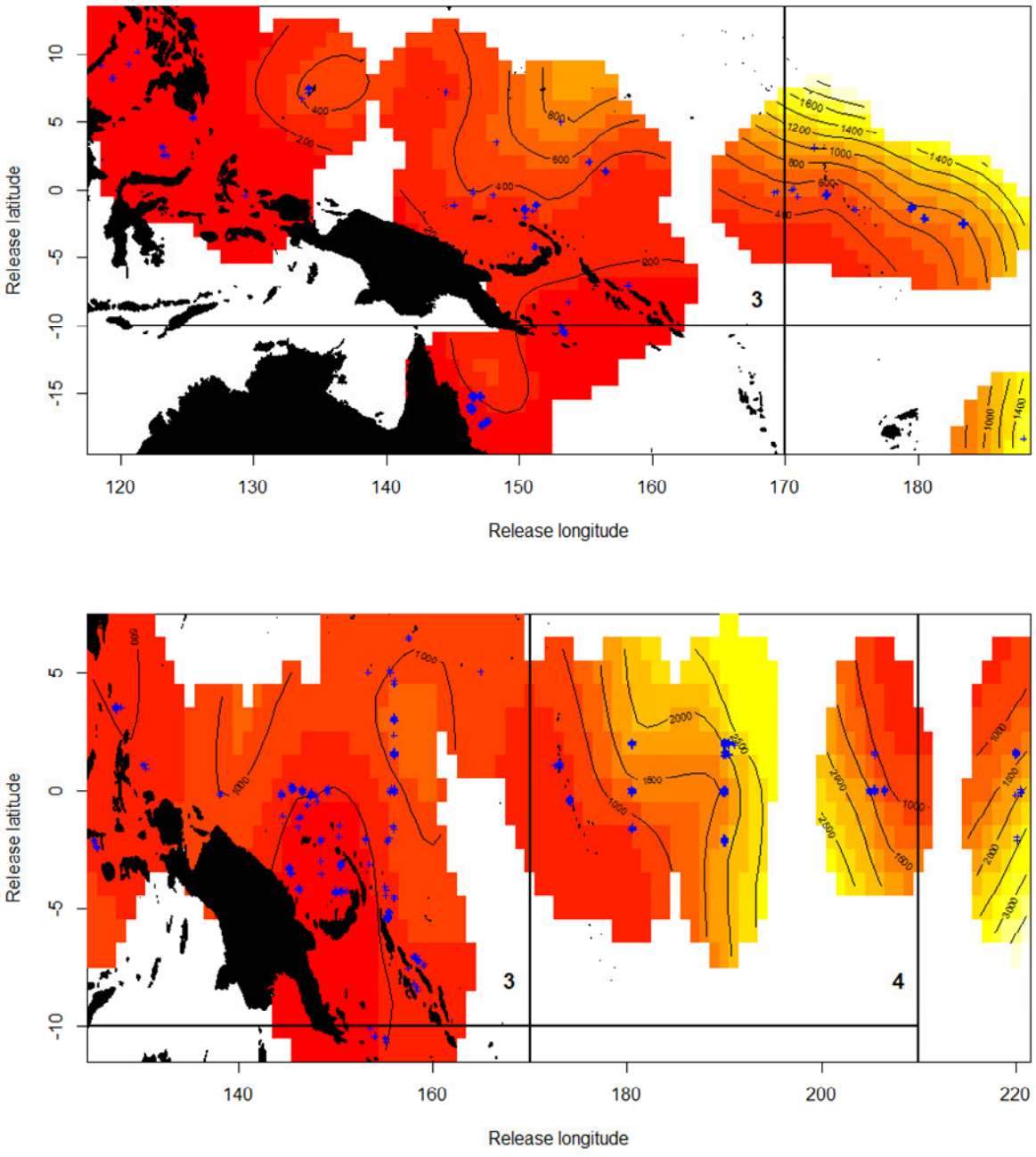

Figure 7: Plots of median displacement by location as estimated by GAMs, for the RTTP (above) and the PTTP (below) for bigeye tuna. Contour lines are at intervals of 200 km (RTTP) or 500 km (PTTP) median displacement. Red indicates smaller displacement. Predictions are for an average length recaptured fish (54cm) after 1 year at liberty. Blue crosses indicate the release locations of tags later recovered. Displacements are predicted for cells within 5 degrees of these locations. (From Hoyle et al. 2013).

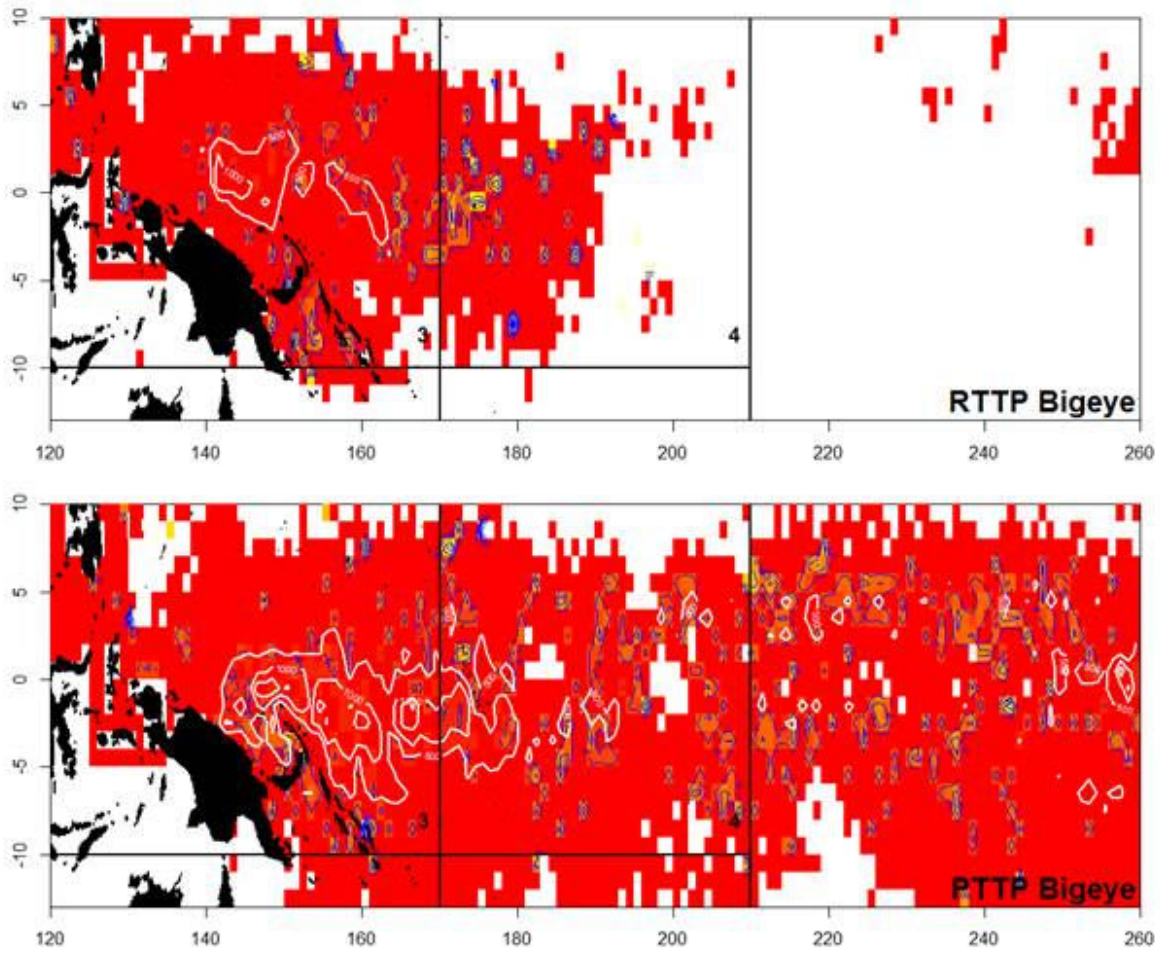

Figure 8: Tag recovery density map per 1 degree square for the RTTP (above) and PTTP (below), for tags recovered after the mixing period. Yellow indicates higher tag density, and responses are on the log scale, so that density increases by a multiple of 4.5 with each blue contour line. The white contour lines indicate the areas of greatest purse seine catch. (From Hoyle et al. 2013).

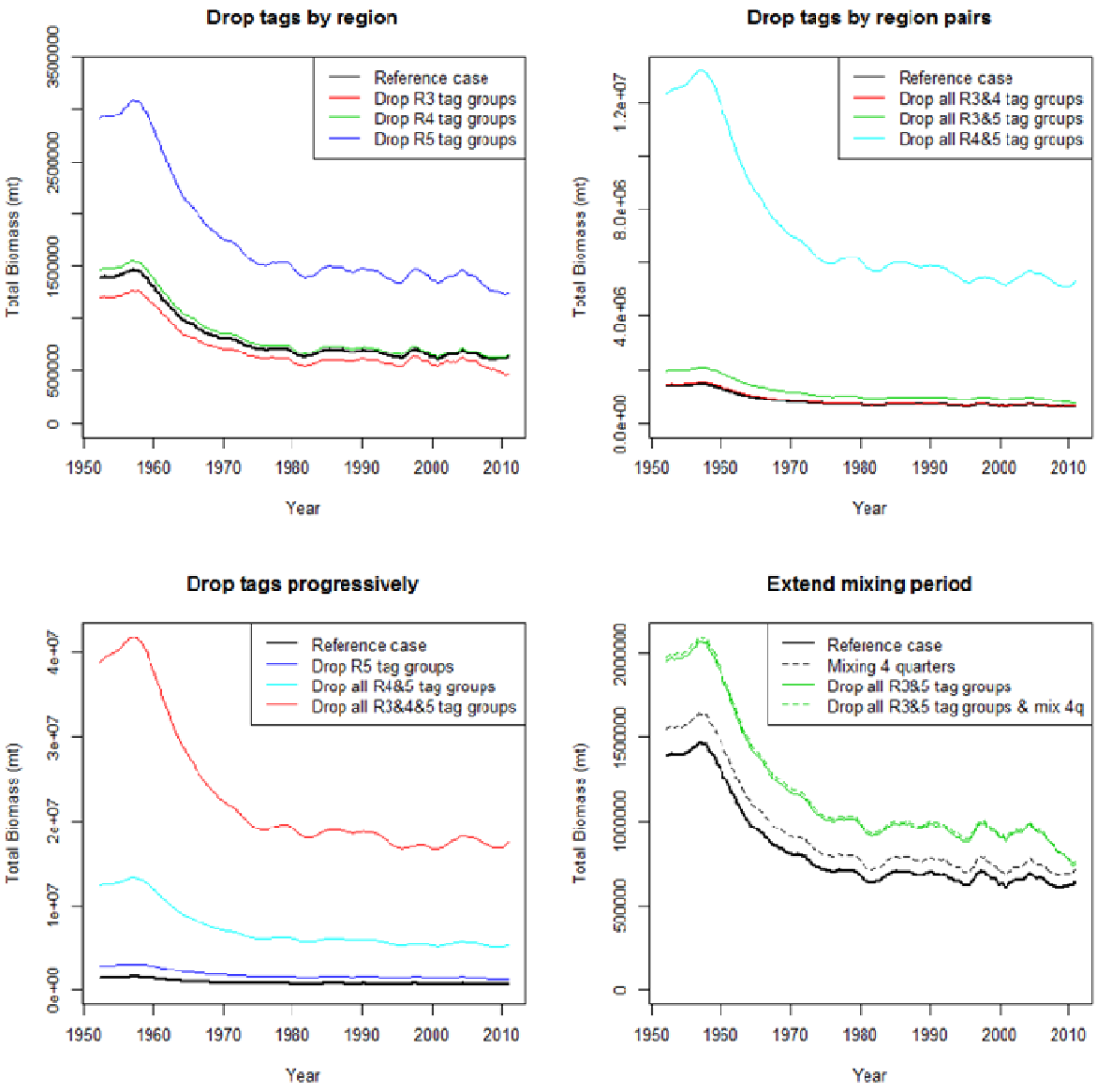

Figure 9: Bigeye tuna total biomass by region estimated in the reference case of the 2011 bigeye assessment (black) versus dropping tags from one or more regions (first three panels) or extending the mixing period from 2 quarters to 4 quarters (bottom right panel). (From Hoyle et al. 2013).

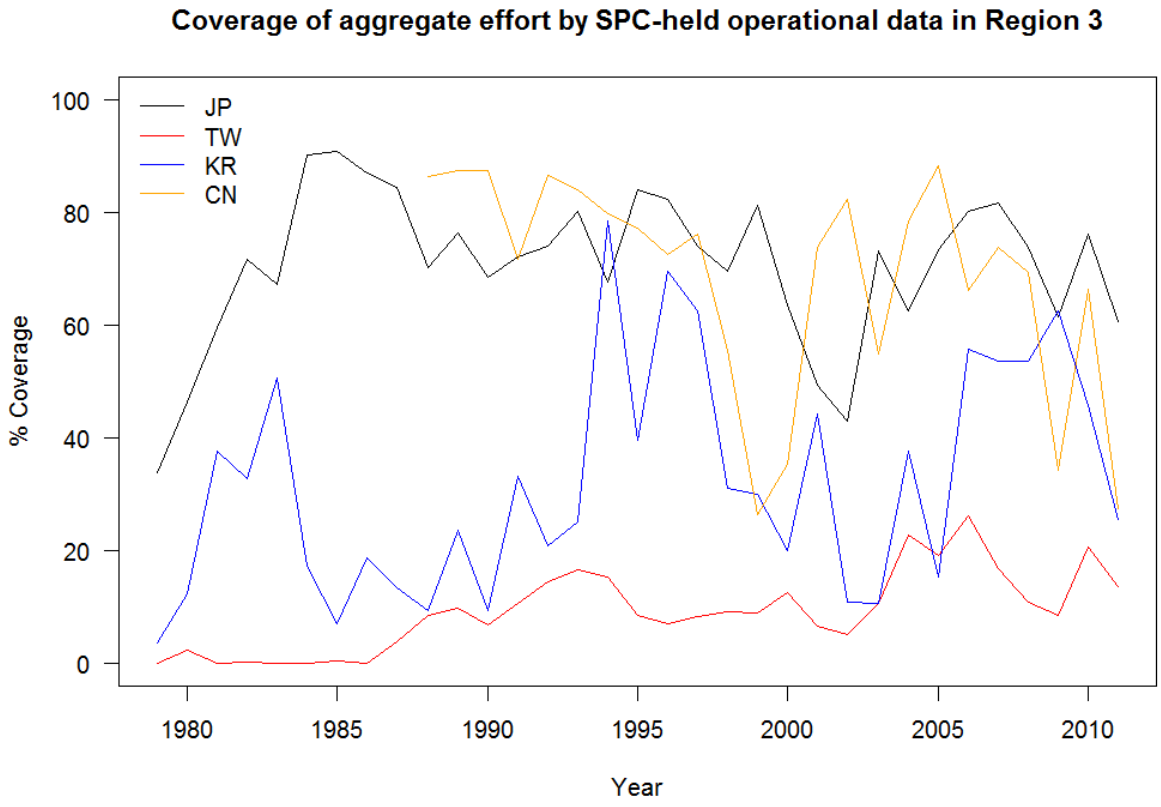

Figure 10: Coverage (% of aggregate effort) of operational longline effort data held by SPC for Region 3 of the bigeye and yellowfin models for the major longline fleets.

Annex 1: Key review recommendations and SPC-OFP responses

Table A1: The full set of recommendations from the review plus some general comments on each from SPC and an indication of what progress will be made on it prior to the next bigeye assessment in 2014.

CATEGORY 1: Best practice			
Review recommendation	**SPC-OFP response**	**Consequences for next assessment**	
1) When moving from one reference model to a modified one, care should be taken to change only one factor at a time to ensure the impact of changes can be fully understood.	Will be a priority for next assessment, but discernment will be required around updates to data which will be numerous, e.g. it will not be possible to make individual model runs for changes to each fishery.	More model results will be reported and the it will add to the length of the report. These results will likely be included in an annex.	
2) The way the fisheries are linked should be more fully documented in the assessment report, and the implications of such linkage should be more fully evaluated.	We will include a table like Table E1 of the review report in future assessment reports.	We will include this extra table.	
19) Sensitivity analyses should continue to be shown to the assumed value for steepness and an appropriate means (e.g., a decision table) used to summarize the management implications of uncertainty regarding steepness.	We will continue to conduct sensitivity analyses on steepness. Implications around the impact of uncertainty in steepness will best be examined through management strategy evaluation.	None as this is already regular practice.	
20) The size of the stock recruitment penalty should be selected which allows the asymptote of the stock-recruitment relationship to be estimated, but is otherwise uninformative about stock size.	We will use an appropriate penalty weight to achieve this outcome	It will be done in the next assessment	
21) Consider fitting the stock-recruitment relationship to the annual rather than seasonal recruitments.	This capability currently exists in MULTIFAN-CL, but has not been fully tested.	If full testing occurs this approach will be included in the next assessment for either the reference case or as a sensitivity analysis.	
22) The statistical weights for each data component (e.g., size composition, tagging, effort deviations) should be re-evaluated and revisited with each subsequent assessment.	We will continue to examine alternative weights as has been done in recent assessments and broadened to also include the tagging likelihood.	The next assessment will include a greater number of runs that examine alternative data weightings.	
23) Future assessments should include both standard and historical retrospective analyses.	The SC report includes a summary of previous estimates of the key management parameters and this should continue to be updated. For future assessments we will examine the impact	The next assessment will include standard retrospective analyses to show how estimates of some recent (but historic) management quantities have changed with	

	of additional years data on key management quantities as a diagnostic.	new data, e.g. F/FMSY and SB/SBMSY for 2009.	
24) Methods should be developed to provide output which accounts for uncertainty regarding the values for the factors considered in the structural analysis.	These are being developed for other assessments (e.g. shark assessments) and as part of the reference point work and will be applied to the next assessments.	The next assessment will have weightings of various levels of factors in the grid. We expect these weightings to be reviewed by the SC and any composite results / stock status conclusions modified if necessary.	
25) Stochastic yield functions should be presented because they may not indicate the same values for management reference points such as *F*MSY and *B*MSY.	Stochastic projections are now possible using MFCL. Some work that may support this area has been undertaken as part of the examination of F-based limit reference points (SC9-MI-WP-03).	This is unlikely to be available for the next assessment as the approach is likely to be extremely computationally intensive, but we will examine it as part of the reference point and harvest control rule work.	
26) Projections considering MSY estimates should account for fishery-specific changes (i.e., likely proportional catches by fishery).	This is currently done as a matter of course in projections, and fishery selectivity can be re-computed for each time step of the projection.	No impact on the next assessment as this is already done.	
CATEGORY 2: Analysis of data that SPC holds			
8) Further explore methods for weighting purse seine length frequencies by catch.	This will be examined as part of the review of purse seine species composition.	This might not be addressed fully prior to the next assessment	
9) Further explore methods for the calculating longline size-composition data by weighting spatial data by long-term average catches.	Further approaches will be considered	This might not be addressed fully prior to the next assessment	
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)	This is an easy recommendation to achieve in a technical sense. SPC holds some operational level data for Japan when they are fishing in some PICT EEZs. This is not necessarily representative of the full operational data set used previously to derive the CPUE indices.	Unless access is provided to the full Japanese operational data it may only be possible to develop methods to address these questions, but not apply them to the data sets previously used to construct the model inputs for the next assessment.	
14) Available data on tag shedding should be examined and be used to provide a value for use in the assessment, noting that this may be challenging given the possibility of correlation between tag loss for each tag for double-tagged animals.	To date, modeling of double tagging data has not indicated continuous longer-term shedding to be an issue. Tag shedding is currently included (along with non-reporting, etc) in a general instantaneous tag loss component.	This might not be addressed fully prior to the next assessment	
16) Future analysis of operational CPUE data should focus on how to identify targeting and investigate year-area interactions and the	This is a high priority area and papers have been submitted SC9. SPC holds some operational level data for Japan when they are fishing in some PICT	As with 12 above	

implications of increasing numbers of year-area cells without data.	EEZs. This is not necessarily representative of the full operational data set used previously to derive the CPUE indices.		
CATEGORY 3: Analysis of data that SPC does not hold			
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. Analysts should gain access to how training vessel trips and any other sampling programs are undertaken, and analyze the available data at the set-by-set level before these length-frequency data are considered for re-inclusion in the assessment.	Agree	A request will be needed from SC/WCPFC to Japan to seek access to these data. If access to these data requires travel to Japan then it is unlikely that this work can be undertaken prior to the next assessment.	
11) Separate the training vessel length frequency data from the commercial data and create a "survey" length composition series to be included in the model.	We agree that this is a good idea. It is an approach adopted in the skipjack assessment to utilize longline training vessel data.	See above	
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)		If the indices for the next assessment are to be based on Japanese-held operational data then it might not be possible to make this change for the next assessment	
16) 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 is a high priority area and papers have been submitted SC9.	As with 12 above	
16b) Remove these unidentified vessels from the latter period is advised (Japanese LL operational data)		As with 12 above	
CATEGORY 4: Assessment specifications for the next assessment			
6) High volume small-fish fisheries (e.g., Philippines and Indonesia) should be retained in the model to ensure their catches are removed from the population correctly with respect to length. However, the model should be	We agree, but we note that the reviewers have not provided any specific advice on how to achieve this, and we note that this is more difficult if the fish are mixing across other regions of the model. We also note that these data are	We will examine alternative spatial structures and data weightings to attempt to minimize the impacts of uncertainty in these data on the overall assessment.	

formulated so that the data for such fisheries do not have a large impact on estimates of population trend and size.	improving slowly over time and less certain aspects of these catches should become less important over time.		
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.	We agree with the general conclusion that alternative spatial structuring may be necessary to better utilize these tagging data. Such changes might not be limited to regions 3 and 5 and may well include region four. Assumptions regarding tag mixing periods will also be important.	Alternative spatial structures and tag mixing periods will be examined as well as the impacts of particular tag recapture data sets.	
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.			
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.	Agree. We also plan to carefully examine tagging data and model fits for both recent and historical tagging to determine if other issues exist. This will be complimented with analyses of mixing rates to determine the best way to model tagging data.		
CATEGORY 5: Further data collection / research activities			
5) Continue tagging programs to allow estimates of movement rates to be obtained for a wide range of environmental conditions	Agree, and we note that this is also important to yellowfin and skipjack tuna which are predominantly taken in surface fisheries. It has been shown that assessments using integrated statistical models for WCPO skipjack in particular are at best unreliable and at worst impossible without good quality and high volume tagging data. This will have considerable budgetary implications. The costs (including tag recovery, database and analytical support) of an annual three month pole-and-line based tagging cruise in the western WCPO and an annual 4-6 week tagging crews in the central Pacific Ocean (targeting BET) are around USD1.5 million.	The 2014 assessment will integrate all available tagging data. Any future tagging will be important for future bigeye tuna assessment including Pacific-wide assessments	
18) Continue seeding experiments due to the impact that reporting rates have on the present model configuration and estimation.	Agree, and this is being done with the cooperation of national observer programmes across the region. These costs will be included within existing tagging programs while the funds are available.		

CATEGORY 6: Assessments to undertake			
3) A Pacific-wide assessment should be conducted soon to evaluate whether the past conclusion that the results from a WCPO-only assessment are consistent with expectations from a Pacific-wide assessment remains true.	Agree	SC9 agreed to schedule this assessment for 2015. It will require collaboration and travel resources to work with the IATTC.	
4) Pacific-wide assessments should be conducted regularly (~every five years) to confirm the assumption that a WCPO-only assessment will provide robust estimates of stock status.	Agree	See above	
CATEGORY 7: MULTIFAN-CL developments (misplaced items that should be in the following section)			
6b) Spatial variation in biological parameters should form a focus for future model development	This is possible, but it is important to examine the theoretical basis for spatial variation – especially in models that estimate movement across sub-regions.	No work will be done on this prior to the 2014 assessment.	
15) Tag loss and tagging-induced mortality should be modeled separately	Agree, although we note that specific estimates of tagging-induced mortality are not available.	Now work likely prior to the 2014 assessment	
16c) Further developments of this useful tool – the MULTIFAN-CL viewer. The additional outputs provided in R (e.g. graphs of mean weight and variation in length and weight composition over time) were also very useful	We continue to develop the MULTIFAN-CL viewer and the R4MFCL library	Continued development to make examination of model results easier. A new version of the viewer will be released in early 2014.	
17) Use methods that simultaneously use both age-length and growth increment data, ideally within MFCL (linked to MFCL (3))	Agree, and note that this is important for other assessments, notably South Pacific albacore.	Some of the development work will be undertaken in 2013/14 and it is possible that age/length data collected under the bigeye tuna biological study (project 35 – the pilot study component) could be included in the next assessment.	
21) Consider fitting the stock-recruitment relationship to the annual rather than seasonal recruitments.	This capability currently exists in MULTIFAN-CL, but has not been fully tested.	If full testing occurs this approach will be included in the next assessment for either the reference case or as a sensitivity analysis.	
25) Stochastic yield functions should be presented because they may not indicate the same values	Stochastic projections are now possible using MFCL. Some work that may support this area has been undertaken as	This is unlikely to be available for the next assessment as the approach is likely to be	

for management reference points such as *F*MSY and *B*MSY.	part of the examination of F-based limit reference points (SC9-MI-WP-03).	extremely computationally intensive, but we will examine it as part of the reference point and harvest control rule work.	

MULTIFAN-CL Developments

Review comment	SPC-OFP response	Consequences for next assessment
a. Test the options for time-varying selectivity – allowing for time-varying selectivity may address some of the issues related to the sometimes poor fits to the length- and weight-frequency data.	This is currently possible by specifying time breaks in fisheries, but we agree a more elegant solution using time blocks as in Stock Synthesis would be better.	It is possible that this might be available, but development and testing is needed so it is uncertain if it will be available for the next assessment.
b. Allow the length bins to be of different widths. One might, for example, want many narrow length bins for the smaller lengths, but fewer but wider length bins for the larger lengths. Allowing for a more flexible length bin structure should also reduce computational times as well as better reflect the available data.	Agree this would be useful.	
c. Allow for long-term and initial tag-loss. Currently initial tag-loss is implemented by reducing the number of animals tagged when inputting data to the model and no account can be taken of long-term tag-loss.	Initial tag loss is also allowed through the reporting rate parameter. But agree that the addition of long-term tag loss, while it is not seen to be significant in the double tagging data available, would be useful.	
d. Include an option which allows the tagging data to inform movement only rather than movement and mortality.	A tag likelihood conditional on tag recapture exists in MFCL but has not been used for WCPO tuna assessments.	It is possible that this might be available, but development and testing is needed so it is uncertain if it will be available for the next assessment.
e. Allow conditional age-at-length data to be included in the likelihood function. This will allow the ageing data from current sampling (e.g. WCPFC-SC6-2010/GN IP-04) to be formally included in the assessment.	Agree that this is a priority. Likewise for tag length-increment data.	Will be available for the next assessment
f. Extend MFCL to allow gender to be explicitly represented. This will allow the impacts of differences in growth and natural mortality between the sexes to be represented. The current approach to modeling, for example, length-specific natural mortality (e.g. WCPFC-SC4-2008/ ME-WP-1) seems unnecessarily complicated given the lack of gender-structure in the model.	This development is close to completion in MFCL, but it is unlikely that sufficient data will exist to use it to implement the 2014 bigeye tuna assessment	It will be available, but it is unlikely that this will be used for the next assessment.
g. Create an output table which lists all of the likelihood components by fleet and automates the process of computing effective samples sizes (and other summary statistics related to model fit).	Agree	Will be available for the next assessment

h. Allow for more general selectivity options, including selectivity patterns where the first age for which selectivity is non-zero is pre-specified. This should help to avoid selectivity being non-zero owing to the functional form for selectivity rather than data.	Agree	
i. Include a "tail compression" option, which would pool all length- and weight-data for large and small sizes based on a specified percentage (e.g. all lengths would be pooled so that the "plus" length-class contained 0.1% of the length-frequency).	We probably need to discuss the merits of this further with the reviewers.	
j. Add an option which allows the analyst to assume a multinomial likelihood for the compositional data in the first phases and only transition to the robust normal likelihood in the later phases.	Agree	Will be available for the next assessment
k. When maturity data are based on length, converting to ages should be done within the model. Presently, the maturity-at-age is based on a fixed age-length relationship.	Agree	
l. An option to add a likelihood weight to the tagging data component should be added.	Agree, although to an extent this exists through the over-dispersion parameter of the negative binomial.	