Report on Yellowfin tuna in the Western and Central Pacific Ocean

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Executive Summary

The 2009 assessment for Western and Central Pacific Ocean yellowfin tuna resulted in a determination that yellowfin tuna was not overfished and that overfishing was not occurring. Previous assessments had determined that overfishing was occurring.

All available relevant sources of information have been used in the assessment including catch, size and effort information. There appear to remain important uncertainties however about the most basic of these data - catch. This should be rectified.

Having been developed specifically for tuna species in the Pacific Ocean, the assessment method is clearly adequate and appropriate for yellowfin tuna and the fisheries exploiting it, and it is well suited to the data available for this assessment. The method seems to have been properly applied. The results can be assumed to be reasonably reliable, but relatively large changes in important fisheries management parameters in successive assessments suggest that the results should be used with care.

All model assumptions seem reasonable, but it is also clear that none of the assumptions is fully satisfied. Similarly, the data seemed to have been properly used, but data are variable and seem relatively scarce. The fact that all model runs presented show more or less the same trends may give a false sense of security. Exploring what changes would be required to produce radically different results might give a sense of the robustness of the results.

The sensitivity analyses of the base case adequately cover the range of possibilities of the model used.

The determination that yellowfin tuna in the Western and Central Pacific is not overfished and that overfishing is not occurring is consistent with the data and seems reasonable, in a relative sense, based on the analyses and sensitivities. This does not mean, however, that the absolute values of BMSY, SSBMSY, and FMSY are estimated precisely.

Future population status and catches are not projected forward in this assessment. The emphasis is on estimating current stock size relative to reference points and these are used to provide advice in terms of fishing effort or fishing mortality. Projections were done in the 2007 assessment but not in the 2009 assessment.

Modeling for this yellowfin tuna resource is pretty much state of the art for the types of data and information available. While modeling can no doubt be improved, it will not be the main avenue to reduce the major sources of uncertainties. Real progress will not be achieved through more modeling - it is more data and knowledge that are required. Reliable estimates of total catch, increased sampling of the most important gear and areas, and well-designed large scale tagging program to better define stock structure and understand migration pattern.

Background

The Pacific Islands Fisheries Science Center (PIFSC) requested an independent review of the stock assessment of yellowfin tuna in the Western and Central Pacific Ocean (WCPO). The Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community, with collaboration from scientists participating in the Scientific Committee of the Western Central Pacific Fisheries Commission, is responsible for conducting the assessment. Results of the 2009 assessment indicate that overfishing of yellowfin tuna is not occurring in the WCPO, which is contrary to the previous assessment (2007). The most influential change in the current assessment was due to assumptions regarding the steepness of the spawner-recruit relationship. Previous assessments used relatively low values of steepness while the current assessment assumes a moderate value (0.75), resulting in a more optimistic assessment of the stock status. The assessment provides the basis for scientific advice on the status of the stock that is provided regularly at both national and regional levels, and directly influences U.S. policy on resource utilization. The most recent stock assessment of yellowfin tuna in the WCPO was completed by the OFP in 2009, with collaboration from U.S. scientists.

The Western and Central Pacific Fisheries Commission (WCPFC) was established in 2004 to coordinate the management of fisheries on Highly Migratory Species (HMS) in the western and central Pacific Ocean. The WCPFC has adopted conservation and management measures for yellowfin tuna, limiting purse seine effort to not exceed that exerted in 2004 or the average of 2001-2004. In addition, the catch of yellowfin tuna is not to be increased in the longline fishery from 2001-2004. (From http://www.nmfs.noaa.gov/fishwatch/species/pac_yellowfin_tuna.htm)

Two main documents were provided for the review: Harley, Hoyle, and Bouyé (2009) provide a sensitivity analysis of the 2007 stock assessment while Langley, Harley, Hoyle, Davies, Hampton, and Kleiber (2009) provide the 2009 stock assessment, including its own extensive sensitivity analysis. In addition, relevant portions of the 2006 (WCPFC SC2, 2006), 2007 (WCPFC SC3, 2007) and 2009 (WCPFC SC5, 2009) reports of Scientific Committee on yellowfin tuna were used.

2007 assessment

The 2007 assessment (WCPFC-SC3, 2007) was slightly more optimistic than the 2006 assessment with approximately equal probability that recent fishing mortality was above or below F_{MSY} but that the biomass was likely above that providing MSY. There was speculation as to the causes of the differences, but no firm conclusions were offered. The phase plot of B/B_{MSY} on the horizontal axis and F/F_{MSY} on the vertical axis suggested that the biomass had decreased from the early 1950s to the mid 1970s at relatively low exploitation rates, and that biomass continued to decrease while fishing mortality increased relatively steadily and rapidly from the mid 1970s to the early 2000s. The assessment suggested that fishing mortality had decreased in recent years and that biomass had increased (Figure 4 in WCPFC –SC3, 2007). The Scientific Committee concluded that the yellowfin tuna fishery can be considered to be fully exploited.

Paragraph 15 of attachment L of WCPFC – SC3 (2007) correctly notes that "*point estimates (including biomass, fishing mortality and target and limit reference points) can be expected to* *fluctuate from year to year due to minor data revisions, model modifications, and the additional information in an extra year of data. These changes should be distinguished from real changes in stock biomass and condition between years. The importance of minor point estimate movements can be over-emphasized if the stock status jumps around either side of a particular reference point. It is much more important to recognize the general stock size trends and the uncertainty encompassed by confidence intervals. With this broader perspective, it is evident that the stock status estimates are actually very similar between the 2006 and 2007 assessments*".

2009 assessment

There was no assessment in 2008, therefore, the 2009 assessment was compared with the 2007 assessment (WCPFC – SC5 (2009)). The report notes that reductions in fishing mortality would be required if the WCPFC wished to maintain average biomass more than 5% above B_{MSY}. The Scientific Committee noted the range of model runs with different feasible values for steepness which were all considered possible. This made it difficult to be prescriptive. While fishing mortality was estimated to be very close to F_{MSY} in the 2007 assessment, the 2009 assessment suggested that there was little probability that overfishing was occurring and even less that the stock was overfished (i.e. that the biomass was less than B_{MSY}). The Scientific Committee noted that exploitation rates differ by region and recommended that there be no increase in the western equatorial region.

Paragraph 31 of attachment L of WCPFC – SC5 (2009) noted that "*the 2009 yellowfin assessment differed in a number of ways from those of the 2007 assessment. These differences largely result from the incorporation of changes recommended by the previous assessment and discussed in the informal pre-assessment workshop and the inclusion of a greater range in the value of the steepness parameter. If a value of steepness similar to the 2007 base case is assumed, results are very similar for MSY based stock status indicators and changes in MSY are also explainable. Many Members felt that these changes, in conjunction with the array of sensitivity analyses conducted to explore uncertainty, provide better understanding of stock status for this species for the Commission*".

Summary of Findings for each Term of Reference

Comment on the adequacy and appropriateness of data sources for stock assessment.

All important sources of data (catch, effort, size) have been used in the assessment, but it is difficult to evaluate their relevance / usefulness / reliability as the basic data are not presented in a way that is amenable to evaluation. For example, Figure 7 of Langley et al. (2009) compares the reported purse seine catch in four fisheries with catch estimates from observer records, but the graphics are poor and do not clearly show the differences except perhaps for PS ASS 3. Later (page 19, paragraph 1) Langley et al. (2009) state that catch in the alternative catch history is about 50% of recent catch for associated fisheries while the unassociated catch is comparable between the two data sets. Paragraph 2 on page 19 (op. cit.) states that it is suspected that actual unclassified catch estimates are substantially lower than reported catch. Paragraph 38 of attachment L of WCPFC SC5 (2009) indicates the alternative catch string is based on grab samples collected by observers from paired grab and spill samples collected during four purse-seine trips in Papua New Guinea in 2008 from a small area and on anchored FADs. More information should be collected.

Apparently (WPCFC SC5, 2009, paragraph 39, attachment L), "*key size data being excluded from the assessment, on the basis of evidence that these data were not representative of catches taken in that region*". It is difficult to evaluate the implications of this statement. Does it mean that the all size frequency information has been reviewed and some was found to be unrepresentative or that only some of the information was reviewed and found to be unrepresentative? In either case, what was the basis for the conclusion?

Page 8, paragraph 3 of Langley et al. (2009) states: "*Effort data for the Philippines and Indonesian surface fisheries were unavailable. Where effort data are absent, the model assumes a constant value of effort and the model predicts the catch using the effort and catchability deviations. The low penalty weight specified for the deviations means that the assumed effort data for these fisheries do not influence the estimates of stock biomass*". While it is probably true that the assumed effort for these fisheries does not influence the estimate of stock biomass, it would be preferable to NOT include these data at all. Graphs are produced of various quantities related to this assumed effort (e.g. effort deviations, catchability trends) which are entirely artificial and not relevant. If useful estimates of effort cannot be made available or derived, it would be preferable to exclude those data.

It is standard in most assessment documents I am familiar with to show in the first few tables total catch by year and area, by gear, by country, etc. This information is not available in the assessment document being evaluated (Langley et al. 2009), except in highly summarized form in Figures 4 to 6. Similarly, the most important results (yearly estimates by age of population numbers, fishing mortality, and biomass) are normally also provided in a tabular form, not only in figures.

Figure 11 of Langley et al. (2009) shows the number of fish sampled for length or weight for each of the fisheries by year. This is useful information, but it would also be useful to show the actual length / weight frequencies by year for each fishery. This would give a better idea of the adequacy / appropriateness of sampling.

It is not clear (Langley et al., 2009, page 9, penultimate paragraph) how quarterly length frequencies were derived for the principal longline fisheries. It is my understanding that the Japanese longliners do spend considerable time at sea (often more than one year), and I expect longliners from other countries to do the same. Assigning a quarter to at-sea samples is straightforward, but if the catch is sampled at the landing port, what is the basis to assign the quarter of the catch?

The threshold for inclusion of length or weight is fifteen fish by quarter and fishery (Langley et al. 2009, page 10, paragraph 1). This is unlikely to be sufficient to adequately describe the length frequency of that fishery and quarter and may only introduce noise in the analysis more than anything else. The minimum number of fish to calculate a quarterly length frequency should be higher, at least 100 - 200 fish. The appropriateness of combining available length frequencies should be assessed to evaluate if this would be a more useful approach.

Tagging data is used in the assessment, but the most recent and most extensive data (2006-2009) is not included (Langley et al., 2009, page 10, penultimate paragraph). This could have a large influence on the assessment results.

In summary, therefore, it appears that all available relevant sources of information have been used in the assessment including catch, size and effort information, but as indicated above, the most recent and most extensive tagging data for 2006 – 2009 were not used. There appear to remain important uncertainties however about the most basic of these data – catch. This should be rectified.

Review the assessment methods: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data.

MULTIFAN-CL is routinely used for tuna stock assessments in the western and central Pacific Ocean (WCPO), and for North Pacific blue shark, Pacific blue marlin, Pacific bluefin tuna, North Pacific swordfish and Northwest Hawaiian lobster (http://www.multifan-cl.org/) as well as in some ICCAT assessments. MULTIFAN-CL implements a statistical, length-based, age-structured model; it combines a method of analysing time series of length-frequency data using statistical theory to provide estimates of von Bertalanffy growth parameters and the proportions-at-age in the length-frequency data (Fournier et al. 1990) and a statistical, age-structured model in which estimates of recruitment, population-at-age, fishing mortality, natural mortality and other estimates useful for stock assessment are obtained from total catch and effort data and catch-at-age samples (Fournier and Archibald, 1982). Fournier et al (1998) provided the first implementation for use in stock assessment.

Having been developed specifically for tuna species in the Pacific Ocean, the assessment method is clearly adequate and appropriate for yellowfin tuna and the fisheries exploiting it, and it is well suited to the data available for this assessment. The method seems to have been properly applied. The results can be assumed to be reasonably reliable, but relatively large changes in important fisheries management parameters in successive assessments suggests that the results should be used with care. MULTIFAN-CL requires skilled users and it would be useful to ground truth the results with simpler methods, e.g. production models, or simple tests like plotting total catch versus an index of total effort (if one can be calculated).

Evaluate the assessment model configuration, assumptions, and input data and parameters (fishery, life history, and spawner recruit relationships): determine if data are properly used, input parameters seem reasonable, models are appropriately configured, assumptions are reasonably satisfied, and primary sources of uncertainty accounted for.

Initial population

Langley et al. (2009, Paragraph 4.1.2, page 12) state: "*The population age structure in the initial time period in each region was assumed to be in equilibrium and determined as a function of the average total mortality during the first 20 quarters. This assumption avoids having to treat the initial age structure, which is generally poorly determined, as independent parameters in the model. The initial age structure was applied to the initial recruitment estimates to obtain the initial populations in each region*". This is probably true in this case, and perhaps the only reasonable option given the limited information available, but it would not be true if the size / age composition at the beginning of the fishery had been well sampled. In that case, it would have been possible and perhaps preferable to estimate the initial age composition rather than assume it to be in equilibrium from average recruitment and fishing mortality.

Growth

The growth parameters used in the assessment agree well with some ageing studies (Langley et al., 2009, Figure 2, page 50) but they seem to overestimate growth when compared to tagging data (op. cit., Figure 3, page 50). The influence of using a growth curve in agreement with the tagging results should be investigated.

Movement

There are limited data to estimate movement (Langley et al. 2009, paragraph 4.1.4, page 12), presumably from limited tagging experiments (see below). It does not seem reasonable to assume that the movements are age / size invariant: small immature fish would be expected to have different migration pattern than older / larger mature individuals, but there probably little data to estimate age / size specific movement rates in the model. WCPFC SC3 (2007, paragraph 17 of attachment L) states "*the movement estimates are supported by some tagging studies, the migration estimates may not be expected to be very reliable (e.g. inter-annual variability is not estimated and migration rates are assumed constant by age)*". Knowledge may exist, however, to crudely estimate different migrations by age / size outside the modeling framework which would be an improvement over the current assumptions.

The model formulation (Langley et al., 2009, paragraph 2, page 24) is such that movement rates between areas are low. This is important in comparing/assessing the effect of each fishery in each area (depletion etc.). If this is in fact a single stock covering the six management regions, depletion in one of the areas may not have severe consequences in terms of protecting the productive capacity of the resource. If the stocks are separate, treating them as a single stock carries significant conservation risks. Whichever hypothesis is true, depletion would have serious social and economic consequences in the regions where it occurs. Better knowledge of stock structure is required to resolve this question.

Reproductive potential

The proportion mature in the base assessment differs considerably from that used in the 2007 assessment for age classes older than 15 (Langley et al. 2009, figure 13, page 60). The reason for the differences should be explained more fully and the effect on the stock recruitment relationship or on SSB trends should be discussed.

Natural mortality

The assessment (Langley et al. 2009, page 5, last paragraph) states that "*natural mortality is strongly variable with size"* but this is not clear from figure 14 (M vs. age). In addition, the difference between the base case and the previous (2007) assessment is very small and it is not obvious that it represents a real change. While the decrease in natural mortality from the youngest age class to age class 5 appears reasonable (Langley et al. 2009, figure 14, page 61), the small bump between age classes 12 and 20 might very well be an artifact of sampling anomalies in one or more years. In addition, the difference in M values between the base 2009 and the 2007 assessment seems trivial. The increased proportion of males with size is attributed to higher M of females (Langley et al. 2009, page 13, paragraph 2) but it could also be due to differences in growth by gender.

Selectivity - catchability

The assessment assumes (Langley et al. 2009, page 7, paragraph 1) that the catchabilities and selectivities do not vary much over time. It is highly unlikely that selectivity or catchability have not changed over the nearly 60 year existence of the fishery. It makes sense to assume that selectivity is fishery – specific (Langley et al. 2009, paragraph 2 of section 4.2.1 page 13) but not that it is time – invariant. Presumably this assumption is necessary because there is insufficient data to detect changes in selectivity with confidence.

Catchability (Langley et al. 2009, section 4.2.2, page 14) is assumed to have increased over time, but by a very small amount, even in Region 3 where the increase is supposed to be 1.4% per year. Further investigation of possible changes in catchability should look at the fishing practices and methods over time to identify major events. Catchability may in fact change in a stepped manner from time to time rather than being a continuous process.

Effort deviations

The decrease in longline catches in recent years (70 000 – 80 000t) compared with the 1970s and 1980s (peaking at about 110 000t) is attributed to presumed "*changes in targeting practices by some of the larger fleets*" (Langley et al. 2009, page 6, paragraph 3). Interactions with other gears may also have had an influence and the increase in PS catches may have played a role in the decrease in longline catches.

Figures 28 and 29 in Langley et al. (2009, pages 78 and 79) suggest trends in effort deviations over time for a few gear area combinations. For the PH HL 3, PH MISO 3 and ID MISC3, this is probably related to the erroneously assumed constant effort being used in the model when effort data is not available. The report states that these do not influence the results. The trend in the effort deviations for most longlines fisheries (Langley et al. 2009, figure 29) suggests that catchability may have changed over time more than is accounted for in the model.

Assessment results

Section 5.4 in Langley et al. (2009, pages 21 – 23) provides a detailed and fair description of fit diagnostics shown in their Fig. 18 to Fig. 29 for total catch, length frequencies (aggregated over time), median fish length, yearly proportions at length, weight frequencies (aggregated over time), median fish weight, yearly proportions at weight, tag returns by period, tag returns by time at liberty, tag returns by gear and time period and effort deviations.

Section 5.5 in Langley et al. (2009, pages 23 – 25) describes the parameter estimates shown in their Fig. 30 – 36 for growth, quarterly movement, proportional distribution of biomass by Region, selectivity coefficients by fishery, average annual catchability by fishery and estimated tag reporting rates by fishery. In section 5.5.3, page 24, paragraph 3, the report states that the "*simulations indicate that most biomass within a region is sourced from recruitment within the region…*". It is doubtful that there is much sampling information to support that result which is more likely the result of the assumed limited movement rather than observation from the fisheries or from the biology of the species. Trends in catchability are identified (Figure 35), but it is not clear how those should be interpreted. Clearly, some are due to faulty assumptions (for Indonesian and Philippines where effort has been assumed to be constant – this is recognized in paragraph 2 on page 25), but presumably, trends in catchability for other fisheries, where data actually exist, are indicative of assumptions that are not met or artifacts of assumption on related parameters.

Section 5.6 in Langley et al. (2009, pages 25 – 30) provides the stock assessment results for recruitment, biomass, fishing mortality, fishery impact, yield analysis, and reference points. Results are presented by region, but it is not clear how meaningful that is. Movement rates are assumed (or constrained) to be small which implicitly mean relatively separate stocks in each region. While it is prudent to assume some form of independence of each region and protect spawning potential in each, if it is present in each, doing separate assessments in each region might result in a higher total estimates of catch and biomass. This highlights the need to better understand stock structure, migration and exchange rates.

In summary, therefore, while all model assumptions seem reasonable, it is also clear that none of the assumptions is fully satisfied. Similarly, the data seemed to have been properly used, but data are variable and seem relatively scarce. The fact that all model runs presented show more or less the same trends may give a false sense of security. Exploring what changes would be required to produce radically different results might give a sense of the robustness of the results.

Clearly, considerable computational work has taken place and few computational rocks seem to have been left unturned. It does seem, however, that assessment results have not been systematically screened for the "red face" test, i.e. do they really make sense. In that context, it might be interesting to calculate an estimate of total catch at age and use it in a VPA / Cohort Analysis to back-calculate historical population and mortality estimates. If this is possible, it would provide an easy ground truthing of the absolute estimates of stock size and stock size trends.

Real progress will not be achieved by changing / refining the model assumptions and structure. Real progress will require increase in knowledge on stock structure and exchange rates, much of which could be obtained from a well-designed large scale tagging program. Such a program could also provide information on mortality rates.

Evaluate the adequacy of the sensitivity analyses in regard to completeness and incorporation of results.

The sensitivity analyses of the base case adequately cover the range of possibilities of the model used. It would have been informative, however, to use other modeling approaches (e.g. Bayesian production models or VPA if total catch at age can be calculated) as checks on the absolute values obtained. A simple graph of total catch versus some estimate of total effort (e.g. by dividing total catch by a CPUE considered representative of stock trends) would also be informative.

Comment on the proposed population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT*); if necessary, recommended values for alternative management benchmarks (or appropriate proxies) and clear statements of stock status.

The determination that yellowfin tuna in the Western and Central Pacific is not overfished and that overfishing is not occurring is consistent with the data and seems reasonable, in a relative sense, based on the analyses and sensitivities. This does not mean, however, that the absolute values of B_{MSY}, SSB_{MSY}, and F_{MSY} are estimated precisely. Estimates of MSY can be found in the reports of the Scientific Committee (WCPFC SC2 2006, table Y1, page 181 and table YFT2 in WCPFC SC5 2009, page 173). These are summarized in the text table below (NB there was no assessment in 2008):

Year	2005	2006	2007	2009
MSY estimate	262 000t	330 000t	427 000t	539 500t

MSY estimates have varied greatly over recent assessments. Absolute estimates of MSY are notoriously variable and it is not a surprise to see the range of estimates for this assessment. While the changes reported above are unlikely to reflect real changes in the productive capacity of yellowfin tuna in the area, real changes in MSY and BMSY may occur over time as the carrying capacity of the environment changes either due to changes in the physical (temperature, salinity) or in the biological environment (prey and predators). This is not unlike the situation for

Atlantic yellowfin tuna reported in Hilborn and Walters (1992, Figure 1.3, page 12) which illustrates how MSY reference points can change when new data are available.

Figure 53 in Langley et al. (2009, page 105) clearly illustrates the enormous influence of the assumption about steepness: MSY varies from slightly more than 400 000t at an assumed steepness of h=0.55 to almost 800 000t at an assumed steepness of h=0.95. But more importantly, if steepness is h=0.55, fishing mortality should not be increased and it would prudent to decrease it while if steepness is h=0.95, fishing mortality could be increased almost 2.5 times. While there is no objective basis to choose a value for steepness within that range using a hockey-stick approach rather than a B&H relationship might prove a pragmatic solution to this dilemma.

The yield analysis (section 5.6.5 in Langley et al. 2009) indicates that estimates of yield are considerably higher than those in the 2007 assessment, which themselves were higher than in the previous two assessments. This suggests that a cautious approach implies not taking the yield estimates at face value, but rather use the assessment results in a relative sense. The assessment suggests that exploitation has increased and that biomass has decreased, but the stock and fishery appear to be within safe biological limits (i.e. F less than F_{MSY} and B greater than B_{MSY}). It would be prudent to restrict future increase in fishing effort until more is known about the biology of the species, particularly about the exchange rate and stock structure.

Figure 4 in Langley et al. (2009, page 51) shows that catches have increased steadily and rapidly from the early 1950s to the early 1990s. However, since then, catches have increased only moderately and can be described as having reached a plateau since about the mid 1990s. If overall fishing effort has been relatively stable or increasing since the mid 1990s, the implication is that current catches are probably close to MSY. Rather than be based on MSY estimates, management advice could be based on surplus production estimates. This might also provide a more rapid feedback on the management decisions taken: it might take decades to find out what the real MSY is, if such a thing exist, for WCPO yellowfin tuna, but it would be considerably easier to assess if the changes in biomass predicted in one assessment did indeed materialize in the next one.

Evaluate the adequacy, appropriateness, and application of the methods used to project future population status.

Future population status and catches are not projected forward in this assessment. The emphasis is on estimating current stock size relative to reference points and these are used to provide advice in terms of fishing effort or fishing mortality. Projections were done in the 2007 assessment but not in the 2009 assessment.

Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices.

As indicated above, considerable computational work has taken place and few computational rocks seem to have been left unturned. Modeling for this yellowfin tuna resource is pretty much state of the art for the types of data and information available. While modeling can no doubt be improved, it will not be the main avenue to reduce the major sources of uncertainties. Real progress will not be achieved through more modeling – it is more data and knowledge that are required. Reliable estimates of total catch, increased sampling of the most important gear and areas, and well –designed large scale tagging program to better define stock structure and understand migration pattern.

Appendix 1: Bibliography of materials provided for review

Fournier, D., and Archibald, C.P. 1982. A general theory for analyzing catch at age data. Canadian Journal of Fisheries and Aquatic Sciences, 39: 1195-1207.

Fournier, D.A., Sibert, J.R., Majkowski, J., and Hampton, J. 1990. MULTIFAN: a likelihood-based method for estimating growth parameters and age composition from multiple length frequency data sets illustrated using data for southern bluefin tuna (Thunnus maccoyi). Canadian Journal of Fisheries and Aquatic Sciences 47: 301-317.

Fournier, D.A., Hampton, J., and Sibert, J.R. 1998. MULTIFAN-CL: a length-based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, Thunnus alalunga. Canadian Journal of Fisheries and Aquatic Sciences, 55: 2105-2116.

Harley, S.J., Hoyle, S.D., and Bouyé, F. 2009. General structural sensitivity analysis for the yellowfin tuna stock assessment. WCPFC-SC5-2009/SA-IP-3.

Hilborn, R and Walters, C.J. 1992. Quantitative Fisheries Stock Assessment – choices, dynamics and uncertainty. Chapman and Hall, 570 pages.

Langley, A., Harley, S., Hoyle, S., Davies, N., Hampton, J. and Kleiber, P. 2009. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. WCPFC-SC5-2009/SA-WP-03.

WCPFC-SC2. 2006. Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean Scientific Committee Third Regular Session. 282 pages

WCPFC-SC3. 2007. Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean Scientific Committee Third Regular Session. 267 pages

WCPFC-SC5. 2009. Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean Scientific Committee Fift Regular Session. 239 pages

Appendix 2: A copy of the CIE Statement of Work

Attachment A: Statement of Work for Dr. Jean-Jacques Maguire

External Independent Peer Review by the Center for Independent Experts

Stock assessment of yellowfin tuna in the Central and Western Pacific Ocean

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org

Project Description: The Pacific Islands Fisheries Science Center (PIFSC) requests an independent review of the stock assessment of yellowfin tuna in the Western and Central Pacific Ocean (WCPO). The Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community, with collaboration from scientists participating in the Scientific Committee of the Western Central Pacific Fisheries Commission, is responsible for conducting the assessment. Results of the 2009 assessment indicate that overfishing of yellowfin tuna is not occurring in the WCPO, which is contrary to the previous assessment (2007). The most influential change in the current assessment was due to was due to assumptions regarding the steepness of the spawner-recruit relationship. Previous assessments used relatively low values of steepness while the current assessment assumes a moderate value (0.75), resulting in a more optimistic assessment of the stock status. The assessment provides the basis for scientific advice on the status of the stock that is provided regularly at both national and regional levels, and directly influences U.S. policy on resource utilization. The most recent stock assessment of yellowfin tuna in the WCPO was completed by the OFP in 2009, with collaboration from U.S. scientists, and three reviewers are requested to review the assessment. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have expertise, working knowledge, and recent experience in various subject areas involved in the review: tuna biology; analytical stock assessment, including population dynamics theory, integrated stock assessment models, and estimation of biological reference points; and MULTIFAN-CL and AD Model Builder. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a "desk" review of the necessary documentation of the current assessment of yellowfin tuna in the WCPO, therefore no travel is required.

Statement of Tasks: Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

<u>Prior to the Peer Review</u>: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact will provide the CIE reviewers with the background documents and reports of the current assessment and sensitivity analyses to be peer reviewed. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

<u>Pre-review Background Documents</u>: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

<u>Desk Review</u>: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

<u>Contract Deliverables - Independent CIE Peer Review Reports</u>: Each CIE reviewer shall complete an independent peer review report addressing each ToRs in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.

2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than (TBD), each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to David Die *ddie@rsmas.miami.edu*. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

9 August 2010	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
11 August 2010	NMFS Project Contact sends the CIE Reviewers the report and background documents
11-30 August 2010	Each reviewer conducts an independent peer review as a desk review
30 August 2010	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
10 September 2010	CIE submits the CIE independent peer review reports to the COTR
15 September 2010	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:

(1) Each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) Each CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
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Key Personnel - NMFS Project Contact:

Gerard DiNardo
Pacific Islands Fisheries Science Center
2570 Dole Street, Honolulu, Hawaii
Gerard.DiNardo@noaa.gov Phone: 808-983-5397

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background and Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

Stock assessment of yellowfin tuna in the Central and Western Pacific Ocean

1. Comment on the adequacy and appropriateness of data sources for stock assessment.

2. Review the assessment methods: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data.

3. Evaluate the assessment model configuration, assumptions, and input data and parameters (fishery, life history, and spawner recruit relationships): determine if data are properly used, input parameters seem reasonable, models are appropriately configured, assumptions are reasonably satisfied, and primary sources of uncertainty accounted for.

4. Evaluate the adequacy of the sensitivity analyses in regard to completeness and incorporation of results.

5. Comment on the proposed population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT*); if necessary, recommended values for alternative management benchmarks (or appropriate proxies) and clear statements of stock status.

6. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status.

7. Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices.